MILK PROTEINS '84

PROCEEDINGS OF THE
INTERNATIONAL CONGRESS ON
MILK PROTEINS
LUXEMBURG, 7-11 MAY 1984

T.E. Galesloot and B.J. Tinbergen (Editors)

Pudoc Wageningen 1985

ISBN 90 220 0860 6

CIP

Printed in the Netherlands.

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Preface

Milk Proteins '84, the first international congress on milk proteins, was organized at a time when the importance of proteins from milk in human nutrition was being increasingly recognized. In the past years, research and promotion activities on milk proteins had been performed only at a national level, including several member countries of the European Community. Since 1980, the need for international coordination of all milk protein activities that has been felt and has been put to effect by the establishment of a combined ASSILEC/EUCOLAIT Working Group 'Promotion of Milk Proteins'. In this way, the interest of both manufacturers and traders of dairy products and proteins from milk were adequately represented. The Working Group took the intiative in planning an international congress on milk proteins in the European Community's Kirchberg Centre in Luxemburg. The Congress could only be organized with substantial financial support from the Community's co-responsibility funds.

At the time the congress was being planned, the European Commission was focusing its attention on the dairy market as a problematic sector of agricultures with the situation becoming more and more dramatic as demand for dairy products stagnated on the domestic market and the world market. It was considered, therefore, gratifying that the dairy industry was initiating a programme of activities to look for new outlets.

The International Milk Protein Congress drew together many experts and authorities in the food and nutrition sector. So it could function as an excellent platform for exchange of the newest developments and insights into the use of proteins derived from milk. Milk as a natural and basic food should form the basis for a milk-protein message throughout the world. Milk Proteins '84 thus aimed at worldwide dissemination of present knowledge of the numerous qualities of milk proteins in traditional dairy products, in other human food and in animal feed.

The scientific information was channelled through five plenary sessions dealing with the themes: World availability and economics of proteins; Nutritional and technological aspects of milk proteins; Innovative uses; Milk Proteins in non-dairy products; and Markets, market requirements and consumer attitudes.

Many invited speakers, all authorities in their field, substantiously contributed to the programme. They displayed information and supplied scientific data for the forum discussion on the final day of the Congress. All the information helped to create a basis for a future milk-protein strategy as laid down in the Congress conclusions and resolutions. Milk Proteins '84 is not the last word on milk proteins. It should be regarded only as a starting point for the continuation of further internationally coordinated efforts. Recognition by the European Community will truly stimulate all further plans.

In the name of the Organization Committe, I thank the professional team of congress organizers P & I, Public Affairs, 's-Hertogenbosch, the Netherlands, for their enormous effort, which contributed in no small measure to the success of the congress.

Those engaged in the preparation and organization of Milk Proteins '84 unanimously approved the dedication of this book to the late Mr Dick Jongejan. As the first chairman of the combined Working Group, he conceived the idea of an international meeting on proteins from milk and was continuously involved in all details of its organization. His serious illness prevented him from taking part in the Congress itself. His enthusiasm and stimulating ideas will remain in our memory.

Bryan Tinbergen,
Congress coordinator

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One needn't be a politician or an economist to know that European agriculture is in trouble. You only have to read the headlines in the newspapers. After long and difficult discussions, Brussels has reached an agreement that neither dairy farmers nor dairy industry can be happy with. We have, however, to face the facts and do our utmost to increase sales in order to serve consumers as well as producers.

Personally I prefer this solution to our problems. You will agree with me that production restrictions will be implemented particularly at the cost of the dairy farmers in those countries where milk is being produced in the most efficient way. Not surprisingly, these typical dairy countries also have the most advanced dairy industries. As to technological and commercial knowledge, insight into marketing, innovation and product development these dairy giants are equal to any international food company.

The food industry has been able to meet consumer demand by developing new products based on advanced technology and knowledge of changes in the market. Often the dairy industry has played a leading role in this respect. That is not so strange. The dairy industry has always understood that it is in their interest as well as the farmers' interest to upgrade milk. In other words, to use milk as a raw material for products with a high incremental value, that are in demand with the consumer.

The awareness that milk and dairy products offer wide options in this respect has not come about overnight, but has existed as long as dairy production. For what else are products like yoghurt, quark, butter and cheese, but milk with an added value? In the last few years a lot of new products have been added to this list, like new kinds of cheese, convenience products, beverages based on milk, buttermilk and yoghurt and a lot of desserts.

Nothwithstanding fierce attacks on the health image of milk and dairy products, the consumer has never lost faith in milk. Its natural origin, its nutritional value, the hygienic safety of modern dairy industry, the awareness that no complicated technological processing is needed to make these products, all these factors have led to the indestructable health image of milk and dairy. Even the fitness and slimming wave has done no harm to this powerful image, because the dairy industry immediately came up with the correct answer to the demand by producing a range of low-fat and protein-rich products that give the consumer the opportunity to choose what he likes. He has been told that milk keeps its nutritional value, even if you skim it. That value is determined by the essential nutrients that milk contains, such as milk proteins, vitamins and calcium.

During this international congress we will concern ourselves exclusively with milk proteins. You may well ask if that is not overexposing one component. The answer is, of course, no. It is not coincidence that you have come to Luxemburg from all corners of the earth to discuss milk proteins from all angles. The interest in milk proteins in the last few years has been growing at an amazing pace. The major reasons for this are nutritional, technological and economic.

The nutritionist regards milk proteins as an essential nutrient of high biological value. Without milk and diary products, it is very difficult indeed for people in developed countries to compose their meals in a nutritionally acceptable way. In developing countries, milk proteins – under specific circumstances – also can play a crucial role in satisfying the need for high-quality proteins, a topic that will be amply discussed during this meeting.

Foods industries have built up an interest in milk proteins in view of their exceptional functional technological properties. In the contemporary processing industry – including the dairy industry – milk proteins are being applied as components that find complete acceptance with the consumer. Apart from dairy products, milk proteins are being used to improve the quality and consumer acceptance of bakery products, sweets and candies, soups and sauces, beverages, meats and processed cheese.

As a result of our changing ways of life, a range of totally new food products have emerged to satisfy demand from special target groups for high-quality protein foods. A lot of these products are based on the specific nutritional properties of milk-protein concentrates and isolates. The consumer today is jogging, bike racing, swimming, playing tennis or squash, aerobic dancing or bodybuilding in order to gain or maintain a healthy body, and milk proteins will help him to achieve this. If he wants to increase or to reduce his body weight he will consume dietary products that nowadays more ofen than not are based on milk proteins. Sportsmen and women, especially bodybuilders, weight-lifters and people that practise endurance sports, are great consumes of milk proteins, for instance in drinking mixes, to improve their performance. Milk proteins are also used in a range of clinical foodstuffs, for example as part of the treatment of severe burns. These aspects will be dealt with during this conference.

The economist will relate milk proteins to the importance of a healthy dairy industry in the European Community. He will also take into account the world's need for complete foodstuffs and the shortage of these in many countries. The dairy industry makes a large contribution to the gross national product and the labour market in many states of the European Community. The consumer in developed countries benefits from the high nutritional value of milk and dairy products, which for a large part is based on their high content of biologically valuable proteins. The dairy industry helps him to keep the cost of living down.

Concerning milk and diary products I see the following three prospects.

First, the consumer market for the traditional milk and dairy products has already reached a high level. Further growth depends largely on the development of new sophisticated products with a high incremental value. A substantial expansion of the total foods market is not to be expected but within this market considerable shifts in demand are possible. I am convinced that it should be possible to increase sales and output of milk by concentrating on the constantly changing tastes and demands of the consumer.

Secondly, there is an immense worldwide market for milk and diary products but, alas, purchasing power in the developing countries is low. Especially in Asian countries, such as Indonesia, where there is no question of real famine but of an extreme shortage of specific nutrients, there is a great need of cheap products with a high protein quality. These populations are willing enough to spend the little money they have to improve the health of their children – one only has to look at the amazing sales of medicine also to the less wealthy in these countries – but they simply cannot afford to buy milk products in the amounts that are quite normal to us. Especially for children recovering from intestinal infections, which are abundant in these countries, there is an enormous demand for products with a high protein value. The dairy industry might develop products that such people can afford and that contain milk proteins to fill this nutritional gap.

Thirdly, the industrial market for technologically advanced products such as milk-protein concentrates and isolates is booming. We are talking here of products with a high incremental value indeed. They have a wide field of application, in the diary industry itself, but also in other sectors of the food industry. It is therefore in the interest of the European dairy industry as a whole to enlarge this market in any way possible. This thought was expressed in 1981 during the IDF conference held at this same Kirchberg Centre.

Wat can we do?

In the first place, we must develop a joint world strategy for milk proteins. Why go it alone when we could be together? The goal of this strategy should be to increase total demand for milk proteins by enlarging our markets and by developing through research new applications of milk proteins. In this respect, let me mention the quest for total milk protein in New Zealand and in the Dutch dairy research institution NIZO. The target groups for this milk-protein strategy are the food and pharmaceutical industries throughout the world. A major group in this market is the manufacturers of special foods like sports and dietary preparations.

In the second place, we must emphasize that milk proteins are a natural food. They can be consumed without endangering our good health and without any ethical objection. We must point out to the public that the body is in constant need of high-quality proteins. These proteins are available in large amounts and at a reasonable price in the traditional milk and dairy products, like cheese and yoghurt. But we should also tell the people that milk proteins play an important role in other foodstuffs that they need and that make their life more enjoyable. We must spread the message that milk proteins are being produced in a most efficient way. The cow converts grass and animal feedstuffs, which are not acceptable nor digestible for man into a product of high biological value: milk, which our dairy industries use as a raw material for a rang of nutritionally valuable and relatively cheap products.

In the third place, we have an interesting story to tell about dairy industry itself. In contrast to vegetable proteins, processing in the dairy industry is still based on the principles farmers have been applying since time immemorial when making cheese and butter. For marketing and public relations, milk protein is a product without problems. There is nothing in milk protein we do not dare to speak about.

Our message, very simply, can be, 'Milk proteins: enjoy a natural food you won't regret', because your health can only benefit from it. Cows that are bred for milk production lead a natural and contented life. They do not have to undergo the strains of bio-industry.

In conclusion, one of the first definitions of public relations was, Be good and say so. There are few lines of trade so well equipped to keep to this rule as the dairy industry. As to milk proteins, only good things can be said about them. But if we want to do this efficiently and successfully, we must join forces. In other words, again: we need a milk-proteins strategy backed by all dairy countries and industries. A major part of this strategy is the continuous transmission of our message to our target groups: the food and pharmaceutical industry and the consumer, but also the dairy industry itself.

This first international congress on Milk Proteins is a step towards this goal. Never before have so many experts from so many countries conferred about so many aspects of milk proteins with such diverse and international audience. I want to express my gratitude to all those people who have made this event possible. Our special thanks go to the European Community, whose generous financial aid has opened the way not only for this congress but also for many other activities, national and international, to promote milk proteins. Concerning this congress, I am glad that marketing is one of the aspects that will be discussed. Technology and nutrition may be important disciplines, but ultimately milk proteins must be sold on diverse markets. The marketing and communication experts can tell us how our efforts can achieve the best results.

Good wishes of the IDF (International Dairy Federation)

E.J. Mann

President of the Commission of Studies of the IDF, c/o Commonwealth Bureau of Dairy Science & Technology, Shinfield, Reading RG 2 9AT (GB)

It is both a great honour and a great pleasure to have been given this opportunity of making a few remarks on behalf of the International Dairy Federation (IDF) during the opening session of this congress. In the first place, I believe that the European Community is to be congratulated wholeheartedly for providing substantial support and excellent facilities for this Congress. At a time when the countries of the European Community are focusing their attention on the dairy market as a sector with urgent problems in view of stagnating markets world wide, the timing of this particular International meeting is both significant and opportune.

The IDF, although not involved directly in the planning and organization, has a number of its experts making active contributions during the next few days. In fact, we feel closely associated with the proceedings of this congress, not only because our 32 member countries include all the member countries of the European Community as well as most of the major milk-producing countries throughout the world, but also because the subject is one which is close to our heart and one in which we can claim to be very active. Many of you present here today will, no doubt, recall the highly successful international seminar on 'Utilization of dairy ingredients in foods' held in these buildings, again with the support and cooperation of the European Community as well as that of the Luxemburg Ministry of Agriculture, exactly 3 years ago in May 1981. This seminar was organized by a group of experts of the IDF dealing specifically with new dairy foods and the utilization of dairy ingredients in foods, and I was very pleased to learn from the congress coordinator, Dr Tinbergen, that its conclusions and recommendations provided some of the inspiration for this congress.

More recently, the IDF has staged two specialized symposia featuring milk proteins, the first in Kiel in the Federal Republic of Germany in March 1983 dealing with 'The role of milk proteins in human nutrition' and the second in Helsingør, Denmark, in May 1983, covering the more specialized subject area of 'Physico-chemical aspects of dried protein-rich milk products'.

As regards the future, some of you may wish to note in your diaries that the national committee of IDF in the United States of America is planning to stage an international seminar under the subject heading of 'New dairy products via new technologies' on the occasion of the food and dairy exposition in Atlanta, Georgia in early October 1985.

Looking still further ahead, to the 22nd International Diary Congress due to be held in The Hague in the Netherlands during September/October 1986, milk proteins will feature prominently in a number of seminars, especially those on 'Milk as a source of ingredients for the food industry' and the 'Market and marketing of dairy products'.

IDF's interests and activities in the subject area of milk protein are too numerous to spell out in detail. Suffice it to say that various groups of experts and rapporteurs are dealing with practically all important aspects of milk proteins, including manufacture, composition, nutritive value, functional properties, analysis and marketing.

Finally, let me reiterate my belief that there is an exciting future ahead for milk proteins. This belief is based on the fact that we are today in a position to manufacture a wide range of milk-protein products with different functional and nutritional properties, using modern technology. Many of these milk-protein products are already finding outlets as foods in their own right as well as in the form of ingredients in food for different branches of the food industry. I feel certain that this congress wil turn out to be a milestone in the history of milk protein utilization and wish its organizers every success.

World availability and economics of proteins

A

World protein production in an economic context

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Summary

The availability of protein is discussed for industrialized and developing countries. Generally the protein requirement will be covered if people get enough food. In industrialized countries, a large proportion of the diet contains products of animal origin. In developing countries, plant products predominate. In industrialized countries there is a tendency to surplus production of food, whereas in developing countries a close race exists between population and food production. The food problem in developing countries and the role of food aid are discussed. Food aid should be linked to development in the developing country. Self-sufficiency in food should not be a target for its own sake. Trade should also have a role.

CAB descriptors: proteins, food, food aid, developing countries, industrialized countries, population

Protein and the world food situation

In order to get a proper perspective, the importance of protein has to be considered in the context of the world food problem, i.e. the availability of food for the people of the world. At one time, it was even considered that the problem of feeding the world was primarily a question of availability of protein and that consequently first priority should be given to increased supply of protein. More recently this view has been questioned in the light of various surveys, including those of FAO, and it is now generally accepted that the real problem is one of food shortage in general, i.e. when people get enough food, they also get enough protein in most cases. In other words, the availability of food is more important than the specific availability of protein.

The world food situation is paradoxical in several respects. The total supply of food has increased more rapidly than the population over the last two decades, and yet hundreds of millions of people in the developing countries are still without enough food.

At the same time, there is a tendency towards surplus production of food in the industrialized countries and so towards measures to restrain the production of food. Thus the food problem of the world could well really be a problem of distribution both geographically between groups of countries, and between income groups within countries, and not one of capacity to produce.

Total food output in the world rose at 2.7 and 2.3% per year in the 1960s and 1970s, respectively, compared to an annual increase in total population of 1.9 and 1.8% per year (Table 1). In de developing countries, food output grew at the historically high rates of 2.9 and 2.8% per year during these periods. But the rate of growth in the population of these countries was alos very high at 2.5 and 2.4% per year so that the average increase in food output per person was limited to 0.4% per year. And within the developing countries, the growth in food output has been highly variable among regions and countries. The tendency has been for growth to be slowest in regions and countries with the lowest income. In Africa south of the Sahara, there was even a decline in food output per person in the 1970s. In the industrialized countries, by contrast, although growth in the total output of food has been lower than in the developing countries, growth in output per person has been almost three times as rapid, because of the modest increase in population.

Leaving aside the viscicitudes and calamities of nature, it may be maintained that increased food production is only part of the solution. Lack of food is a result of poverty, and it can only be solved by creating purchasing power among the hungry. They need to be able to produce or earn access to their food supply.

Plant products and animal products in the total food supply

When we look at the composition of the total food supply as between plant and animal products, the food diet in the developing countries proves to be completely dominated by plant or vegetable products. In the industrialized countries, the diet has

Table 1. Growth rates of population (% per year) and food output, 1960-1980. (from FAO, 1982)

	Population		Food output			
			total		per person	
	1960-1970	1970-1980	1960-1970	1970-1980	1960-1970	1970-1980
Developing countries	2.5	2.4	2.9	2.8	0.4	0.4
Industrial market economies	1.0	0.8	2.3	2.0	1.3	1.1
Non-market industrial economies	1.0	0.8	3.2	1.7	2.2	0.9
Total	1.9	1.8	2.7	2.3	0.8	0.5

a much larger component of animal products which provide about 30% of the total supply of energy, quite apart from the fact that the total in these countries is about 50% more than in developing countries (Table 2).

The difference between the two groups of countries is even more pronounced in the composition of the supply of protein. In the industrialized countries, animal products provide more than half the total supply of proteins as against little more than 20% in the developing countries. The difference in the total supply of protein between the two country groups is also relatively larger than for energy (Table 3).

These differences in the composition of the diet would naturally reflect similar differences in the composition of the agricultural production. It is thus a general feature that the proportion of plånt products in total agricultural production increases as you move from north to south on the Northern Hemisphere. In the Nordic countries, plant products constitute only about 25% of the total agricultural production, as against about 45% in France and about 60% in Italy. In the tropics, where most of the developing countries are situated, the proportion of plant products is even higher.

In most developing countries, cereal crops, roots and tubers form the staple food and predominate in crop production. In the industrialized countries of the temperate zone, a large part of the total plant production, including pasture and rough grazings, is eaten by animals; in the Nordic countries, this proportion can be as high as 80 tot 85%. In addition to the effect of the agroclimatic conditions, the composition of agricultural production and of diet is also a reflexion of the standard of living. Experience has shown that with rising incomes people not only spend a smaller proportion of their income on food, but they also tend to buy less staples such as cereals and potatoes, and more high-quality animal products as well as more fruit and vegetables.

Table 2. Energy supply per person (kJ/d). Average 1978-1980. (from FAO, 1982)

	Totaal food	Vegetable products	Animal products
Developing countries	9 743	8 868	0 875
Developed countries	14 258	9 864	4 394
All the world	10 952	9 136	1 820

Table 3. Protein supply per person (g/d). Average 1978-1980. (from FAO, 1982)

	Totaal protein	Vegetable protein	Animal protein
Developing countries	58.7	46.5	12.2
Developed countries	98.7	43.1	55.5
All the world	69.4	45.6	23.8

The difference in food between the two groups of countries is also apparent in their use of cereals as food or feed, respectively. Cereals play a major role as food for man in the developing countries, where they supply 55 to 70% of energy and protein. Even in the industrialized countries, they make up about 30% of the diet in these terms.

The total supply of cereals is about evenly divided between industrialized and developing countries, though developing countries comprised almost 75% of the world population in 1980. More than a third of the total cereal supply is used for feed to animals, and by far the largest part of this in the industrialized countries, where the amount of cereals given to animals is markedly larger than the amount consumed directly. In the developing countries the proportion given to animals is of course very limited (Table 4).

In the industrialized countries, the growth in output of food has been stimulated by the rising demand for high-value food products, such as animal products. This has stimulated rapid growth in the production of cereals, particularly in North America and Australia, as changes in animal husbandry have resulted in heavy demand for feed grain.

Although animal products provide a large part of the total supply of protein of high quality, yield of food crops from cultivated land is more than of animals. In intensive production systems, animals will compete with man for certain types of concentrates. It has been claimed that grain converted to meat loses 75 to 90% of its energy and 65 to 90% of its protein, and this has led to the contention that supply of grain to cattle, pigs and poultry takes food away from the hungry.

The issue is not a simple one, however. The main use of cereals for feed takes place in industrialized countries where this pattern of grain use reflects the high level of income. If cereals were not fed to animals, cereal production in these countries would decrease sharply. Alternatively, a massive transfer of purchasing power would be needed, if consumption of cereals were to be shifted from animals to people. In the event of this unlikely prospect, the longer-term consequences would also be problematic. Most of the world's poor and hungry are farmers or live in farm areas where cereals are grown. It would therefore be difficult, if not impossible, to transfer large amounts of cereals to such areas without reducing incomes and production in the very regions where increased income is most needed. Although direct food aid has an im-

Table 4. Amount of cereals used as food and feed in 1981 (million tonnes). (from FAO, 1982)

	Food	Feed	Total cereals
Developing countries	710	100	810
Developed countries	354	486	840
All the world	1064	586	1650

Table 5. Agricultural area and total population, 1981. (from FAO, 1982)

	Area (million hectares)				
	crop land	permanent pasture	farmland	Population (millions)	Agricultural area per person (ha)
Developing countries	796	1899	2695	3336	0.8
Developed countries	672	1273	1945	1177	1.6
All the world	1468	3172	4640	4513	1.0

portant role to play, it needs to be carefully balanced with other types of aid that will stimulate food production and incomes.

Almost 70% of the total agricultural area in the world is made up of permanent pasture and rough grazings (Table 5). A large part of these areas is unsuitable for cultivation and thus could only provide food for man through animals. The situation is the same for fibrous forage, crop residues and byproducts. Animals also provide draught power and manure for crop production, and it is often overlooked that farm animals represent a considerable food reserve to buffer man from variations in plant production.

In the same vein, as pointed out in a recent FAO/DANIDA report (1984), dairy development can play a major role as an instrument of rural development by providing income and creating employment, as well as by saving foreign exchange through import-substitution and utilizing unused resources.

The food gap and food aid

The world food situation presents a mixed picture insofar as ample world food supplies contrast with persistent food problems in many places. In the industrialized countries, the trend is towards surplus production of food. Technical progress together with fixity of resources in agriculture leads to increases in food production that surpass demand. The result is market imbalance and in due course introduction of quotas and a desire to grant more food aid. On the other hand, the situation in developing countries is one of increases in population chasing the increase in food production, and there is in general a political bias in favour of the urban groups, which limits the incentives given to food producers. As a result, the food-import requirements of the developing countries have increased considerably over the last 20 years or so.

The increasing food requirements are mostly covered by cereal imports as well as food aid in cereals (Table 6). Despite the criticism levelled against it, food aid continues to play a role in this connexion, albeit generally a minor one. But for some of the poorest countries, especially in Sub-Saharan Africa, food aid has become very important. At the same time, food aid is no solution to the food supply problems of

Table 6. Cereal imports and food aid, 1961-1981 (million tonnes). (from Huddleston, 1984)

	Commercial imports	Food aid	Total cereal imports
All developing countries			
1961-1963	18.5	11.6	30.1
1976-1978	55.1	8.7	63.8
1981	89.5	8.3	97.9
Sub-Saharan Africa			
1961-1963	1.5	0.1	1.6
1976-1978	4.1	0.9	4.9
1981	6.7	2.0	8.8

developing countries. The problem of lack of food is mostly a problem of lack of purchasing power, and food aid does not produce purchasing power, unless it is used to stimulate development. What is really needed is higher priority to agricultural and rural development.

The most critical nutritional deficiency in the developing countries is in energy, and it therefore seems logical that animal proteins only play a minor though not unimportant role in total food aid (Table 7). There are also special problems in the use of dairy products as food aid, which make it necessary to exercise close supervision over their distribution and use. This is of special importance to the countries of the European Community, since they are the world's major donors of dairy products as food aid. They supply more than half the skim-milk powder and almost all the butter oil made available for this purpose. The biggest direct aid project is for 31 000 tonnes of skim-milk powder and 12 700 tonnes of butter oil to Operation Flood in India and the biggest indirect aid is to the World Food Programme (WFP).

The most appropriate form of food aid would be project aid that reaches the poor directly with additional food. But this form is administratively demanding and limits the absorptive capacity of the recipient country. Thus FAO has estimated that less than a third of the food aid needed in the coming years can be provided as project aid. Most of the remainder will have to be sold on the open market and used for

Table 7. Shipments of food aid (thousand tonnes). (from FAO, 1984a)

	1980/81	1981/82	1982/83
Cereals	8900	9100	9200
Skim-milk powder	288	333	268
Butter oil	30	59	41
Other dairy products	38	36	25
Meat and meat products	7	6	6

general budget support plus a small amount allocated for emergency food aid. There are ways of using cash sales productively in poor countries, but it is always vital that the use of food aid be coordinated and integrated with the food and agricultural policy of the recipient country as well as with other elements of technical and financial assistance to its agricultural sector.

Main issues and conclusions

The food problem of the world is a matter of sufficient supply of energy more than that of protein, and it is a question of distribution more than of production capacity. Increased food production is only part of the solution, and the concomitant problem of poverty can only be solved by the creation of purchasing power among the hungry.

Man competes with animals for cereals, but a massive transfer from the industrialized countries to the developing countries of the cereals used to feed animals would reduce incomes and production in the poor regions, where increased income is most needed.

The developing countries require increasing food imports, and food aid has become important for some countries. But animal proteins only play a minor role, and the use of dairy products as food aid requires careful supervision. Food aid provides no real solution to the food problem, and what is really needed, is a higher priority for agricultural and rural development.

The developing countries will have to supply the bulk of the increasing demand for food themselves; and experience has shown that they have the means, if the political will is there. Even so, self-sufficiency in food should not be an end in itself. International trade in foodstuffs will continue to play an important role in spite of all the obstacles. But food deficits in the developing countries cannot justify industrialized countries in producing surplus food for which there is no market.

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Milk proteins with reference to human needs, and world food supply and nutritional situation

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Summary

To establish a framework for linking milk proteins to the maintenance of human health and well-being, the paper starts with an account of some evolutionary features of human protein nutrition and a short survey of the history of the study of proteins in the diet of man. From this, an appreciation should emerge for the various stages in the development of nutritional deficiency disease and the factors responsible for widespread protein-related malnutrition. The current and evolving world-food and nutrition situation is considered before a presentation is given of the international efforts that have been made to assess the protein needs of population groups. This latter topic begins with reference to the first estimates and guidelines proposed in 1935 by the Technical Committee on Nutrition of the League of Nations, continuing with various joint FAO/WHO expert Group reports and culminating with the most recent recommendations of a joint FAO/WHO/UNU consultation on energy and protein requirements.

The applicability of these recommendations to conditions prevailing in developing regions is considered, particularly in relation to the higher protein needs associated with the catabolic effects of diarrhoea, respiratory and other infectious diseases and with catch-up growth during recovery. The relative capacity of food proteins to meet these requirements will be considered, in relation to the concept of reference proteins, as proposed by the international expert groups, where proteins of milk have been used as a reference protein, in view of the generous concentration and high availability of nutritionally indespensable (essential) amino acids in this food. Milk proteins with their superior nutritional value, if made available to the consumer in attractive forms and at reasonable cost, have a significant role to play in the maintenance of an adequate nutritional status of human populations throughout the world.

CAB descriptors: milk protein, proteins, nutrition, nutritional requirements, malnutrition, world population

Introduction

To develop a framework for linking milk proteins to the maintenance of human health and well-being, this paper will begin with a short account of some evolutionary features of protein nutrition and a brief survey of the history of the study of proteins in the diet of man. Our intent is to present a basis for an appreciation of the various stages that occur in the development of nutritional deficiency disease and an understanding of the various factors responsible for the existence of widespread, protein-related malnutrition. With this background, the current and evolving world-food and nutrition situation will then be considered, before a brief account is given of the international efforts that have been made to assess the dietary protein needs in population groups. Then, a discussion will be made of the relative capacity of food proteins to meet these requirements, and included here will be the concept of use of milk proteins as a reference. The applicability of these estimates to conditions prevailing in developing regions will be considered, particularly in relation to the higher protein needs associated with the catabolic effects of diarrhoeal, respiratory, and other infectious disease and with catch-up growth during recovery from malnutrition. Our discussion will terminate with an assessment of the role of milk proteins in the diet of man, including mention of the reasons for choosing particular food proteins and the broader health implications of such choices.

Evolution of protein and amino acid nutrition

Thus, to understand the relationships between milk proteins and the maintenance of human health and well-being, it might be useful to recall first the basis for human nutrient needs.

Biological aspects The earliest forms of life were probably simple bacteria-like organisms that could synthesize all of the molecules they needed from salts, simple carbon compounds and sources of nitrogen and, of course, water. When the first animal cells developed, about a thousand million years ago, they differed from plant cells in their need to obtain certain additional carbon compounds already synthesized from their environment. These compounds (some 8-10 amino acids), which cells and organisms must obtain from exogenous sources, are now classified as essential nutrients. Although there are many specific metabolic differences between the animal species, there is a general quantitave and qualitative pattern of nutrients required throughout the animal kingdom.

This can be explained by the selective advantage arising from the reduced need to continue the formation and maintenance of a genetic apparatus for the manufacture of compounds. Thus, as primitive forms of life evolved into animal cells, the species that subsequently emerged from these ancestral beginnings lacked the ability to synthesize these compounds, but they survived by obtaining them from the environment. It is as if all animals suffer from an inborn error of metabolism or a hereditary disease that arose during the remote past and to which plants are immune.

As a consequence of evolution, therefore, a general feature of animals is their dependence on outside sources of various carbon compounds. A fundamental distinction between animals and plants is that all animals need to ingest the compounds, whether the animal is a single-celled protozoan or a complex multicellular form, such as man. In the context of protein nutrition, the plants have retained the capacity of their primaeval ancestors to make, from simple carbon and nitrogen sources, all of the 20 common amino acids found in cellular proteins. Animals, on the other hand, depend on their diet to supply about half of these amino acids, as well as a utilizable source of nitrogen, which is needed to make the remaining amino acids. These biochemical changes that occurred in the remote past have profoundly influenced the course of the subsequent evolution in animals and the development of human civilization. Thus, the organization of contractile tissues and of a nervous system to control and coordinate movement increased the opportunity to secure an adequate supply of nutrients and favour survival of and domination by various species. However, with this evolutionary changes, nutritional deficiencies, that affected the health of many of our ancestors, continue to threaten the lives of millions of people in our world today. At least 45, and possibly 50, dietary compounds and elements are now recognized as essential if people are to lead full healthy lives (Scrimshaw & Young, 1976).

The course of experimental study (Table 1) Included among the classes of nutrients with which we are concerned are, of course, the proteins, a term coined by the Dutch chemist Mulder in the mid 19th Century (Munro, 1984). However it emerges from Haller's textbook of physiology, published in 1757, that health and well-being already had been recognized to depend on a substance present in generous amounts in animal foods and in lower concentrations in plant foods. Also, with identification of amino acids as structural components of proteins, new concepts of the nutritive value of proteins emerged and in the first decade of this century Wellcock and Hopkins firmly established a link between differences in the nutritive value of proteins and their amino acid compositions. Their work was confirmed and extended by Osborne and

Table 1. Some landmarks in the study of proteins in nutrition. (based on reviews by Munro, 1964, 1984)

Investigator	Date	Observation
Beccari	1746	Plant gluten
Haller	1757	Gluten as animal tissue builder
Rutherford	1772	Nitrogen discovered
Magendie	1817	Importance of dietary N compounds
Mulder	1838	'Protein' coined
Boussingault	1839	N balance (cows)
Willcock & Hopkins	1906	Nutritional value and amino acids
Rose	1938	Classification of amino acids
Schoenheimer	1939	Protein turnover

Mendel in 1914, culminating in the classification, by W.C. Rose in 1938, of amino acids as being either nutritionally essential (indispensable) or non-essential (dispensable) for human protein nutrition.

In addition to the developments briefly summarized, discussed in more detail by Munro (1964; 1984), work by Schoenheimer and his colleagues (Schoenheimer, 1942) had a considerable influence on the further understanding of protein metabolism and of the needs for dietary protein. Thus, they showed that even in steady state, body proteins continually undergo breakdown and resynthesis. During growth, not only is there a net deposition of protein but also the rates of both synthesis and breakdown are increased. The principles underlying this process of protein turnover now have been described in some detail (Waterlow et al., 1978).

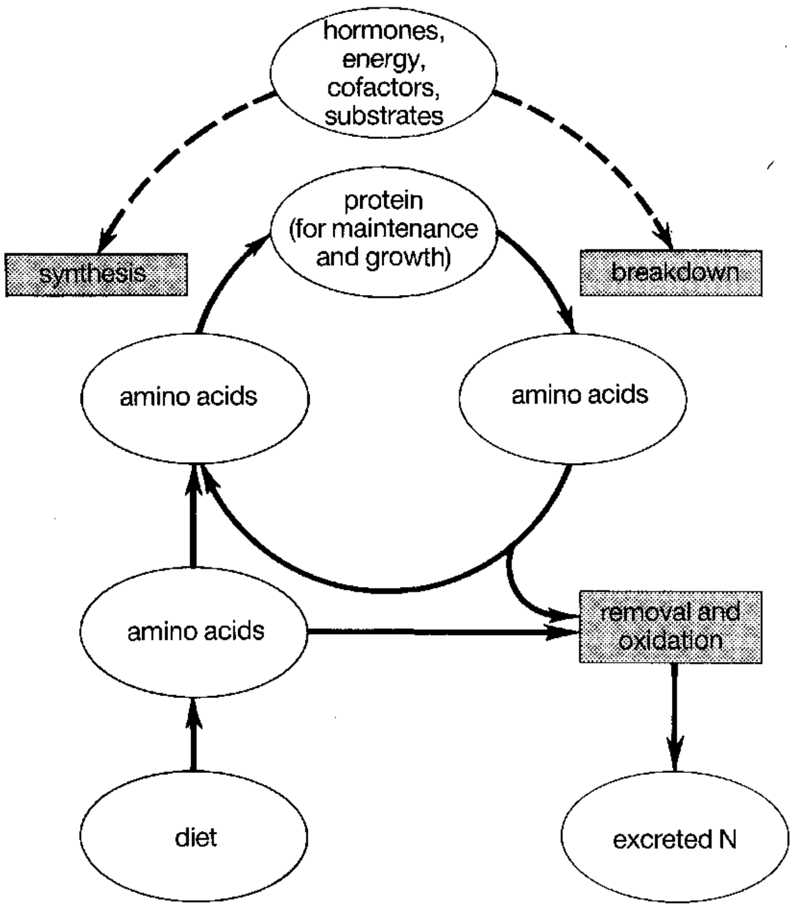

Fig. 1. Body and organ protein content is determined by the balance between the rates of protein synthesis and breakdown and each of these phases of protein metabolism are influenced by factors including hormones, substrate (amino acids, nitrogen) and energy supply. The recycling of amino acids is a major pathway of whole-body amino acid metabolism.

Briefly, the rates of protein turnover vary from tissue to tissue, and the relative contributions of different tissues to total protein turnover in the body change with age and adaptation to various levels of protein intake (Waterlow et al, 1978; Young et al., 1984). The amino acids released by breakdown are reused for protein synthesis but during this process of recycling some amino acids are lost by oxidative catabolism, and for this reason, both essential amino acids and a dietary source of utilizable

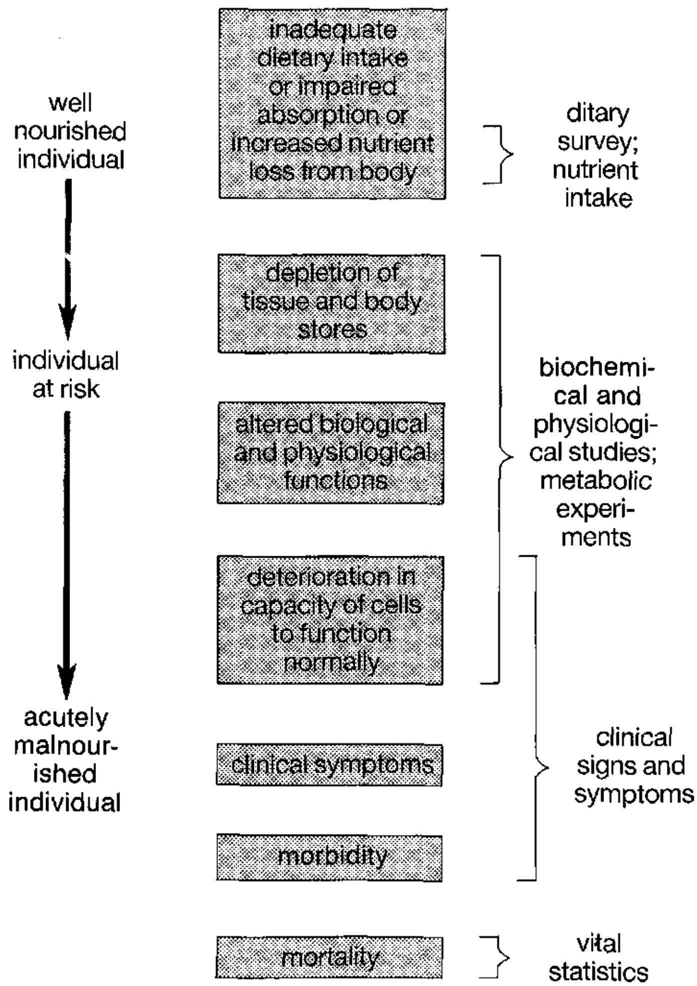

Fig. 2. Major stages in the development of nutritional deficiency disease. Nutritional deficiency begins with an inadequate availability of a nutrient to body cells and organs. This inadequacy may be due to various factors, including low dietary intakes or relatively high rates of loss from the body. Subsequently biochemical deterioration occurs with the appearance of clinical symptoms. Knowledge of these various stages and approaches to explore them may be used to assess human nutrient requirements and nutritional status. (from Beaton & Patwardhan, 1976)

nitrogen are needed. The daily turnover of body proteins is, in fact, several-fold greater than the total intake of protein, showing that reutilization of amino acids is a major contributory factor to the body's protein metabolism (Young & Scrimshaw, 1978). In essence, therefore, the protein requirement is determined initially by the amount of nitrogen and amino acids that must be supplied to meet the continual loss of amino acids, by their incomplete reutilization. This cycle of amino acid and protein metabolism is depicted in Figure 1.

If the intake of protein or of specific amino acids is less than the amount required to meet the metabolic needs of the organism, a sequence of events is set in motion, which leads, eventually, to the appearance of symptoms of clinical deficiency states (Fig. 2); initially, if the dietary intake of a nutrient or its supply to body tissues continues to be inadequate, the content of the nutrient in body tissues and fluids falls. If the deficiency continues, biochemical and physiological lesions develop, such as reduced plasma albumin and a deficient level of enzymes necessary for the maintenance of normal cell function. These events may be considered characteristic of the subclinical phase of nutritional disease and they are followed eventually by the appearance of clinical signs and symptoms indicative of nutrient deficiency. For protein nutrition, this may take the form of a stunting in growth or the appearance of gross oedema, as seen in the kwashiorkor form of protein-energy malnutrition (Waterlow & Alleyne, 1971).

Thus, the issue to be considered now is whether malnutrition is due to an inadequate protein intake or supply of amino acids to cells and organs, whether, arising from primary or secondary causes (Fig. 2), it occurs with sufficient frequency to be an important public health problem and whether milk proteins can contribute to an alleviation of such a problem. So let us briefly consider, the nutrition situation at an international level.

Nutrition world wide

Major changes have taken place over the last two decades in the ways that malnutrition and its causation are viewed on a global basis. Many reasons contribute to these changes in perception, but a major one was the realization (Scrimshaw et al., 1968) that malnutrition and infection bore a synergistic relation to each other. Furthermore it became clear that solutions to the problems of malnutrition, to be successful, required more than simple provisions of food and nutrients and that there was a causal relationship between malnutrition, poverty and economic development. Health care facilities also differ widely. This is illustrated in Table 2, which shows that the range between the best and worst in the world for infant mortality rate (of which nutrition can be a major causative feature) can differ by a factor 25 and, even more dramatically, maternal mortality may differ by a factor 200.

Over the last few decades, the traditional deficiency diseases, such as scurvy, beriberi and pellagra, have declined in prevalence but, in contrast, protein-energy malnutrition in children is still increasing, especially in the urban slums of developing countries. However estimates of those suffering from hunger and malnutrition have

Table 2. Comparison between national maternal and child mortality rates. (from WHO, 1980a)

	Highest levels (A)	Lowest levels (B)	Ratio A/B
Infant mortality per 1000 live births	200	8-10	20-25
Childhood mortality per 1000 of population	45	0.4-1.0	45-75
Maternal mortality per 100 000 live births	1000	5-10	100-200

differed widely. In an attempt to bring some reason to a confusing situation, Poleman (1981a,b) has attempted to estimate the nutrition situation in developing countries. Estimates of numbers of nutritionally deficient individuals have fallen to about 14% of the world's population, from a height of some two-thirds about twenty years ago (Table 3). Nevertheless, this more recent estimate involves still an enormous number of affected people. The nutrition situation has not improved to this extent, since the earlier estimates were probably too pessimistic. Though different assumptions were made for the various assessments, all were derived from consideration of protein energy availability compared to individual requirements.

Thus, though arguments could be made about the specific number of people suffering from hunger and malnutrition, it is still a major problem of the world. So before considering causation, we should discuss the major forms of malnutrition that threaten large population groups.

Table 3. Estimates of numbers identified as nutritionally deficient in the major world food surveys. Adapted from Poleman (1981a,b); 1980 data from 90 developing countries. Nutritionally deficient for 1977 and 1980 data defined as food energy availability less than 1.2 times basic metabolic rate.

Year	Population size assessed (millions)	Nutritionally deficient (millions)	Proportion affected (%)	Reference
1946	2000	1000	50	FAO (1946)
1952	1900	1100	60	FAO (1952)
1961	2800	1900	68	USDA (1961)
1963	2500	1000[a]	40	FAO (1963)
1964	2900	1900	66	USDA (1964)
1976	1500[b]	1100	73	Reutlinger & Selowksy (1976)
1977	2900	400	14	FAO (1977)
1980	2300	436	19	FAO (1982)

a. Protein deficient; number would fall to 400 million (16%) for food energy deficiency.
b. Major developing countries only.

Major problems of malnutrition In Table 4, the characteristics of hunger and some of the major world nutritional problems are listed. Problems other than these, such as scurvy, rickets, beri-beri, and pellagra still exist but are generally less widespread than the conditions tabulated. Of hunger, there is no doubt that the problem is widespread; conditions that could be described as hunger range from the gross manifestion of prolonged starvation to mild and apparently reversible growth failure.

Table 4. Characteristics of hunger and major nutritional disorders. There is a considerable degree of overlap in infants between protein-energy malnutrition and low body weight. Protein-energy malnutrition (e.g. body mass as a function of age or height) when early or of mild-moderate severity is usually subclinical and can only be diagnosed by anthropometric criteria. Low birth weight is defined as below 2500 g. In developing countries, the majority of low birth weights are due to foetal growth retardation. (courtesy McClaren, 1973)

	Hunger	Protein-energy malnutrition		Xeropthalmia	Goitre	Iron deficiency anaemia	Low birth weight
		Nutritional marasmus	Kwashiorkor				
Causation/ precipitation long-term	Poverty, poor agriculture		Low-protein diet	Low intakes of carotene or retinol	Low intakes of iodine	Low intake or absorption of iron	Poor dietary intake since conception. Infections of mother
Causation/ precipitation immediate	Poverty, crop failure, war	Early weaning; infections	Infections	Early weaning; infections		Blood loss from infections	Low weight gain in pregnancy
Vulnerable groups and main age of incidence	All ages	Children less than one year	Children between 1-2 years	Preschool children	Older children; women	Children < 3 year and women of child-bearing age	Mothers of poor socio-economic status
Major features	Growth failure, wasting, lethargy	Wasting	Oedema, fatty liver, reduced serum albumin	Night blindness, xerosis of conjunctiva and corea, keratomalacia, low serum retinol	Enlarged thyroid	Low haemoglobin (microcytic hypochronic anaemia, if severe)	Hypoglycaemia, hypothermia, poor resistance to infection (low immunoglobin 196)
Consequences	Reduced growth, reduced work capacity, high mortality	High mortality, impaired mental development	High mortality, impaired mental development	High mortality especially when associated with protein-energy malnutritions, blindness	Cretinism	Pallor, reduced work and learning efficiency	High mortality, sub-optimal development, high incidence of infection

The conditions of protein-energy malnutrition and the factors causing low birth weight in babies overlap to a considerable degree with hunger (UNICEF, 1984), so much so that they may be indistinguishable. The majority of infants with low birth weight (<2500 g) in developing countries are those of normal gestational age. The frequency of birth of such infants is more than twice as great as in developed countries (WHO, 1980b; UNICEF, 1984). Such children are more prone to infections and also lag in their subsequent development (Omalulu et al., 1981). Maternal dietary supplements can increase birth weight (Lechtig et al., 1979). But in an environment where health care is often lacking, maternal mortality is high. Furthermore, the desire by mothers for small babies (and easier birth) should be recognized, since this can negate programs for nutrition intervention until health care facilities are improved.

The world prevalence of protein-energy malnutrition has been estimated from data of some large-scale surveys (Bengoa 1973; Bengoa & Donosa, 1974; Puffer & Serrano, 1973). Thus, using the proportions estimated by Bengoa & Donosa (1974) but the 1980 population estimates, it is probable that some 87 million cases of protein-energy malnutrition currently exist in the developing regions. These numbers probably represent a minimum, since many children are reported to have died from infectiou disease where malnutrition was a likely underlying, or major, simultaneous cause.

Another nutritional problem of considerable significance is hypovitaminosis A, considered to be the most common cause of blindness in developing areas of the world (WHO, 1976; Underwood, 1978). Recent estimates (Sommer et al., 1982) from studies in rural Indonesia indicate an incidence of 2.7 per thousand for corneal xerophtalmia amongst preschool children. Half of these children probably develop bilateral blindness. Extrapolation of this rate to the preschool children of Bangladesh, India, Indonesia and the Philippines would indicate a frequency of 500 000 cases per year for corneal xerophtalmia with up to ten times as many with less severe deficiency (e.g. Bitots spots).

It seems likely that hypovitaminosis A, as a public health problem, will only be eliminated when the society has access to a diet sufficient in vitamin A and also in the other nutrients that affect vitamin A metabolism. This requires a more equitable distribution of the benefits of national development. Serious hypovitaminosis A occurs most frequently in countries where protein-energy malnutrition of children and generalized poverty are also major problems (Underwood, 1978).

Iron-deficiency anaemia is a widespread nutritional disorder and it is the most frequent cause of anaemia in both developing and affluent societies (Baker, 1978). Data on serum ferritin indicate that iron deficiency is not synonymous with anaemia and that this latter condition is only a late sequel to iron depletion. Iron deficiency is, thus, a major concern of public health throughout the world, but more so in developing countries (Beaton, 1974) where detectable and significant effects on resistance to infections, morbidity and mortality, and impairment of physical work have been described.

To assess any contribution of milk proteins in the alleviation or prevention of one or more of these forms of malnutrition, and in the maintenance of health in populations, let us consider the causes of nutritional problems.

Causes of malnutrition As was indicated above, general views on the causation of malnutrition have undergone considerable change over the last two decades. It is now increasingly recognized that malnutrition may be caused, in addition to primary nutrient deficiencies, by many interrelated social, political and economic factors (Pellett, 1983). Because of this multifactorial causation, solutions must also be multifaceted, even if elimination of poverty and improvement of living standards are central.

Some especially important and broad groups of causes of malnutrition are:
- inadequate food production and supply, soil, climate, poor techniques, overpopulation
- poor food distribution within region (poverty, transport) or within family
- poor education, including lack of knowledge on nutrition and health
- poor health and sanitation, infections and infestations, synergism.

The interplay of these factors not only produce, but perpetuate, malnutrition and hunger. The problem of controlling hunger and malnutrition is a difficult and complex task and success will depend on how effectively four major efforts are undertaken: increasing the supply of the right kind of food where it is needed, reducing poverty, stabilizing food supplies, and reducing pressures on the food supply, including decreasing the rate of population growth. These actions, however, all lie more in the political, economic and socio-cultural spheres and less in the sphere of nutrition. These points should be considered in the assessment of the role of milk proteins in human diets.

Food and agriculture in relation to global nutrition The state of the world's food and agriculture situation is assessed on a regular basis by the United Nations Food and Agricultural Organization. World food production (Table 5) increased by 2.9% in 1981, after the near stagnation of the two previous years and marginally above the average rate for the 1970s. Per person in the population (Table 6), there was some recovery of the growth in food production, lost in 1980 but the level is still below 1978. Africa remains a region of major concern, especially for production per person: the situation there is now worse than in 1969-1971. Some of the reasons for the poor agricultural performance in Africa have persisted, despite a higher infusion of foreign aid per person than for other developing regions. They have been reviewed by Eicher (1982); coordination of aid and agricultural activities together with long-term planning and more effective transfer of technology are among the major procedural changes advocated.

Food balance sheets (FAO, 1980) have been the main source of data used for the assessment and appraisal of the world food situation (Table 3). Limitations to these data are recognized (FAO, 1980; Poleman, 1981a). Nevertheless food balance sheets tabulated regularly over a period of years show the trends in overall national food supply, disclose changes that may have taken place in the types of foods consumed, indicate major differences between regions and reveal the extent to which the food supply of the country as a whole may be adequate to meet nutrition requirements. It is now, however, considered more reliable to assess undernutrition on the criterion of whether available food energy exceeds basal metabolic rate by a factor 1.2, rather than on other estimates of energy requirements. This criterion (about 6.3 MJ/d) corresponds to the critical limit below which an individual's ability to perform minimal

Table 5. FAO index numbers of world and regional food production. A value of 100 taken for the period 1969-1971. (from FAO, 1982)

	1979	1980	1981	Change (%)	
				1979-1980	1980-1981
Developing market economies	129	133	139	3.1	5.0
Africa	115	120	123	4.0	2.7
Far East	129	133	142	3.2	6.7
Latin America	135	139	146	2.6	5.2
Near East	134	138	141	2.5	2.2
Asian centrally planned economies	136	136	141	−0.1	3.1
All developing countries	131	134	140	2.0	4.4
All lowest developing countries	116	120	122	3.3	2.1
Developing market economies	121	121	124	−0.6	3.0
North America	126	123	135	−2.5	9.4
Oceania	137	122	131	−11.0	7.3
Western Europe	119	123	120	3.4	−2.3
Eastern Europe and Soviet Union	118	116	115	−1.9	−1.2
All developed countries	120	119	121	−1.0	1.7
World	125	125	129	0.3	2.9

Table 6. FAO index numbers for food (crops and livestock) production per person in the world regions. Values of 100 taken for the period 1969-1971. (from FAO, 1982)

	1979	1980	1981	Change (%)	
				1979-1980	1980-1981
Developing market economies	103	104	107	0.7	2.6
Africa	89	90	90	1.0	−0.4
Far East	106	107	112	1.1	4.5
Latin America	108	108	111	0.2	2.7
Near East	105	105	104	−0.3	−0.7
Asian centrally planned economies	116	115	117	−1.4	1.7
All developing countries	108	108	110	–	2.3
All lowest developing countries	92	93	92	0.5	−0.6
All developed countries	112	110	110	−1.6	0.9
World	106	105	106	−1.3	1.2

necessary activities would be impaired (Alangir, 1980). Even on this stringent criterion, more than 400 million people, representing some 20% of the population of ninety countries, are presently estimated as being severely malnourished (FAO, 1982).

Somewhat more optimistic conclusions can be drawn if comparison is made of food-energy supply between the mid-1960s and the late 1970s (Table 7). Out of a total of 95 countries for which detailed information was available in both periods, as many as 41 countries (62% of the total population) had an average available energy of less than 9.2 MJ/d in 1966-1968. By 1977-1979, the comparable figure had declined to 31 countries, comprising 48% of the total population in those countries.

Population growth is a major determinant of available food per person and some

Table 7. Changes in available food energy per person in 1966-1968 and 1977-1979 for 95 countries. Values in parenthesis are the proportions (%) of the total population involved. (from FAO, 1982)

	Number of countries (proportion of population) with available energy per person (MJ/d)			
	< 9.2	9.2-10.5	10.5-12.6	> 12.6
1966-1968	41 (62)	30 (15)	10 (6)	14 (17)
1977-1979	31 (48)	20 (24)	26 (13)	18 (15)

Table 8. World population estimates, projections and related rates of change (1980-2000). (from FAO, 1982, based on UN medium variant)

	Population (millions)			Rate of change (% per year)	
	1980	1990	2000	1980-1990	1990-2000
Developing market economies	2193	2765	3413	2.4	2.1
Africa	378	515	699	3.2	3.1
Latin America	364	459	566	2.4	2.1
Near East	212	279	357	2.8	2.5
Far East	1235	1505	1784	2.0	1.7
All developing countries	3268	3992	4790	2.0	1.8
Developed market economies	787	840	893	0.7	0.6
North America	248	274	299	1.0	0.9
Western Europe	371	380	387	0.2	0.2
Oceania	18	20	22	1.1	1.0
Other developed market economies	150	167	186	1.1	1.1
Eastern Europe and Soviet Union	378	410	435	0.8	0.6
All developed countries	1164	1250	1329	0.7	0.6
World	4432	5242	6119	1.7	1.6

recent United Nations projections are shown in Table 8. Slower rates of population growth are beginning to appear but the total population continues to grow. The majority of the increase will be in developing regions, especially in Africa. Thus, the population in the developing areas is expected to double by AD 2025, whereas the population in developed areas will be 25% greater. For Africa, the population is expected roughly to triple.

Nevertheless the numbers of young people will not increase as rapidly as in the past (Table 9) and there will be increases in the proportion above 65 years in both developing and developed countries. Also rapid growth in cities and in urban populations are anticipated (Table 10). These changing demographic patterns have major implications for food, agriculture and nutrition. A lower proportion of the population will be self-sufficient in food; marketing and transport systems will need to expand and be made more efficient, and patterns of food demand are likely to change.

The significance of these agricultural and population data for human protein nutrition requires, in part, knowledge of intakes of protein that would be sufficient to pre-

Table 9. Age composition of the population and projection to A.D. 2000. (from FAO, 1982)

	Year	Population (millions)	Proportion of population (%) in age groups (years)			
			<5	5-14	15-64	>65
Developing countries	1980	3300	12	28	55	5
	2000	4800	11	23	60	6
Developed countries	1980	1100	8	15	67	10
	2000	1300	7	15	66	12
World	1980	4400	11	24	58	7
	2000	6100	10	20	62	8

Table 10. Urban and rural populations and projection to A.D. 2000. (from FAO, 1982)

	Year	Proportion of population (%)	
		urban	rural
Developing countries	1980	31	69
	2000	44	56
Developed countries	1980	71	29
	2000	79	21
World	1980	41	59
	2000	51	49

vent the development of malnutrition in the population groups at risk. Let us consider dietary recommendations for protein and then milk proteins in this context.

Quantitative needs for protein and amino acid in man

Earlier views Among the earliest estimates of protein requirements are those in 1865 of Playfair, in 1881 of Voit and in 1894 of Atwater. These estimates were simply the averaged observed intakes of individuals of groups of subjects considered to be healthy and leading active lives (Table 11). The assumption was made that what healthy people normally consumed was an estimate of what they needed. Standards developed on this basis were generally high. Later these estimates were challenged by others (Table 11), who considered that lower intakes were adequate. However after World War I, these opinions of individuals were superceded by decisions made by national and international committees.

A recommendation of a protein intake of 1 gram per kilogram body weight represents the first international standard, proposed by the League of Nations (1936). The League of Nations Committee confined itself to the following statement: 'In practice, the protein intake for all adults should not fall below one gram of protein per kilogram of body weight. The protein should be derived from a variety of sources, and it is desirable that a part of the protein should be of animal origin. During growth, pregnancy and lactation, some animal protein is essential and in the growing period it should form a large proportion of the total protein'. This recommendation remained a basis for protein requirements until 1957 and Munro (1984) has recently described the course of further developments in international cooperation on nutritional standards. These continued with the report of the 1955 FAO Committee concerned with protein (FAO, 1957b), the 1963 joint FAO/WHO Expert Group on Protein Requirements (FAO/WHO, 1965) and the 1973 FAO/WHO report covering both energy and protein requirements. The 1973 report estimated protein needs from obligatory nitrogen losses by a 'factorial' approach, taking into account estimates for individual variation (twice the standard deviation of 15% about the mean) and for the change of efficiency of nitrogen utilization as nitrogen intake approached that

Table 11. Some early views on adult protein (and energy) requirements. (from Munro, 1984)

Author	Year	Recommended intake	
		protein (g/d)	energy (MJ/d)
Playfair	1865	119	12.6
Voit	1881	118	12.8
Atwater	1895	125	14.2
Siven	1901	30	–
Chittenden	1905	40	–
Hindhede	1913	low	–

needed to achieve nitrogen equilibrium. A summary of the estimates made by these earlier committees for the protein needs of adults is given in Table 12.

Current view The most recent international reassessment of protein requirements and allowances was undertaken in 1981 by a Joint FAO/WHO/UNU Expert Group on Energy and Protein Requirements (FAO/WHO/UNU, 1984). The protein needs of adults have been estimated directly from data obtained in both short-term and longer-term N balance studies, rather than by prediction based on the 'factorial' method. As in previous reports, the 1984 recommendations rely upon indirect estimates of the protein needs of the different age groups, other than those for the infant and young child, and for young adult male and females. Table 13 lists the safe protein intakes of high-quality protein for the various age groups, as recommended by this international committee.

Differences in capacity of food proteins to meet estimated needs Table 13 gives the intakes of high-quality protein for maintenance of an adequate protein status but proteins differ in their capacity to maintain protein status at equal protein intake. If the amount of an indispensable (or essential) amino acid in a protein is less than required by the consumer, the capacity of that protein to meet physiological needs will be less than of a protein(s) supplying indispensable amino acids in amounts equal to or in excess of the consumer's needs. By definition, the nutritional value of these proteins will differ. So if differences in nutritional values of proteins are observed in metabolic studies, a major reason can likely be found in differences in the content and availability of one or more indispensable amino acid in the proteins. Of course, other factors that are characteristic of particular food proteins may also affect the digestion of proteins and the utilization of amino acids they contain:

– Cereal proteins, in particular, contain supportive structure (e.g. cellulose).

Table 12. Successive United Nations recommendations for protein intakes (g protein/kg body weight per day) in adult men. (modified from Munro, 1984)

	FAO (1957b)	FAO/WHO (1965)	FAO/WHO (1973)
Mean requirement	0.35	0.59	0.34
Addition for variability (+2 SD)	0.53 (+50%)	0.71 (+20%)	0.44 (+30%)
Correction for non-linearity	None	None	0.57 (+30%)
Biological value correction (%)	80	80	75
Recommended intake	0.66	0.89	0.75
Term	Safe practical allowance	Protein requirement	Safe level of intake

Table 13. Safe protein intakes relative to body-weight (g/kg.d) as recommended by FAO/WHO/UNU (1984). Values are not corrected for biological values (amino acid scores) of mixed dietary proteins for infants and children, nor for digestibility for all groups.

Age group	Males	Either sex	Females
3-6 months		1.85	
6-9 months		1.65	
9-12 months		1.5	
1-2 years		1.2	
2-3 years		1.15	
3-5 years		1.1	
5-7 years		1.0	
7-10 years		1.0	
10-12 years	1.0		1.0
12-14 years	1.0		0.95
14-16 years	1.0		0.9
16-18 years	0.95		0.8
Adults	0.75		0.75
Supplements			
– pregnancy			6
– lactation 0-6 months			17.5
> 6 months			13

– Proteins have different primary structure.
– Foodstuff contain antinutritional factors, such as phenolic compounds (tannins, resorcinols), proteinase inhibitors, amylase inhibitors and lectins.
– Heat processing may be beneficial or deleterious.
These factors determine the availability of the constituent amino acids and therefore the total intake from a given protein or mixture required to maintain an adequate protein nutritional status. However these factors are not of significance for milk proteins but rather for plant proteins.

The amounts of nitrogen required, relative to body-weight, are least for diets based on proteins such as milk and egg, as against those largely based on plant proteins, with the differences being greater for young children (Tables 14 and 15). Because the digestibility of animal proteins, such as those from milk, is high, the lower digestibility of diets based on plant foods probably accounts for the greater part of the difference between the nutritive value for adults of diets containing different proteins. Although these metabolic data do not provide a definitive statement about the protein requirement for the different age groups the summaries presented in Tables 14 and 15 do emphasize the excellent nutritional value of proteins from cow's milk. This topic has been reviewed recently by Young (1983).

Partly on the basis of these and similar observations, milk or egg proteins are used as standard reference proteins in studies of protein nutrition (FAO/WHO, 1965). Milk proteins are taken to be of high protein quality for normal healthy children and

Table 14. Estimates of average nitrogen intake relative to bodyweight from various protein sources to maintain nitrogen balance in adults. M, male; F, female. (summarized from FAO/WHO, 1973)

Source of protein	Subjects		Intake of N (mg/kg.d)
	number	sex	
Animal			
Egg	9	M	74
Egg	6	M	76
Milk	4-5	F	68
Casein	6	M	81
Mixed animal and plant			
42% cereal, 33% meat, 25% miscellaneous plant	10	M, F	80
80% vegetable, 20% milk	7	F	89
70% cereal, 20% milk and meat	10	F	74
50% rice, 45% miscellaneous plant, 5% fish	18	M	77
Plant			
Yeast (Torula)	4	M	110
Rice	10	M	90
White flour	4-5	F	117
75% cereal, 25% other plant	6	M, F	99
Wheat, maize, oats	29	M	80-90
	8	F	
42% cereal, 33% soya, 25% other plant	6	M, F	107

adults. Data are essentially lacking on the comparative aspects of the nutritional quality of different protein sources for physiological and pathological conditions (adolescence, old-age, pregnancy, illnesses) where requirements for total protein and of indispensable amino acids may differ from those of healthy children and non-pregnant young adults. However one may guess that milk proteins would also be of high nutritional value in these conditions. Indeed, casein or milk proteins are often used in the formulation of liquid preparations intended for enteral feeding of patients requiring special nutritional therapy.

In summary, milk proteins are of high nutritive value and, thus, can effectively meet the requirements for nitrogen and indispensable amino acids in any age group.

Comment on the application of estimates of protein requirements to populations in developing regions There are problems in application of the estimates of protein needs to population groups in developing regions. These have been discussed elsewhere (Viteri et al., 1979). One problem that deserves emphasis is that earlier estimates of the protein needs for the young did not take into account that normal growth does not proceed at equal daily increments and that in children after a period of illness catch-up growth may proceed at a large multiple of the normal growth rate.

Table 15. Estimates of average nitrogen intake relative to body-weight from different sources that met various criteria in previously malnourished preschool and school-age children. (summarized from (FAO/WHO, 1973)

Source of protein	Chronological age (years)	Intake of (mg/kg·d)	Criterion
Animal			
Egg	2-3	163	N retention; growth
Cow's milk	preschool	153	N retention 70 mg/kg·d
Cow's milk	3-7	147	N retention 40 mg/kg·d
Human milk	3-7	124	N retention 40 mg/kg·d
Legumes			
Soya bean products	3-7	147	N retention 40 mg/kg·d
Groundnut flour	3-7	260	N retention 40 mg/kg·d
Cottonseed flour	3-7	256	N retention 40 mg/kg·d
Sesame flour	3-7	262	N retention 40 mg/kg·d
Cereals or cereal based			
Wheat or rice-based	2-5	360	N retention 100 mg/kg·d
Wheat	3-5	280	N retention ⩾40 mg/kg·d
Maize	preschool	286	N retention 70 mg/kg·d
Cereal-based	8-12	250	N retention ⩽30 mg/kg d

When recovering from infection under village conditions, catch-up growth may be 8 or 9 times a normal growth rate and under hospital conditions it may be much greater still. Even well nourished children in privileged circumstances will experience periods when they are not growing and other periods when they are growing at two or four times the average rate. These conditions demand larger amounts of dietary energy and especially of protein.

Indeed, predominantly vegetable diets may be quite adequate for growth at the mean rate but insufficient for the peaks of normal growth and grossly inadequate for optimum catch up after episodes of infection. Under these circumstances, a small amount of milk or other animal protein can be critical in preventing stunting of normal children and in facilitating catch-up growth.

So estimates of the adequacy of diets of children in developing countries can be so misleading when compared with estimates of 'normal' requirements. Such comparison must take into account variations in normal growth and the markedly enhanced requirement of protein for catch-up groth. Children's diets without milk or other concentrated source of good-quality protein during and after weaning may fall short of the optimum amount of protein for these contingencies.

Moreover, the amount of protein needed to maintain adequate health is affected by the existence of stressful stimuli, such as those arising from infection or physical trauma, or even those of psychological origin. Early in the infectious episode, there is an increased synthesis of immunoglobulins and of other proteins characteristic of the initial metabolic response to the infectious agent. This is followed by a net catabolic response that results in increased losses of nitrogen, some vitamins and minerals in the body, and in decreases these nutrients in blood. Furthermore, absorption of nutrients may be interfered with if there is a significant disorder of the gastrointestinal tract. The net result of these responses is depletion of nutrients, followed by an increase in the physiological need for nutrients during convalescence in order to promote effective and prompt recovery and compensate for earlier losses. Although acute and chronic infections and other stressful stimuli, including anxiety, pain and physical trauma generally increase the requirement for many essential nutrients, there are inadequate quantitative data to help determine how far nutrient intakes should be increased under these circumstances.

So the protein requirement estimates as derived from studies in healthy subjects and as recommended in Table 13, for example, may underestimate the actual needs of population groups that experience the less favourable environmental conditions typical of many developing areas of the world. The continued and increased availability of food of high quality, including protein foods of high nutritive value, is of even greater significance than might first appear from mere consideration of the protein needs of already healthy subjects.

Milk proteins in the world food problem

Global aspects Let us consider in more detail the possible role of milk proteins in the nutrition of human populations and in the context of the nutritional problems and food protein needs in today's world.

The major potential nutritional contribution of milk for children, for example, can

Table 16. Representative values for the composition of human and cow's milk (per 100 g). From Kon (1972); for human milk Lonnerdal (private communication). Note: Unfortified values are shown. Instant non-fat milk products in the United States can contain 2200 IU (66μg) retinol per 100 g.

Type	Concentration (per litre)								
	energy (MJ)	N (g)	Lys (g)	S animo acids (g)	Thr (g)	Try (g)	Ca (g)	retinol equiv. (mg)	riboflavin (mg)
Human	3.01	1.9	0.7	0.45	0.55	0.2	0.28	0.67	0.4
	Content (per kilogram)								
Whole									
Friesian	2.59	5.1	2.5	1.05	1.40	0.45	1.2	0.42	1.5
Guernsey	3.14	5.7	2.8	1.20	1.55	0.50	1.3	0.65	2.0
Dried skim	14.85	56.4	27.5	11.60	15.50	4.95	12.6	0.13	15.3
Dried whole	20.84	39.2	19.1	8.10	10.80	3.45	9.1	3.83	11.5

be seen when comparison is made between milk composition (Table 16) and nutritional requirements (Table 17); though 200 ml of milk supplies only 10% of daily food energy needs for a three-year-old child, it will supply some 25% of the retinol equivalent, about 30% of the calcium, 40% of the riboflavin and protein, and 50% or more of the essential amino acid lysine. Despite the high nutritional value of milk as a protein source, the contribution of milk to the diet varies enormously throughout the world. Though conceding the limitations of food balance-sheet data (Table 18 is

Table 17. Estimated requirements for protein, food energy and four essential amino acids for children 0-6 years. Protein and amino acid data calculated from values presented by FAO/WHO/UNU (1984), using mean body weights compiled at National Center for Health Statistics (Hamill et al., 1979); protein assumed to be of high digestibility and high quality; vitamin and mineral data from NAS/NRC (1980).

Age groups (years)	Bodywt (kg)	Requirement									
		energy (MJ/d)	protein (g/d)	N (g/d)	Lys (g/d)	S amino acid (mg/d)	Thr (mg/d)	Try (mg/d)	Ca (mg/d)	retinol equivalent (μg/d)	riboflavin (mg/d)
<0.25	4.5	2.09	9.0	1.44	0.60	380	390	150	360	420	0.4
0.25-0.5	6.6	2.72	11.3	1.80	0.75	480	490	190			
0.5-0.75	7.9	3.14	12.3	1.97	0.82	520	530	210	540	400	0.6
0.75-1	9.0	3.77	12.9	2.07	0.86	550	560	220			
1-2	11.0	5.02	13.3	2.13	0.85	450	530	190	800	400	0.8
2-4	14.0	5.86	15.7	2.51	0.97	410	570	190	800	400	0.8
4-6	18.0	7.11	18.9	3.02	1.17	490	680	230	800	500	1.0

Table 18. Consumption of nutrients per person from milk and milk products in various regions of the world. Values in parenthesis are contributions of milk products to total consumption of nutrient (%). (data for 1979 from FAO, 1980)

		Consumption					
	Population (millions)	energy (MJ/d)	protein (g/d)	calcium (mg/d)	retinol (μg/d)	retinol equivalent (μg/d)	riboflavin (mg/d)
Africa[a]	343.6	0.18(2)	2.4(4)	86(21)	20(16)	22(2)	0.12(15)
Latin America[a]	336.1	0.62(6)	8.2(13)	272(55)	73(28)	81(14)	0.39(36)
Near East[a]	196.2	0.35(3)	6.1(8)	184(41)	48(21)	52(8)	0.29(29)
Far East[a]	1158.9	0.21(2)	3.0(6)	93(29)	16(28)	18(4)	0.12(17)
North America[b]	240.1	1.94(13)	22.2(21)	680(71)	193(34)	213(20)	0.97(46)
Western Europe[b]	367.0	1.27(9)	18.4(19)	585(68)	176(29)	194(16)	0.76(43)
Oceania[b]	16.9	1.52(11)	20.9(19)	706(75)	182(21)	202(15)	0.98(45)
Eastern Europe[c] and Soviet Union	368.9	1.59(11)	17.8(17)	556(67)	164(38)	181(19)	0.80(46)
All developing countries	3017.0	0.19(2)	2.7(5)	87(26)	20(20)	23(4)	0.12(16)
All developed countries	1136.6	1.15(9)	15.8(17)	518(66)	149(33)	176(17)	0.74(44)
World	4153.5	0.49(5)	6.8(10)	222(46)	61(29)	65(9)	0.31(30)

a. Developing market economies.
b. Developed market economies.
c. Centrally planned economies.

based on food disappearance rather than food consumption; values are averages for whole regions), there are dramatic differences between world regions in the contribution of milk to the nutrient supply; for developed countries as a group, milk supplies six times as much protein and energy per person as in developing countries. The contribution of milk, though low in absolute terms, in developing countries can, nevertheless, still be a significant source of calcium, ready synthesized retinol and riboflavin.

Milk proteins in infant and childhood nutrition The protein needs of an infant up to four months of age will be furnished if the energy needs are met providing that the food contains protein of quality and quantity equal to that of human milk. The composition of various humanized milk products has been discussed in detail by others (Fomon, 1974; Beal, 1980; Brostrom, 1981). However breast feeding is recommended wherever possible. This recommendation is based less on simple nutritional grounds and more on presence of protective substances acting against diarrhoeal disease, on the potential contraceptive effects and on the psychological benefits to the mother-child dyad (Jelliffe & Jelliffe, 1971; Hambraeus & Sjölin, 1979). Nevertheless, in good environments, human infants grow and develop when they receive a wide variety of modified and synthetic diets based on cow's milk (Fomon et al., 1971; Cockburn, 1983).

Questions have been raised about whether milk (whole or skim) is a suitable food for this purpose because of its lactose content and the reductions in lactase activity with malnutrition and whether vicious cycles of malnutrition could be initiated that might reduce the speed of nutritional recovery (Torun et al., 1983). Low lactose milk has been proposed as an alternative to whole normal milk to avoid this risk. However recent studies (Torun et al., 1983; Solomons, 1984) indicate that clinical recovery was identical, whether whole milk or lactose-hydrolysed milk was used for the refeeding of malnourished infants. In studies reviewed by Solomons (1984), comparable and adequate growth could be obtained with either soya proteins and milk proteins, provided that a zinc supplement was used. So milk products, without preparation with enzymes to reduce lactose content, can be used routinely as a basis in diets for the refeeding of malnourished infants. Similarly, modest intakes of milk can be well tolerated by adults with genetically caused low intestinal lactase activity (Newcomber, 1984). The significance of lactase deficiency in such populations may well have been exaggerated in the past.

Because the primary nutritional function of dietary protein is to furnish the essential amino acids and total nitrogen for the synthesis of tissue and organ proteins especially in children, it is usual to consider the various food proteins and protein sources in relation to their capacity to meet the amino acid and nitrogen requirements of the host. However, as emphasized elsewhere (Young, 1981), a comprehensive evaluation of different sources of protein based on the overall nutritional health of the individual and of populations requires an assessment of the effects of alternative sources of protein, on the utilization of and requirements for energy-yielding substrates and other individual essential nutrients.

The composition of such a variety of sources of food protein is shown in Table 19. This summary indicates that there are substantial differences not only in the content of protein in food but also of the other proximate constituents, including carbohydrate, fat, and fibre. These compositional differences have important consequences for satisfaction of nutritional requirements, particularly in individuals whose nutrient requirements are relatively high. For instance if protein and energy needs are supplied in major part from a rice-based diet, the energy content of the diet, as traditionally prepared, would be relatively low (Table 20). Indeed, some investigators (McLean et al., 1978; Church, 1979) have pointed out that the bulk of traditional staple diets, such as rice diets, would make it difficult to meet energy requirements for growing infants and children. So although the quality of rice protein is good and, in theory, capable of meeting the requirement for essential amino acids when the sole protein source, the overall composition of this food and the way in which it is prepared has particular significance for meeting the energy requirement of the young. The interrelationships between the protein content, energy content and bulkiness (volume mass) of plant-protein sources are major considerations for the nutritional quality of the predominantly vegetable-based diets in many developing areas of the world and for appropriate nutritional intervention to improve the quality of diets and nutritional status of populations groups in these regions. From this standpoint alone, the use of milk in the diet has a considerable advantage over many other sources of protein, especially in comparison with the further use of traditional staples.

Table 19. Composition of selected protein sources: content of proximate constituents. (summarized from Paul & Southgate, 1978)

Food	Protein (g/kg)	Carbohydrate (g/kg)	Fat (g/kg)	Fibre (g/kg)	Water (g/kg)	Energy (MJ/kg)
Cereal						
oatmeal (raw)	124	728	87	70	89	16.8
flour (white, 72%)	113	733	12	30	145	14.1
Milk and dairy products						
milk (fresh, whole)	33	47	38	–	876	2.7
eggs (boiled)	123	trace	109	–	748	6.2
Meat and meat products						
beef (minced, raw)	188	–	162	–	645	9.2
Frankfurter	95	30	250	–	595	11.5
Fish						
lemon sole (raw)	171	–	14	–	812	3.4
Vegetables						
beans (baked, tomato sauce)	51	103	5	73	736	2.7
Nuts						
peanuts (fresh)	243	86	490	81	45	23.8

Table 20. Energy and protein contents of selected foods. (from Paul & Southgate, 1978)

Food	Energy (MJ/kg)	Protein (g/kg)	quotient of protein to energy (g/J)
Boiled rice	5.1	22	4.3
Potatoes (new, boiled)	3.2	16	5.0
Bread (white)	9.7	78	8.0
Milk (whole, fresh, cow's)	2.7	33	12.1
Beef (lean)	5.1	203	39.4

Milk protein as a supplementary source of protein for children Milk has been widely used as a supplementary protein in vegetable mixtures to combat malnutrition. Many mixtures have been proposed that will meet protein and energy needs of infants at low cost (Cameron & Hofvander, 1976; Pellett & Mamarbachi, 1979; Pellett & Pellett, 1983). Examples of mixtures of dried skim milk and whole milk powder with some widely used staples are shown in Table 21. These mixtures are designed to supply about 1.5 MJ (about a third of daily requirement for a one-year-old) with 6-7% of the energy from high-quality highly digestible protein.

An alternative approach, now that amino acid requirements have been worked out for a range of ages (FAO/WHO/UNU, 1984), is to base calculations on whether mixtures can meet amino acid needs rather than on protein quality and protein complementation. In Table 17, daily requirements for children below six years were shown for energy, protein (nitrogen) and four nutritionally indispensable (essential) amino acids, lysine, total sulphur amino acids, threonine and tryptophan. The amino acid requirements for each age group were calculated from the composition of human milk (below one year) or the pattern of requirement for two-year-old children. For instance in Table 22, deficits between intake and requirement for lysine or total nitrogen were calculated on the assumption that total energy needs were met from the staple foods wheat, rice, maize and cassava flour alone. Such intakes would frequently not be practical since their water-holding capacity would make them far too bulky. Nevertheless such calculations allow approximations to be made for the amount of milk needed to supplement cereal staples so as to meet protein or amino acid needs.

Table 21. Composition of mixtures of food staple and milk powder to give 1.46 MJ with net dietary protein supplying 6-7% of energy. The first value of each pair (in grams) is the food staple and the second the milk powder. To these amounts of edible food should be added 10 g oil or 5 g oil and 10 g sugar (0.33-0.38 MJ). Multimixtures should be made by adding green leafy vegetables or fruit to the mixtures whenever possible. (from Pellet & Mamarbachi, 1979).

	Oats	Wheat	Rice	Maize	Banana	Cassava flour
Dried skim-milk	65 + 5	65 + 15	65 + 10	65 + 10	175 + 15	60 + 15
Dried whole milk	60 + 5	55 + 15	50 + 15	60 + 10	120 + 20	40 + 25

For the cereal products, the total nitrogen needs are met if energy needs are met but that there are significant deficits with respect to the intake of lysine (Table 22). Although not shown in Table 22, other essential amino acids are also in short supply but to a lesser extent. For cassava, there are significant deficits in total nitrogen and in all essential amino acids, a reflection of the much lower total protein content of this staple. What is of possible interest is the rather constant nature, over a wide range, of the estimated lysine deficits for the cereal diets; some 400 mg/d for wheat and some 300 mg/d for the rice and maize. These daily deficits are almost constant because decreasing requirements with age are accompanied by increasing total intakes of amino acids from the cereal protein to meet energy needs. In practice, intake of milk of 0.1-0.15 l/d will increase intake of lysine (and of all other essential amino acids) to meet daily needs for children below 6 years of age and on diets in which the total energy intake is based almost exclusively on cereals. This small milk supplement would, of course, also contribute calcium, retinol equivalent and riboflavin but would not always to reach requirements for these nutrients. This volume is much below the estimate of 0.6-0.75 l of milk (or equivalent in dried skim-milk) that would be needed if sufficient of a wheat-milk mixture (Table 21) were consumed to supply the 5.86 MJ/d needed for a 3-year-old child. The higher intakes of milk (and smaller intakes of cereal) are desirable, not only to meet the needs of other nutrients but also to reduce the volume of food. However they would often be economically impossible unless milk products were subsidized and made more widely available. These calculations, however, reveal that amino acid needs may be met over a wide range of age groups by means of basic diets with rather small amounts of milk as a supplement. For diets based on cassava, with a much lower content of protein, the diet would be

Table 22. Calculated deficits of nitrogen or lysine and the milk required to meet the deficit assuming food energy needs are fully met by wheat, rice, maize or cassava flour. No assumption is made that the amounts of staple could be consumed in practice. The water-holding capacity, and hence large bulk, could make such amounts impossible to consume. If lysine deficit is met, so also are deficits for all other amino acids.

Age (years)	Requirement		Amount of food (g/d[a])	Calculated deficit on staple of							
				wheat		rice		maize		cassava flour	
	energy (MJ/d)	N (g/d)		N (g/d)	Lys (mg/d)	N (g/d)	Lys (mg/d)	N (g/d)	Lys (mg/d)	N (g/d)	Lys (mg/d)
<0.25	2.09	1.44	140-150	–	370	–	260	–	240	1.05	500
0.25-0.5	2.72	1.80	180-190	–	430	–	290	–	290	1.30	620
0.5-0.75	3.14	1.97	210-220	–	470	–	310	–	220	1.40	670
0.75-1	3.77	2.07	250-260	–	430	–	230	–	10	1.40	680
1-2	5.02	2.13	330-350	–	280	–	30	–	–	1.20	610
2-4	5.86	2.51	390-410	–	310	–		–	–	1.40	690
4-6	7.11	3.02	470-500	–	360	–		–	–	1.70	830
Approximate volume of milk required to meet nitrogen or lysine deficit (ml)				150		100		100		200-300	

a. Depends on staple used.

lacking in total nitrogen and all essential amino acids; 0.2-0.3 l of milk (20-30 g of dried skim-milk) would be needed per day, together with cassava in order to meet protein and amino acid needs.

Food choices and milk proteins In view of the evidently high nutritional value of milk proteins, several factors will determine whether this food protein source makes a significant and continuing contribution to human nutrition and health. In addition the physiological aspects with which we have been mainly concerned, several factors will be responsible for intakes of animal foods, in particular milk proteins:

– availability of the food
– income of the consumer
– cultural and social factors
– physiological factors (e.g. tolerance, bulkiness)

A key factor is availability: food is not eaten if it is not available. Advances in food processing and technology and in the distribution and marketing of foods have markedly improved accessibility of uncontaminated acceptable foods through the year. Of course, it is necessary to be able to pay for foods. So income determines amounts and types of foods consumed. It plays a significant role in food selection. Many studies have suggested that increases in real income, at least up to a threshold level, result in a shift from cereal-based diets to diets in which animal-derived foods predominate. Social and cultural factors have been discussed extensively by others.

Since animal foods, such as milk, may account for a significant proportion of total intakes of many essential nutrients, one should assess contributions made by milk and milk protein foods to nutrients often consumed in considerable excess of needs, particularly lipid (fat) and protein. This is pertinent particularly in the technically advanced nations, where the development of degenerative diseases is a major concern of public health, because these conditions have been connected with excess and imbalances of nutrient intakes. Although many questions remain unanswered, present evidence suggests it should be prudent to moderate intakes of fat and of cholesterol to reduce risk of developing heart disease.

Conclusions

We have considered the physiological basis for good-quality food proteins in maintenance of human health. We have reviewed the current food and nutrition situation throughout the world and have shown that inadequate diets, often with large bulk and low protein content, still affect large population groups, especially the disadvantaged young in developing regions. The nutritional quality of milk proteins is also, as we have discussed, high and complements readily the cereal and starchy root staples widely used in infant and child feeding in many regions through the world. They are also a good source of highly available amino acids for adults, especially for meeting the increased demands for protein during pregnancy and lactation. However, having recognized these nutritional virtues of milk proteins, which extend beyond indispensable amino acids because this food can also supply generous amounts of

Table 23. Major environmental and socio-economic factors in nutritional status.

Sequence	Some causes or solutions
Food availability	political and economic factors at national level
Family purchasing power	subsidies or target economic assistance
Family food-purchasing system	nutrition education; improved food selection
Food distribution in family	nutrition education; improved food distribution
Utilization of foods by consumer	health advice and services; improved food utilization
Individual nutritional status	

vitamin A, calcium and riboflavin, careful consideration must be given to the ways in which milk proteins are to be incorporated in diets through the world. The potential is, in theory, enormous when comparisons are made of the relative uses of milk and milk products in developing and developed regions, with their nutritional implications (Table 18).

Problems pertaining to the introduction or increased use of milk proteins to improve and to maintain the protein status of populations must be addressed at several levels (Table 23). For milk proteins to have an impact, they must be desired and be available at prices the consumer can afford. Availability and purchasing power are outside of the domain of nutrition but nutrition education is the route by which purchasing pattern and food distribution in the family can be greatly influenced. Finally, the supreme importance of hygiene and cleanliness must be emphasized. The nutritional value of a product, such as milk protein, high though it be, is of little consequence if it acts as a vehicle for transfer of pathogenic bacteria to an infant. It becomes the cause of gastro-enteritis and infection and subsequent failure to thrive, rather than serving as a solution to the nutritional problem.

Individual nutritional status can be improved, in part, by increased reliance on milk proteins despite our being unable to affect, in marked degree, the basic societal causes of poverty and malnutrition. Though one can and must act at the micro-level: 'Generating employment and income for the poor is essential to the solution of hunger and malnutrition. It is not enough to grow more food crop if the poor and hungry consumer has no ability to purchase it. The deeply-rooted povery in the low-income, densely populated countries remains the greatest single impediment to the eradication of hunger' (UNU, 1982). In this broader context, we must try to secure a more substantial and nutritionally rational role for milk proteins in meeting the nutritional needs and food wants of populations throughout the world.

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Production of food for mankind by crop and livestock farming

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Summary

Crop and livestock farming are compared for their efficiency in producing food for mankind. It is often stated that the production of food with livestock has a low efficiency. However this question has to be evaluated in a less simple way. The efficiency has to be studied by comparing average output of food with average input of feed, both expressed in the same measure of acceptable and utilizable energy and protein for man. By this approach, quite different figures come out. For maximum production of food for man in the world, both livestock and arable farming are needed.

CAB descriptors: arable farming, livestock farming, food production, efficiency.

Introduction

Many consumers in developed countries are convinced that production of their food by livestock farming has a low efficiency. Also in some scientific papers (Holmes, 1970; Duckham et al., 1976b; Ensminger & Olentine, 1978), this view was introduced bluntly stated though hedged on further elaboration of the issues, certainly for ruminants. A clear indication that farm animals are not inefficient as food producers is their large number in developing countries, even in those with food shortage. This is especially so for ruminants but also for pigs and poultry (Table 1; FAO, 1983a; Holmes, 1983). In view of their lower production than in developed countries, this is the more remarkable (Table 2).

Apart from economics, our interest in the efficiency of food production stems from concern for the world's food supply. News of famine in parts of the world reach us time and again (FAO, 1983b). We know also that, in countries where food supply is just enough, the richest 10% of the population use far more and better food than the poorest 10% so that the poorest are severely malnourished and undernourished (Zwartz & Hautvast, 1979). Undernutrition in several developing countries is simply

Table 1. Distribution of human and livestock population between developed and developing countries.

	Numbers (thousand millions)				Proportion in agric.
	cattle	sheep, goats	pigs	man	man %
Developed	0.4	0.6	0.3	1.2	12
Developing	0.8	1.0	0.4	3.4	57

Table 2. Comparison of livestock production rates between developed and developing countries.

	Production rate per animal (kg/year)		
	beef and veal	pork	milk
Developed	74	100	3100
Developing	18	48	700

due to low intake of food, i.e. of both energy and protein. Low energy intake, moreover, worsens protein supply to the body tissues because part of the protein is used as a source of energy. In countries with staple foods like cassava that are very low in protein, energy intake is often sufficient but protein intake is not. Poor health increases protein requirements as Dr Young shows. To prevent famine, attention has to be paid to both energy and protein supply.

Providing everybody with sufficient food, energy and protein is a goal that is extremely difficult to achieve (Duckham et al., 1976b; Holmes, 1983). Simple measures like food aid for developing countries or eating less meat in developed countries have no effect (FAO, 1983b). Solution of this complex multidisciplinary problem demands a tremendous amount of cooperation from all who can be of help. I shall try to show that the world's food supply is best served with an appropriate integration of crop and livestock farming. This integration is a process that has already played a part for many years, especially in developing countries, and it has a beneficial effect on prices of food for consumers. I shall reserve the word 'food' for products eaten by man in contrast to 'feed' for products eaten by farm animals.

Use of land for production of food and feed

Most of the more fertile land of the world ($= 14 \cdot 10^6$ km^2) with a reasonable climate is in use for production of food and industrial crops (FAO, 1983a; Butterworth, 1984). This is simply a consequence of such land giving more economic profit or more food for one's own consumption than when used for animal husbandry. There are

Table 3. Proportions and yields of edible and inedible plant material. Data from various sources.

	Proportion of straw & leaves in crop (%)	Yield of main product (kg/ha) developed countries	Yield of main product (kg/ha) developing countries	Proportion of byproduct in crude product (%)	Depression of price by sales of byproduct (%)	
Wheat	>35	2100	1700	25	bread	4%
Barley	>35	2100	1400	20	beer	2%
Maize	>45	5400	2000	10		
Rice	>50	5300	2800	10		
Sugar-cane	–	82000	54000	70		
Sugar-beet	>40	32000	21000	40	sugar	12%
Potato	>40	16000	11000	10		
Soya bean	>50	2000	1400	75	veg.oil	60%
Pea	>40	1000	1200	10		

exceptions to this general rule. In countries with a high living standard, the demand for and thus often also the prices of animal products may become so high that it is profitable for the farmer to use part of his land for animal husbandry. The same is sometimes true in developing countries near large cities. The major part of the land of the world ($32 \cdot 10^6$ km^2) is used as pasture. Most of this is too unfertile or otherwise not suited for arable farming (Dasmann, 1973; McCloud, 1974; Wedin et al., 1975; Owen, 1976; Duckham et al., 1976b). Some 'fertile' land is more suitable for animal husbandry than for crops, for instance because it is too marshy, too hilly or contains too many rocks. Even during periods of low food supply, for instance during a war, only a small part of pasture land is converted to arable land. Only a third of all the land at present used as pasture could be used for arable farming but is not attractive as such for the farmer for economic reasons. The other two-thirds would produce less food if used for arable instead of animal farming (Table 3).

Use of plant material as food or feed

The organic matter of plants consists mainly of carbohydrates, proteins and fats. Carbohydrates, such as starch and sugars, as well as the proteins and fats can usually be easily digested by man and animals with their own digestive enzymes. Grinding and cooking can assist the digestion process because the enzymes can then reach these substances more easily. The enzymes consist largely of protein, some of which is lost during the digestion process. Therefore, digestion of organic matter always requires some protein.

A considerable proportion of plant produce is not used as food, i.e. not for human nutrition, partly because it is not palatable, partly because the material is not very digestible for man. Plants defend themselves against being eaten by depositing less palatable or even toxic substances in stems and leaves, and by enclosing their seeds in firm coats. Most of the plant carbohydrates, other than the starch and sugars in the seeds, tubers, and sometimes in stems and roots, consist of celluloses and hemicelluloses. Monogastrics, such as man, the pig and the hen, cannot digest such carbohydrates (Stevensh, 1977; van Es, 1981; Black, 1983). They do not produce the necessary enzymes to hydrolyse these polysaccharides in the stomach and small intestine. Such carbohydrates in the digestive tract can only be of use to the animal after being fermented by microbes, since some microbial species possess the enzymes to hydrolyse celluloses and hemicelluloses. Despite the lack of oxigen in the digestive tract, they succeed in gaining some energy from a partial oxidation of the carbohydrates while converting these into the volatile fatty acids acetic, propionic and butyric acid, methane, carbon dioxide and water. These acids can easily pass across the wall of the digestive tract and are a good energy source for the host animal, which so receives some 70% of the energy of the fermented carbohydrates. The fermentation process proceeds slower and less completely with advancing maturity of the plant, especially of stems, seed-coats and leaves. The increasing degree of cross-linking, lignification and, in some plants, deposition of silica hinders the microbes from doing their work. At higher environmental temperatures, all these three processes proceed more rapidly and more completely. This is one of the reasons for the low intake and digestibility of tropical forages by ruminants (van Soest et al., 1978; Ehle et al., 1982). Fermentation is not confined only to celluloses and hemicelluloses. Starch and sugars, as well as proteins, are fermented; fat hardly.

The microbes of the fermentation processes in the digestive tract of animals consist largely of protein, apart from water. This protein has a high biological value (Tamminga, 1983). For their growth, they need energy and a nitrogen source, whose kind is, however of little consequence. Animals can use only amino acids as a nitrogen source, microbes can use also many other N compounds, usually after decomposition to ammonia. Plants, especially when growing rapidly, contain considerable amounts of such non-amino-acid nitrogen, mostly in leaves, stems and roots.

Fermentation in the digestive tract may thus help animals to utilize considerably more of the ingested plant material than they could with their own digestive enzymes only.

Ruminants benefit most from fermentation. It takes place in their large forestomachs, where they maintain an optimal environment for this process (Black, 1983). The advantages are the supply of energy from celluloses and hemicelluloses because of their conversion into volatile fatty acids with subsequent absorption and the supply of amino acids resulting from the microbial growth in the forestomach which can be digested in the true stomach and small intestine. There are also some disadvantages. Most of the starch, sugars and proteins of the feed is fermented too, though it might have been digested with the animal's own digestive enzymes. Furthermore, a narrow orifice between two of the forestomachs causes large feed particles to be kept in the forestomachs until chewing, rumination and fermentation has reduced their size sufficiently. So ruminants cannot eat large amounts of feeds that ferment slowly, for instance straw and tropical forages.

Monogastrics also harbour microbes in their digestive tract that ferment part of the digesta. This process occurs in the hind gut. In the hen, the process is quantitatively negligible (van Soest et al., 1983; van Soest, 1984). In man, it is a very small to small process depending on the fibre content of the diet. In pigs, it affects 5-25% of the feed, again depending on its composition. In Equidae, it is considerable but still only 70-40% of the process in ruminants on comparable diets (van Soest et al., 1983). The disadvantage to the ruminant of fermentation of starch, sugar and protein before digestion does not apply in these animals. On the other hand, monogastrics do not benefit from the protein of the microbes because this is excreted, either directly or after decomposition. There is no narrow orifice in their digestive tract that reduces rate of passage of large particles. So on low-quality diets rich in cellulose, Equidae and geese can and do increase their feed intake. Rate of passage will be higher, reducing rate of fermentation somewhat, but still increasing the total amount the animals can digest with their own enzymes.

This survey has shown a considerable part of plant produce is not physiologically suited for man and monogastric farm animals with an only small extent of fermentation in their digestive tract. However much of such plant material can be well utilized by ruminants.

Production of edible and inedible plant material

Few people are willing to eat forages like grass, legumes and immature whole cereal crops. If they did, they would hardly benefit from eating it.

Table 3 shows that also a large part of the dry matter of mature food crops is not eaten by man. Stems, leaves and straw are not eaten by him at all; some of these are used as feed for ruminants but not all because of their heavy lignification.

That part of plant material used as a source for food is also not completely available as edible food for man. Most main food products are first refined, as process which results in byproducts hardly used as food for man, if at all. In many such products, this is because the content of cellulose and hemicellulose of the main product is still too high in view of the low rate of fermentation in human gut. What is, however, more of a consideration is that man is rather particular in choice of food, especially when there is an ample supply of all kinds of food and he has enough money to buy what he likes. In such a situation, man is inclined to reject any food that has poor appearance, flavour or taste, or which is (or which he thinks is) contaminated.

Farm animals are far less particular in their choice of feed. The ruminant, moreover, is excellently adapted to eating cellulose and hemicellulose. Thus most of the byproducts and such parts of the main product contaminated with dirt or of bad flavour. This use as animal feed is an economic advantage; their removal in a different way might even have cost money. Thus food prices for the consumer benefit from this integration of arable farming and livestock. In view of the value of the respective byproducts for livestock, beet sugar, bread, beer and soya oil would cost about 12, 4, 2 and 60% more, respectively, if beet pulp and molasses, wheat bran, brewer's grains and soya bean oilmeal could not be sold as feeds.

Efficiency of conversion of plant material into edible food by farm animals

As a first approach in most papers on this subject, the input of energy and protein (or N) with the feed is compared to the output (i.e. production) of the same by the animal as far as this is edible for man (Holmes, 1970; Ensminger & Olentine, 1978). Next, the input of energy digestible by the animal is used instead of the input of total energy. Both calculations give efficiencies far below 100%, somewhat lower for energy than for protein. Such efficiencies have often been quoted and influence the opinions of many consumers.

In my opinion, these measures do not reflect what one really wishes to know: do the animal products (the output) contain less or more acceptable and utilizable food for man than is present in the feed (the input) the animal needed to produce these? Similar views are obviously held by Wedin et al. (1975), Balch & Reid (1976), Cravens (1981) and Cunha (1982), but these authors did not present estimates of such a measure. In the comparison both input and output should be expressed as the same component: acceptable utilizable food. Both input (feed) and output (products) should refer to the average life-span of the farm animals. Also feed for parent stock, for rearing, and for diseased or lost animals should be included in the input. I have made comparisons of this type in earlier papers (van Es, 1975; 1981). In these, the following assumptions were used. Forages were considered not to be acceptable for man. Two situations were distinguished for the acceptability of the concentrate mixtures used for dairy cattle, pigs, poultry and veal calves. In the first, there is severe food shortage; in the second, there is ample food supply and sufficient buying power as in developed countries. For the first situation, all concentrate mixtures were assumed to be completely acceptable as food for man, probably an exaggeration. For the second situation, acceptabilities of 50, 60, 75 and 100% of the mixture were used for these four types of concentrate, respectively. For the mixtures at present in use in the Netherlands for dairy cows, which consist almost entirely of byproducts, an acceptability of 25% was used. Milk and eggs were assumed to be entirely acceptable as food; the same was done for meat but only for the edible parts of the carcase.

To account for differences in utilizability, I have calculated how much metabolizable energy and digestible protein for man both the input and the output contained. Quantitatively man's largest requirement is for energy, in fact nutrient energy which can be used for the production of adenosine triphosphate (ATP). This compound is the main fuel in human energy metabolism for maintaining the body in a good active state and for physical work. Maintenance is the main activity of human metabolism because he does not perform much physical work, certainly not in developed countries, and the rate of processes of synthesis during growth, pregnancy and lactation is low. The content of metabolizable energy (energy in food minus energy in faeces and urine) of the ingested food is a good measure of its potential for ATP production (Schiemann, 1958; Blaxter, 1962; Livesey, 1984).

Man's second largest requirement is for protein, in fact a need for amino acids. In these calculations, the biological value of the proteins was not taken into account. It is true that most animal proteins have a higher biological value than most plant proteins. It was assumed that man in all cases would ingest more than one kind of protein, which usually improves the biological value of the diet compared to the values of the separate foods. Not all the protein but only the apparently digested part was taken into account because many plant and some animal proteins are not completely digestible.

Both for metabolizable energy (ME) and digestible protein (DP), contents were used that were appropriate for man, as a monogastric with little fermentation. Few estimates of ME and DP have been made for man with feeds normally used for animals. However from comparability of the digestive tract and from the few digestion data available, we know that ME and DP values for man are close to those for poultry and pigs, which themselves differ only slightly. Such data were taken from feeding tables and multiplied by the acceptability to arrive at the product's content of acceptable utilizable energy (ME_h) and protein (DP_h, where h stands for human).

Table 4 gives some results of such output/input ratios for the Netherlands for 1975. The same values still hold for 1982, except for dairy cows. With increasing milk yield, the use of concentrates rose to 2100 kg per cow per year and the concentrates used contained only byproducts. The great use of byproducts in the Netherlands and surrounding countries is due to cheap transport, low prices of byproducts and intensive research on these products as feeds for animals.

For other countries, the ratios will differ somewhat depending on the local situation. Higher values are obtained at higher production level (a smaller part of the total feed is needed for parent animals, rearing and maintenance) and at higher use of forages and of products in compound feeds with low acceptability for man. Thus milk and meat production in New Zealand, Australia and Argentina mainly from forage with little concentrates has a high ratio. In developing countries in general, ratios are high despite the moderate to low production levels, because farm animals receive little feed that man would accept to eat (Wedin et al., 1975; Sprague, 1975; Duckham et

Table 4. Output/input ratios for acceptable utilizable energy (ME_h) and protein (DP_h) in animal husbandry in the Netherlands. Based on feedstuffs used in 1975.

	Hunger		Ample food	
	Me_h	DP_h	ME_h	DP_h
Chicken (meat)	0.22	0.32	0.29	0.43
Laying hen (eggs)	0.17	0.30	0.23	0.40
Pig	0.24	0.21	0.40	0.34
Veal calf	0.26	0.31	0.28	0.33
Beef (intensive)	0.21	0.44	0.41	0.94
Beef (extensive)	0.7	1.3	1.3	2.7
Dairy cow[a]	1.2(0.6)	1.4(0.8)	2.4(2.3)	2.7(3.0)

a. Figures for 1982: 5100 kg milk and 2100 kg compound feed, mainly byproducts, per cow per year.

Table 5. Production of energy and nitrogen acceptable and utilizable by man from farmland.

	Good arable land		Land suited only for pasture	
	metabolizable energy for man (MJ/ha·a)	digestible protein for man (kg/ha·a)	metabolizable energy for man (MJ/ha·a)	digestible protein for man (kg/ha·a)
Wheat	45 000	340	little	little
Potato	90 000	–	little	little
Sugar-beet	100 000	–	little	little
Soya bean	30 000	750[a]	little	little
Cow's milk	25 000	290	25 000-5000	290-50

a. Most of it eaten by livestock.

al., 1976b). It will be clear that milk production and extensively kept beef cattle add considerably to the world's protein and energy production for man. Production of food with the help of monogastric farm animals, indeed, results in food loss.

Table 5 shows average production of ME_h and DP_h from land in plant and dairy husbandry. For milk, it was assumed that production of dry matter from pasture on good arable land would be 10 000 kg/ha·a, sufficient for 2.5 cows to produce 8750 kg of milk per hectare per year. Good arable land yields most food. However, for nearly half of the cultivable land of the world most food is yielded by animal husbandry because it is only suited for ruminant husbandry.

Fighting hunger in the developing countries

Despite their low conversion ration, non-ruminant farm animals can be of some help in improving the food situation, provided that they receive feed that man does not like and that production levels are not very low. Use of left-overs from kitchen and meals by a few hens and pigs belonging to a family is a common example (Duckham et al., 1976b; FAO, 1983b). Ruminant farm animals play a far more important part as food producers in view of the abundance of land not suited for arable farming. Moreover, cellulose-rich byproducts and offal can be used by them (Preston, 1984; Nestel, 1984b). They are not only producers of food of high digestibility and protein of high biological value, but they also serve as a store of food for periods with low food supply. Besides, large ruminants are used for traction, their dung is used as fuel for cooking and as an organic fertilizer (FAO, 1983b; Nestel, 1984b).

Furthermore, possessing many animals is a sign of wealth. Somtimes this interferes with efficient food production. Ruminant production levels in developing countries are usually low. This is partly caused by the low quality of feed grown in warm environments or by ruminants reducing their intake because of their high heat production and so their own heat but also milk or meat production when it is warm and humid. Partly, however, it is caused by feed shortage, e.g. when too many animals are kept for social status. It often leads to overgrazing. Reducing their number would provide more feed per animal and lead to higher production. For the remaining animals less maintenance feed would be needed and total production would in some situations be higher.

It has been proposed to fight hunger by a ban on the use of food as feed for animals in developed countries. It is not very probable that such a measure would help (FAO, 1983b). Developing countries have little buying power so that world prices of the banned foods would soon fall below the value at which they could be produced without loss. Soon the producers would switch to other products or stop production altogether.

Another solution might be food aid but this too may have negative side-effects. Often the food arrives late or cannot be distributed because of bad transport facilities. What is more serious, food aid free of charge, when practised regularly, would depress the prices paid to local farmers for the food they produce (Duckham et al., 1976b; FAO, 1983b). In most developing countries, these prices are already kept low by the governments to provide the consumers, especially those in the cities, with cheap food. Low to very low prices for their products prevent farmers from buying seeds, fertilizers and small equipment, so needed to increase production. Só food aid should only be given in emergencies.

The only practical solution, propagated more and more, seems to be to stimulate local food production in the developing countries and by preference also family planning (Duckham, 1976a; Pawley, 1976; Zwartz & Hautvast, 1979; Holmes, 1983; FAO, 1983b). The promising developments in food production and family planning in a few countries in the recent past threaten to be stopped or reversed by the world's economic crisis. So developed nations should now give the governments of developing countries ample funds for improvement of local food production in a combined international effort. The governments should use these for improving the infrastructure, for education and for providing their farmers with a better income, e.g. by offering them seed, fertilizers and small farm equipment at low prices.

Conclusions

To maximize production of food for man in the world, both livestock and arable farming are needed (Kapsiotis, 1976; Belyea & Tribe, 1983; Spedding, 1984). Livestock should by preference be fed with feeds that man cannot utilize or does not like. Especially the ruminant is excellently suited for converting the large amounts of plant material from non-arable land, as straw and leaves and as in byproducts into food. This animal species are essential in all countries with warm climates where the vegetation contains much cellulose, often heavily lignified.

Food shortage in some parts of the world should be lessened by food aid only in emergency. In all other situations, funds to developing countries should aim to improve their infrastructure and food production.

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Report of plenary session A

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In the three lectures, much attention was paid to famine in the world. Interest in the efficiency of food production should stems both from economics and from concern about the world's food supply.

The world food supply is best served with an appropriate integration of both plant production and animal husbandry.

About 60% of the cultivable land in the world is used for animal husbandry. Most of it cannot be used for arable farming. A considerable part of the plant material eaten by animals (milking cows) consists of feedstuffs that cannot be digested by man. Man is far more particular in his food choice than farm animals.

Ruminants (including milking cows) have an important role, not only as a producer of food, which would otherwise not be produced, but also for traction, fuel and fertilizer in developing countries.

To forbid the use of food as feed for animals in Western countries would not help in the fight against hunger in the developing countries.

The current food-and-nutrition situation throughout the world is often characterized by large bulk and low protein concentration and by inadequate diets. These characteristics affect large population groups, especially the disadvantaged young people in developing regions.

The nutritional quality of milk proteins is high and complements the cereal and starchy root staples widely used in infant and child feeding in many region of the world. They are also a good source of highly available amino acids for adults, especially to meet the increased demands for proteins during pregnancy and lactation. Milk protein is an excellent supplementary food protein source for children.

Milk proteins, if they are to have any impact, must be desired and available at prices the consumer can afford. Of supreme importance are hygiene and cleanliness.

Dairy products can be of great help in emergency aid and should be linked to food strategies and to development as in the World Food Programme. However food deficits in the developing countries can never justify the production of surpluses in the Western countries.

Milk proteins with their superior nutritional value, if made available to the consumer in attractive forms and at reasonable cost, have a significant role to play in the maintenance of an adequate nutritional status of human populations throughout the world.

Nutritional aspects of milk proteins: research findings

B

Importance of milk proteins in human nutrition: physiological aspects

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Summary

The physiological role of milk proteins in human nutrition is discussed, not only the classical role of protein from the strict nutritional point of view, but also the role of some milk proteins in defence against microbial infections and the role of certain low-molecular minor milk proteins as growth factors and modulators. In comparison between human milk and cow's milk, the differences in ratio of casein to whey proteins and in the content of lactoferrin and lysozyme are of importance. Also considered is the supplementary nutritional value of milk proteins in the diet.

CAB descriptors: milk protein, proteins, nutrition, nutrition physiology, milk, human milk.

Introduction

The use of various dairy products in the human diet takes advantage of the fact that milk represents one of the most complete single food items. It has to be complete since the newborn has to rely upon that single source of nutrients, the milk. Consequently an animal or human baby never have less chances of compensating for any lack of nutrients in the diet. Furthermore pronounced growth and maturation of the tissues, create a high demand for essential nutrients during the neonatal period. Concomittantly there is a limited tolerance for deviations in intake of nutrients because the liver and kidney, which both play essential roles in the metabolism of proteins and amino acids are immature. It has been assumed that the composition of milk, which varies considerably between mammalian species (Jenness, 1974), is the indicator of the neonatal requirements of the newborn in relation to their metabolic capacity. This assumption proves especially valid for qualitative and quantitative aspects of milk proteins.

Role of milk proteins in the diet

In the industrial countries dairy products play an essential role in human diet providing 15 to 25% of dietary protein. The physiological role of milk proteins in diet can be divided into three categories:

– Nutritional role. The classical role of milk proteins in nutrition is as a source of essential amino acids and nitrogen for synthesis of protein and amino acids. This is of special importance for the newborn if milk-based formula are used as supplements or alternatives to human milk. The nutritional role of milk proteins is also relevant during adolescence and convalescence which both constitute anabolic states.

– Antimicrobial role. Much studied has been the role of some milk proteins in defence against microbial infections, i.e. lactoferrin, secretory immunoglobulin IgA, other immunoglobulins and lysozyme.

– Other physiological roles. Milk contains some minor components that may modify or enhance physiological functions in the newborn. Such components include some enzymes (e.g. lipase, xanthine oxidase, lactoperoxidase), proteinase inhibitors, and hormones (e.g. epidermal growth factors, prostaglandines, thyroxine). Some proteins bind specific nutrients, such as folic acid or vitamin B-12, or stimulate the intestinal flora. More attention should be directed to nutritional functions and physiology of these minor components in milk. Such minor components might exert significant roles on the metabolism and the nutritional status of the consumer of milk, newborn or adult.

Research has concentrated on dominant protein fractions in milk and their role as sources of protein, of amino acids, especially the essential ones, and of nitrogen. This has led to studies on the nutritive and biological properties of protein components in milk in relation to that of other animal or vegetable proteins in the human diet. As the dairy industry in the industrialized countries is based mainly on cow's milk, research on milk proteins has concentrated on proteins of cow's milk.

Only during the last few years have the minor protein components of milk been studied in more detail. Thus attention has concentrated on the specific whey proteins, which seem to be essential in the defence against gastro-intestinal infections. Trace components of milk with a hormone-like effect as modulators of protein metabolism and growth have recently attracted attention (Gaull, 1984).

When studying the physiological role of various milk proteins, considerations should furthermore be given to the following matters:

– Are some proteins more milk-specific than others, and is species specificity more essential from the nutritional point of view than organ specificity?

– Should we be more concerned about the role of those proteins that are exclusively or essentially synthesized in the mammary gland than other protein components of milk?

– To what extent is the variation in the content of the various milk proteins due to environmental factors, e.g. mother's diet, nutritional status or intake of various drugs? Does this have a significant metabolic or nutritional implication for the offspring?

Obviously there is a slight conflict between a strict nutritional approach to the protein content of milk and a physiological approach. In the nutritional approach we calculate the total protein content of the milk assuming that this is available as a source of amino acids or nitrogen. However specific milk proteins may have a physiological role that required that they be not absorbed in the intestines and consequently not available and utilized as a nutrient. So they should not be included in calculations of available protein in milk. This is relevant in calculations of the protein requirement of offspring based on indirect calculations of milk consumed multiplied by protein content (Hambraeus et al., 1984). It is also of import whenever discussing the nutritional and metabolic implications of the milk composition and variation in composition with environmental factors.

Nutritional value of milk proteins

Assessment of the nutritional value of food proteins comprises several types of analyses.

Biochemical analysis

The biochemical analysis based on assay of the nitrogen content, usually by the Kjeldahl method in order to estimate crude protein content. Some estimates are also based on the Lowry method, by which tyrosine is estimated spectrometrically. In food tables the protein content is based almost exclusively on indirect calculations from nitrogen content. The nitrogen value found is multiplied by a conversion factor based on the mean nitrogen content of protein, usually being 16%. However since the nitrogen content of various amino acids differ (Table 1) the conversions factor depends on the amino acid composition of the protein, and different factors should be used for different proteins (Table 2). However, when calculating the protein content of milk from nitrogen content one needs to know not only the exact amino acid composition of the milk protein but also the ratio between protein nitrogen and non-protein nitrogen.

Although the titles of this paper and congress are about milk proteins, let me stress that the nutritional role of proteins is not only as source of amino acids but also of nitrogen. Consequently we are also interested in the content of non-protein nitrogen (NPN) which constitutes about 5% of the total nitrogen content in cow's milk, but as much as 20-25% in human milk (Lindblad & Rahimtoola, 1974; Lönnerdal et al., 1976a,b). This difference also affects the nitrogen conversion factor.

Lastly when considering the nutritional effect of the protein content in milk, we must consider how far the various milk proteins are nutritionally available and how far they play other physiological roles (Hambraeus et al., 1984). Quite a few of the proteins have a specific physiological role. This role usually depends on them remaining functionally intact within the gastro-intestinal tract and not being absorbed to any significant degree. One can thus question how far proteins, such as lactoferrin, secretory immunoglobulin IgA and lysozyme in human milk are nutritionally

Table 1. Content of nitrogen in amino acids (%).

Less than 16%		More than 16%	
tyrosine	7.7	asparagine	18.7
phenylalanine	8.5	glycine	18.7
methionine	9.4	glutamine	19.2
glutamic acid	9.5	lysine	19.2
aspartic acid	10.5	histidine	27.1
hydroxyproline	10.7	arginine	32.2
isoleucine	10.7		
leucine	10.7		
cystine	11.7		
threonine	11.8		
valine	12.0		
proline	12.2		
serine	13.3		
tryptophan	13.7		
alanine	15.7		

Table 2. Conversion factors from mass of nitrogen to mass of protein.

Wheat (whole grain)	5.83
Maize	6.25
Rice	5.95
Potato	6.25
Bean	6.25
Soya bean	5.71
Beef	6.25
Egg	6.25
Cow's milk	6.38
Breast milk	6.38[a]

a. if corrected for non-protein nitrogen in line with data from Lönnerdal et al. (1976a), the conversion factor would be 5.18.

Table 3. Concentration of nutritionally available protein in breast milk (g/l) calculated by different procedures.

Based on nitrogen	
conversion factor 6.38	11-12
conversion factor 5.18 to correct for non-protein nitrogen	8-9
Based on true protein	
total protein	8-9
corrected for nutritionally unavailable proteins (i.e. lactoferrin, secretory immunoglobin A and lysozyme not included)	5-7

available. When calculating available protein or nitrogen in milk, the conversion factor based on nitrogen should allow for:

– content of non-protein nitrogen
– ratio of nitrogen to protein in an amino acid mixture corresponding to the amino acid composition of the proteins
– the nutritional availability of the proteins.

Table 3 shows the differences in the calculation of nutritionally available protein in human milk with these corrections. As lactoferrin constitutes 10-25%, secretory immunoglobulin IgA 5-10% and lysozyme another 5% of the total protein in mature human milk, this might mean that the nutritionally available protein in human milk is 20-40% less than that found by chemical analysis (Hambraeus et al., 1984). This, according to my point of view, is one of the best indicators of the extremely high biological value of the milk proteins, especially of the whey proteins which predominate in human milk. However we need to consider whether more interest should be focused on the non-protein nitrogen fraction from the nutritional aspect.

Amino acid analysis

Some indication of the nutritional quality of food proteins is given by amino acid analysis and by relating the result to the amino acid composition of reference proteins. The amino acid at lowest content relative to the content of the same amino acid in a reference protein is called the (first) limiting amino acid and the percentage represents the chemical score (Block & Mitchell, 1946). The following comments can be made on the estimations of amino acids:

– Firstly measurements of amino acid do not distinguish between protein-bound

Table 4. Essential amino acids in casein, whey protein and breast milk relative to fad egg reference (FAO/WHO, 1965) and FAO provisional amino acid scoring pattern (FAO/WHO, 1973) (%).

	Casein		Whey protein		Human milk	
	FAO (1965)	FAO (1973)	FAO (1965)	FAO (1973)	FAO (1965)	FAO (1973)
Isoleucine	82	135	115	190	74	123
Leucine	108	136	135	169	103	130
Lysine	127	147	177	205	101	118
Methionine + Cystine	58	91	95	149	67	106
Phenylalanine + Tyrosine	111	185	70	117	76	127
Threonine	92	118	165	210	86	110
Tryptophan	100	160	150	240	NA	NA
Valine	103	150	99	144	71	104
Total essential amino acids	100	142	119	169	–	–

amino acids and free amino acids. Thus there is some discrepancy between content of protein-based amino acids and that of total amino acids.

– Secondly some amino acids are destroyed during hydrolysis before chromatographic estimations, for instance tryptophan, and others may form unavailable components, for instance lysine.

– Thirdly the validity of any calculation of chemical score depends almost entirely on the relevance of the reference protein used. This is illustrated in Table 4 which shows relative content in skim milk powder, casein and a whey protein concentrate in relation to the FAO reference pattern of 1965, which was essentially based on the amino acid pattern of egg, and to the FAO provisional amino acid scoring pattern of 1973. The sulphur amino acids are the limiting ones in casein with reference both to the FAO/WHO (1965) reference protein and the FAO/WHO (1973) provisional pattern, with chemical scores of 58 and 91, respectively. Phenylalanine and tyrosine were limiting in whey proteins giving a chemical score of 70 with reference to the FAO reference patterns of 1965. They were also the limiting amino acids with reference to the 1973 pattern, against which the chemical score, however, increases to 117. This could be falsely assumed as an indicator of an increased nutritive value of the proteins but is of course only result of modifications in the basis for calculations.

Biological evaluation of food proteins

To approach the nutritional significance of the amino acid pattern and nutritional availability, evaluations of protein must also include biological estimations. These include the use of certain micro-organisms and enzymic digestion in vitro. However most biological assays are based upon some type of feeding study with growing laboratory rats. A limitation to such studies is however that each animal species has its own requirements for protein and amino acids, as is so clearly indicated when the milk composition of various mammalian species is compared.

In conclusion a perfect method for the evaluation of food proteins from the nutritional point of view is lacking and would probably be impossible to develop as many factors are involved in the protein utilization in the body. On the other hand, there is reason to believe, not least on teleological basis, that the milk proteins are as close as we can expect to the optimum amino acid composition from the nutritional as well as metabolic point of view.

Nutritional role of specific milk proteins

Milk comprises a heterogeneous mixture of proteins, which can be separated and characterized by various methods. In general, the chemical methods are based on solubility differences and the precipitation of casein, the main protein components of cow's milk, has long been the basis for the classification of milk proteins into two major groups: the caseins and the whey proteins. More recently using gel chromatography, ion exchange chromatography and electrophoresis have increased the scope for separation and characterization of milk proteins. As basis for discussion of the milk proteins in this review, the following classification has been used:

- Major protein components
  caseins
  whey proteins
- Minor protein components
  enzymes
  hormones
  others

For more detailed discussion of the characteristics of milk protein the reader is referred to review articles elsewhere (Fox, 1982, Jenness, 1974; Kauffmann, 1983; Kon & Cowie, 1961; Mckenzie, 1971).

Caseins

Caseins are the main milk proteins in cow's milk where they constitute 78-80% but constitute only 20-30% in human milk. They are highly specific proteins for milk as they are synthesized in the mammary gland. They are characterized by a high content of ester-bound phosphate, a high proline content and low content of sulphur amino acids especially of cystine and a low solubility at pH 4-5. The molecular structure of caseins is furthermore unique as they occur in micelles containing calcium and inorganic phosphate. The caseins thus represent some of the few naturally occurring phosphoproteins. The caseins have been fractionated into alpha, beta and kappa-caseins. The alpha-caseins occur in milk from ruminants and represent phosphoproteins that precipitate at low concentrations of calcium in the absence of kappa-casein. The beta-caseins can be distinguished from other casein fractions by the temperature dependence of their association and solubility in the presence of calcium. Beta-casein is the dominant form found in casein from human milk. Kappa-casein occurs in human milk, cow's milk, goat's milk and ewe's milk. It remains soluble in calcium solutions where all other casein components have precipitated. Kappa-casein also stabilizes the other caseins in the presence of calcium and may play a key role in the formation of calcium-containing casein micelles. Curd formation is also related to the specific hydrolysis of a peptide bond in kappa-casein by chymosin and several other proteinases. Kappa-casein is the only major casein component with carbohydrate side-chains.

It has been assumed that the primary function of the caseins is the nutrition of the newborn. Their role is then not only as source of amino acids but also as sources of calcium and inorganic phosphate. Casein micelles containing calcium phosphate make the content of calcium and inorganic phosphate in milk far higher than would be expected from the physico-chemical solubility of calcium phosphate in milk.

Curd formation may also be of physiological interest for the function of the digestive tract and for gastric enzymes to start protein digestion in the newborn. There are, however, considerable physico-chemical differences between casein from human milk and cow's milk resulting in differences in curd formation in the stomach. The coagulum from human milk is soft and flocculent whereas that from cow's is more resistent and firmer. Research is needed to find whether this has any physiological and/or nutritional implication for the consumer.

Being specific phosphoproteins, the caseins probably play a significant role in the phosphorus balance in adults as well as in the newborn offspring. As dairy products play an essential role in the human diet in most industrial countries, their role as sources of calcium and phophorus is significant. In Sweden, 75% of the calcium intake from the diet is derived from dairy products.

Nutritionally, the caseins are unique in their amino acid composition (Table 5). The caseins have a very low content of cystine resulting in a methionine/cystine ratio which is 2-3 times as high as that in other animal proteins and more than 7 times as high as in the whey protein fraction. Human milk has a very high content of whey protein and so has an extremely low methionine/casein ratio. This is of considerable interest especially for human nutrition as the premature infant lacks the enzymic capacity to convert methionine to cystine and this metabolic pathway may be rate limiting even during the neonatal period (Räihä, 1980). Thus cystine is an essential amino acid for the premature infant. Its content is almost exclusively derived from the whey proteins in cow's milk, namely beta-lactoglobulin and alpha-lactalbumin. The high content of casein in infant formula based on cow's milk could therefore be a nutritional disadvantage.

Table 5. Amino acids in casein and some food proteins expressed as mass of amino acid divided by mass of total nitrogen (g/kg).

	Casein[a]	Whey protein[b]	Breast melk[c]	Beaf[a]	Wheat[a]	Soya[a]
Isoleucine	345	476	254	301	204	284
Leucine	607	736	471	507	417	486
Lysine	518	704	337	556	179	388
Methionine	178	151	78	169	94	79
Cystine	23	174	114	80	159	83
Phenylalanine	334	224	171	275	282	309
Tyrosine	371	214	223	225	187	196
Threonine	297	527	228	287	183	241
Tryptophan	103	147	.*	70	68	80
Valine	430	449	296	313	276	300
Arginine	239	175	171	395	288	452
Histidine	186	144	114	213	163	158
Alanine	196	341	166	365	226	266
Aspartic acid	455	766	451	562	308	731
Glutamic acid	1406	1231	1000	955	1866	1169
Glycine	126	126	98	304	245	261
Proline	738	450	513	236	621	343
Serine	385	374	228	252	287	320

Sources: a. FAO, 1970; b. Forsum et al., 1973; c. Lönnerdal et al., 1976a.
* means not analysed.

The amino acid pattern of casein is futhermore characterized by a high content of proline and arginine and a low content of isoleucine, leucine, lysine and threonine relative to the contents in whey proteins. As the latter are all essential amino acids this might indicate another nutritional disadvantage of casein.

One conclusion from this reasoning is that there is little scientific evidence for the use of casein as a reference protein in nutritional evaluation of food proteins. Nevertheless it is still much used as reference protein in biological assays (Pellet & Young, 1980).

Whey proteins

Whey proteins comprise the non-casein proteins that remain soluble when the caseins have been precipitated enzymically by rennet or isoelectrically with acid. The whey proteins are an even more heterogenous protein mixture than the caseins and share few common characteristics other than being soluble under conditions that precipitates casein. Milk from carnivorous mammals contains a considerable amount of milk-specific non-casein proteins whereas milks from other species, especially rodents contain very little (Table 6) (Jenness, 1974). Some of the whey proteins seem to have distinct physiological roles. So it is not as selfevident that the essential physiological role of the whey proteins is as source of nutrients.

Besides the wide difference between the ratio of casein to whey protein in cow's

Table 6. Mass ratio of casein to whey protein in milks from various mammals. Jenness, 1974.

Woman	0.25
Indian elephant	0.6
Mare	1.1
Cat	1.1
Sow	1.4
Kangaroo	1.0
Northern fur seal	1.1
Dolphin	1.3
Lioness	1.6
Polar bear	1.9
Bitch	2.5
Camel	2.9
Buffalo	4.6
Cow	4.7
Ewe	5.1
Goat	6.3
Blue whale	2.0
Rhesus monkey	2.2
Hamster	2.5
Rat	3.2
Guinea pig	4.4

milk and human milk, there are clear-cut differences also in the composition of the whey proteins (Table 7). Unfortunately we do still not fully understand the reason for this difference neither its physiological or its metabolical significance.

Beta-lactoglobulin is the dominant whey protein fraction in cow's milk and is relatively heat labile. It occurs in milks from all ruminants but is said to be almost absent from human milk, camel's milk and guinea pig's milk. The physiological role of beta-lactoglobulin is not yet understood, although it has been speculated that it plays a role in the phosphorus metabolism of the mammary gland. Its heat lability could explain some of the changes in milk that has been heat-treated, the formation of disulphide bonds between beta-lactoglobulin and kappa-casein leading to aggregation. From the dietetic point of view, the lack of beta-lactoglobulin in human milk has suggested that, being a foreign substance, it may be one of the responsible factors for cow's milk allergy in man.

Alpha-lactalbumin is one of the three major whey protein fractions of human milk. It has a stable configuration at pH 5.4-9.0 and is the most heat-stable whey protein. It occurs in the milk of all mammals and its concentration is related to the lactose content. As it is part of the enzyme lactase synthetase alpha-lactalbumin is said to regulate the synthesis of lactose. The amino acid composition of alpha-lactalbumin seems to be optimum for the requirement of the human infant and so the biological value of alpha-lactalbumin is very high (Forsum, 1974).

Iron-binding proteins in milk are of two kinds: transferrin and lactoferrin. All mammals seem able to produce iron-binding proteins but there is a striking difference between species in the concentrations of these two proteins (Table 8). The transferrin seems to be almost identical to that in blood. Lactoferrin was earlier called red protein. It is synthesized in the mammary gland and occurs also in saliva, tears and semen (Masson, 1970). Lactoferrin and alpha-lactalbumin are the principal whey proteins in human milk (Hambraeus et al., 1978).

Lactoferrin, like transferrin, is a glycoprotein and binds two ferric atoms with the

Table 7. Composition of whey protein in breat milk and cow's milk: mass concentrations of protein in the milk (g/l).

	Breast milk	Cow's milk
Protein		
alfa-lactalbumin	1.6	0.9
beta-lactoglobulin	–	3.0
lactoferrin	1.7	0.012
lysozyme	0.4	0.0001
erum albumin	0.4	0.3
Immunoglobulins		
secretory immunoglobin A	1.4	0.03
immunoglobin G	0.01	0.6
immunoglobin M	0.01	0.03

Table 8. Concentration of lactoferrin and iron in breast milk during the first two weeks of lactation (Fransson, 1983b; Lönnerdal et al., 1976b).

	n	Haemoglobin (g/l)	Lactoferrin (g/l)	Iron (μmol/l)
Indian women				
1.	5	>80	14.6-4.9	5.4-25.1
2.	12	80-110	11.1-3.7	3.6-10.7
3.	12	>110	10.4-4.6	5.4-10.7
Swedish women	23	120-14	3.5-0.5	1.8-9.0
Ethiopian women				
privileged	9	135-14	3.8-0.9	5.4-9.0
underprivileged	9	135-14	0.5-0.2	

incorporation of two molecules of bicarbonate. However neither lactoferrin nor transferrin are fully saturated with iron. Transferrin is known as an iron carrier in the body and lactoferrin could play a similar role for the absorption of iron in the gut of the newborn (Brock, 1980). Iron bound to lactoferrin is absorbed to a much higher degree (50-75%) than iron in other forms (haemoglobin iron and inorganic iron).

Antimicrobial effects of milk proteins

Lactoferrin is also considered to play an essential role in resistance to intestinal infections caused by *Escherichia coli* (Bullen et al., 1972). Lactoferrin occurs in a highly unsaturated form in milk, only 2-4% of its iron-binding capacity being saturated (Fransson, 1983a). It probably functions as such a strong binder that no iron is available for the growth of the bacteria. Saturation of lactoferrin has also been shown to reverse its bacteriostatic effect in nature (Reiter, 1978). The role of lactoferrin as some sort of homeostatic regulator of the availability of iron from breast milk has been discussed. The lactoferrin content of breast milk seems to be influenced by the iron balance of the mother. Thus the lactoferrin content is increased in mothers with a very high iron intake in their diet. However an increased lactoferrin content has also been described in anaemic mothers (Fransson et al. 1984). The nutritional importance and significance of the lactoferrin content in various milk products may therefore have great nutritional interest. According to my point of view, the possible role of iron-binding proteins for iron absorption from dairy products should be studied in more detail. This is of special interest as the iron content in dairy products represents one of their weakest points nutritionally.

Immunoglobulins represent another heterogenous group of proteins in the milk. Immunoglobulin IgA seems to be the most specific one and occurs primarily in colostrum and mature milk of certain species, e.g. milk from primates. In milk from ruminants the less milk-specific immunoglobulins IgG and IgM predominate. Immunoglobulins seem to play no significant nutritional role but are mostly engaged in the defence against intestinal infections.

Other whey proteins include a number of enzymes (see below) whose main physiological role seems to be the defence against intestinal infections and preservation of the milk against deterioration by micro-organisms.

Minor protein components in milk with specific physiological roles

So far most interest has been devoted to the major protein components of whey. However other proteins occur in small amounts. Some have specific physiological roles while the physiological role of others is still not understood. Furthermore there are trace components that are said to have specific effects as growth promotors. The various trace components can be divided into three categories: enzymes, hormones and others.

Enzymes

Enzymes most often described are lysozyme which occurs in substantial amounts in human milk, and xanthine oxidase. More than 40 other enzymes have been described. The physiological role of these enzymes in milk is still not fully understood (Shahani et al., 1973).

Xanthine oxidase is present in substantial amounts in cow's milk, more so than in milk from other ruminants. The concentration in human milk and in milk from non-ruminants is low to moderate though it is high in milks from rats and donkeys (Groves, 1971). Xanthine oxidase is associated with the fat globule, where it constitutes 8-10% of the membrane protein. It is consequently concentrated in the cream but can be released into the aqueous phase under special circumstances, such as homogenization. As xanthine oxidase is relatively heat stable, it is only partly inactivated during pasteurization. It contains molybdenum and iron, and each molecule incorporates two molecules of flavin adenine dinucleotide (FAD). Fransson (1983b) showed that the iron bound to xanthine oxidase in human milk constitutes a substantial fraction of the total iron in milk. Oster (1971) postulated that xanthine oxidase, not being inactivated by the pasteurization of homogenized milk, is absorbed through the intestinal wall. If it is made biologically available by breaking up of fat globules during homogenization, it could injure the cell membranes of heart muscle and arterial walls and could thus be a factor in the high prevalence of atherosclerosis in the industrialized countries (Oster, 1971). For xanthine oxidase in homogenized milk to be accepted as a causative factor in atherosclerosis, it must be shown that xanthine oxidase is in fact absorbed through the intestinal wall without complete inactivation, a matter of some disagreement. Although much scientific work has been devoted to this problem there is still no conclusive evidence (Clifford et al., 1983; Deeth, 1983). Despite risk of inactivation by the digestive juices xanthine oxidase can reach the intestinal wall at least partly active and may be absorbed though at a very low rate. However it is still much debated whether the enzyme can cause tissue damage directly related to atherogenesis which would make homogenized milk a major dietary risk. Furthermore one basis for the Oster hypothesis is the fact that plasmalogen depletion is a causative factor in the development of cardiovascular disease. Evidence for this hypothesis is still considered insufficient. If xanthine oxidase is deposited in heart tissue or arterial wall, oxidation of membrane lipids may occur and may be a more credible explanation of any potential harmful effect than the Oster hypothesis (Deeth, 1983).

Lactoperoxidase is one of the most prominent enzymes in human milk (Groves, 1971). It may play an essential role in the defence against microbial infection of milk also of cow's milk. The lactoperoxidase system may also represent a potential to be used in the preservation of milk in the future by food technology.

Protease inhibitors are present in large amounts in cow's milk, especially in colostrum, and have also been shown to occur in human milk (Lindberg, 1979). Their physiological role is still not quite clear but they might contribute to the local defence against gastro-intestinal infections and enhance intestinal absorption of immunoglobulins and other macromolecules especially during early infancy. An inhibition of the activity of proteolytic enzymes during digestion of milk proteins may consequently be of great significance and another reason that some of the milk proteins are not available as food proteins.

Lysozyme occurs in large amounts in human milk but only in very limited amounts in cow's milk. Its bactericidal effects are to degrade the bacterial cell walls to enhance the activity of immune antibodies.

Lipases occur in various forms in milk. There is a special lipoprotein lipase in bovine milk (Castberg et al., 1975) which is bound to the casein micelles to a large extent. Human milk also contains a serum stimulated lipoprotein lipase in addition to a bile salt stimulated lipase, whose activity is about 175 times that of the lipoprotein lipase (Hernell & Olivecrona, 1974).

Hormones

Hormones and hormone-like substances are present in milk. They may exert a supplementary or modulator effect on the physiological functions of the offspring. Although their action is essentially intended to affect the offspring, little is known of their possible impact on the adult consumer.

Other trace components

Epidermal growth factor, EGF, in milk of various species enhances the growth of cultured cells (Klagsbrun, 1978; Tapper et al., 1979). The factor has been studied in human milk, and has been found to be mitogenic for cultured cells. As the factor does not seem to be completely destroyed in the digestive tract, it may act directly on the gastro-intestinal tissues and is perhaps also absorbed and acts also in other tissues of the newborn.

Prostaglandins exist in milk. Most studies have been performed on human milk.

Prostaglandins may have an affect on the motility of the gut (Lucas & Mitchell, 1980). To what extent these components affect also the adult consumer of cow's milk remains to be elucidated.

Miscellaneous proteins occur in minor amounts. Much discussed are a group of acid glucoproteins that promote the growth of bifidobacteria and have sometimes been called *bifidus* factors. Among these are alpha-1-glucoprotein, which was earlier called orosomucoid.

Coeruloplasmin is a copper-binding protein that occurs in serum but also has been detected in human and cow's milk (Hansson et al., 1967). Also present in milk are several proteins that bind nutrients and components, such as folate (Ford et al., 1972), vitamin B-12 (Gregory & Holdsworth, 1955), and corticosteroids (Payne et al., 1976). Some of these may have significant nutritional and metabolic roles that merit further study.

Supplementary nutritional value of milk proteins in the diet

Not only the nutritional value of single protein components should be considered, neither that of milk proteins as such. The role of milk proteins in the diet as single source of protein is only valid for the newborn. As dairy products constitute a substantial part of the diet of adults, the milk proteins in a mixed diet are also of considerable interest. One must analyse the supplementary effect of milk proteins on the nutritional value of other food proteins. As the concentration of essential amino acids in milk is high and furthermore seems to represent an almost optimum mixture one of the most valuable applications of milk protein in the diet would be to supplement cheaper vegetable proteins of lower nutritional value (Forsum, 1975). This supplementary effect is most obvious when relatively small amounts of milk are added to cereals. This has significant international application with respect to famine in some parts of the world and the gluts of milk in others.

In the conventional diet, milk products are used in two ways, as liquid milk, fresh or fermented, or as milk protein moiety in various milk products, namely fermented products and cheese. Cheese manufacture is one way of preserving the nutritionally high value of milk proteins which otherwise could not be stored. However most cheeses are based on casein precipitation leaving the valuable whey proteins in the whey. This makes whey a byproduct and gives rise to a problem of waste disposal. During the last few years an increasing interest has been directed to use of whey proteins in human diet. The content of essential amino acids is higher than in casein and is usually far above the content in many other animal proteins. It can thus be utilized as a very good supplement to most cereals.

One of the characteristics of the whey proteins is their low content of the aromatic amino acids phenylalanine and tyrosine. This has led to its use as protein source in formula for infants with disturbances in the phenylalanine and tyrosine metabolism (Hambraeus et al., 1974).

The use of whey proteins in the dietary treatment of phenylketonuria is just one example of their potential as protein source in clinical dietetics. In my opinion, there is still much to be done in expanding the use of milk products and especially of whey-protein-based products in the dietetic treatment of various diseases and conditions. This is furthermore a welcome way to stress the nutritional value and status of dairy products.

Conclusion

I have tried to illustrate various physiological characteristics of the different milk protein components, major components as well as minor protein components. My intention has been to focus on the fact that we may have devoted our research interest too much on the dominant proteins and almost forgotten the minor protein fractions which, however, from the physiological and nutritional point of view may be just as essential.

Greater interest for the specific but minor protein components may be beneficial but may also give rise to a problem. By producing various isolated protein fractions to be used for specific purposes, we may 'pick out the raisins from the cake'. It could then be argued that we are creating a new surplus and sewage problem if the residues have to be taken care of. On the other hand, the specific components may be marketable at another price, perhaps within the pharmaceutical sector. This will not only help to balance the economy of dairy production but also contribute by giving a 'status' to milk products and milk proteins.

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Milk proteins in contrast to plant proteins: effects on plasma cholesterol

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Summary

Studies with rabbits have shown that the nature of dietary protein can influence the concentration of cholesterol in blood plasma and the severity of arterial lesions. The feeding of milk protein preparations such as skim-milk powder, lactalbumin and casein resulted in elevated concentrations of plasma cholesterol. On the other hand, when rabbits are fed on diets containing plant-protein preparations such as wheat gluten, groundnut protein and soya protein, plasma cholesterol remained low. The rise in plasma cholesterol induced by casein in comparison with soya protein was found also in guinea pigs, pigs, rats, hamsters and monkeys, but not in domestic fowl, calves and mice. In most controlled studies with man, no clear differential effect of casein and soya protein on plasma cholesterol could be demonstrated. Thus it is questionable whether changes in the nature of the protein in the diet of man will really make an important contribution to the prevention of coronary heart disease by lowering plasma cholesterol.

CAB descriptors: protein sources, casein, soya protein, plasma, cholesterol, animals, man, milk protein, plant proteins.

Introduction

There is no doubt that a decrease in the concentratioh of cholesterol in bloodplasma of people from developed countries will reduce the incidence of heart attacks (Lipid Research Clinics Program, 1984). Plasma cholesterol can be decreased/reduced by dietary means such as a low fat and cholesterol intake and replacement of saturated fats by polyunsaturated fats (Connor & Connor, 1972). It has also been suggested that replacement of animal proteins in the diet by plant proteins will help to prevent coronary heart disease (Carroll, 1978; Kritchevsky, 1979). In this paper, we summarize the evidence that the nature of the protein in the diet of various experimental animals can have marked quantitative effects on plasma cholesterol. Furthermore, we emphasize that there is a substantial variation between species in susceptibility to the type of dietary protein, and that man is rather insensitive.

Studies with rabbits

Seventy-five years ago, Ignatowski (1909) stated that atherosclerosis in rabbits could be induced by dietary means. Rabbits fed on diets containing meat, milk and eggs developed arterial lesions, which he ascribed to the animal proteins in the diets. About fifty years later, this idea was supported by experiments with cholesterol-free semipurified diets in which protein was the only variable. Lambert et al. (1958) and Wigand (1959) found in rabbits that casein was more atherogenic than soya bean protein.

The induction of atherosclerosis in rabbits fed on casein was associated with a marked increase in the concentration of plasma cholesterol, whereas on diets containing soya protein, plasma cholesterol remained low (Carroll, 1978; Kritchevsky, 1979). When rabbits on the soya-protein diet were transferred to the diet containing casein, plasma cholesterol increased rapidly. Conversely, changing the rabbits from the diet containing casein to the soya-protein diet resulted in a decrease in plasma cholesterol (Figure 1). Other milk proteins such as skim-milk powder and lactalbumin also elevate plasma cholesterol concentrations in rabbits when compared to plant protein preparations such as wheat gluten, groundnut-protein concentrate and soya-protein

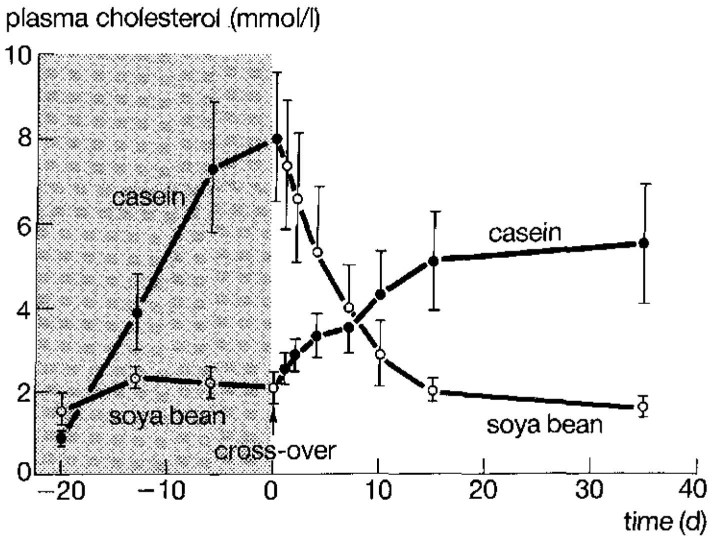

Fig. 1. Concentrations of plasma cholesterol in rabbits fed on cholesterol-free semipurified diets containing either casein (closed symbols) or soya protein (open symbols), at 400 g/kg. Results are expressed as means for 6 rabbits. Bars indicate standard error. Data from Terpstra et al. (1982b).

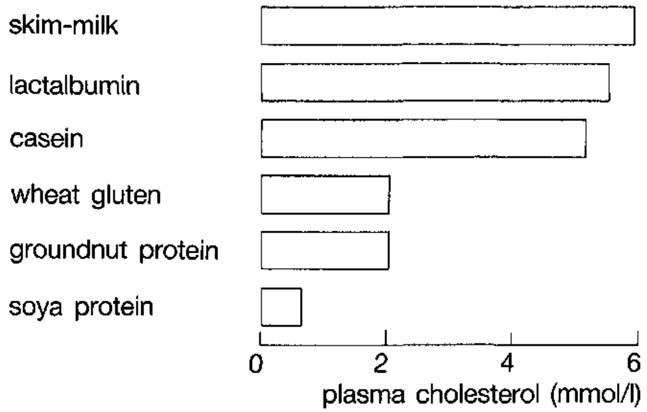

Fig. 2. Concentrations of cholesterol in plasma of rabbits fed for 28 days on semipurified diets with various milk proteins and plant proteins to supply a nitrogen content of 42.3 g/kg. Data from Carrol & Hamilton (1975).

concentrate (Figure 2). Thus milk proteins seem to raise serum cholesterol relative to plant proteins.

Comparative studies with experimental animals

In most studies on dietary proteins and plasma cholesterol, the effects on the relatively pure preparations, casein and soya protein have been compared. There are marked differences between animal species in the effect of dietary casein in contrast to soya protein on plasma cholesterol (Figure 3). Rabbits are the most sensitive animals. Guinea pigs, rats, pigs, hamsters and rhesus monkeys also respond to the type of dietary protein, whereas domestic fowl, calves and mice appear to be rather insensitive.

Figure 3 gives only a general impression of the species-dependent sensitivity to dietary proteins. Other components of the diet, such as the type of fat and fibre, and characteristics of the experimental animals such as age, sex and strain may also determine the susceptibility to proteins in the diet. However the differential effect of casein and soybean protein was certainly more pronounced in diets enriched with cholesterol.

Figure 3 suggests, for example, that rabbits are clearly more susceptible to the nature of the dietary protein than calves. However it could be argued that substances other than protein in the test diets were not the same in the studies with calves and rabbits, and that these dietary components may have overridden a possible protein effect in the calves. This possibility can be ruled out. We have fed rabbits on the milk substitutes for pre-ruminant calves. The milk substitute containing skim-milk powder significantly raised plasma cholesterol in rabbits over that with the substitute containing soya protein (Beynen et al., 1983). Thus rabbits seem very sensitive to the protein source in the diet with respect to plasma cholesterol.

The difference between animal species in their plasma-cholesterol response to dietary proteins is also seen when we compare the effects on rabbits and domestic fowl of the amount of casein in the diet. In rabbits, cholesterol-free semipurified diets containing increased proportions of casein (added at the expense of maize starch) raised plasma cholesterol (Terpstra et al., 1981). Similar observations were made with diets

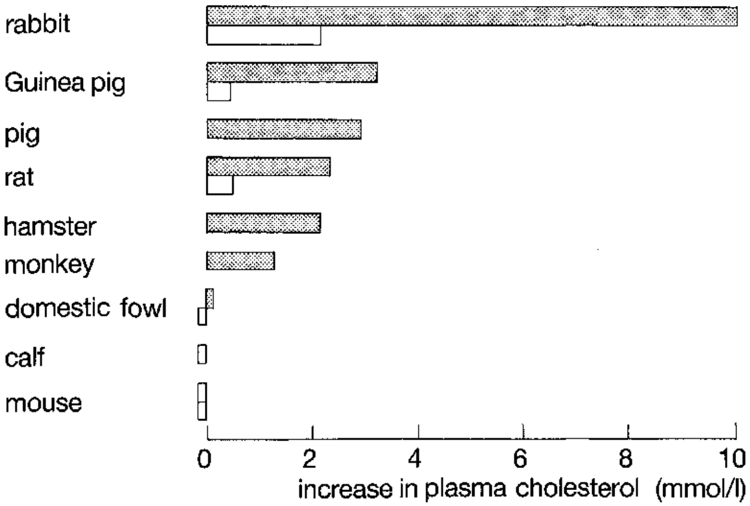

Fig. 3. Increase in plasma cholesterol on casein diets with respect to diets containing soya protein. Diets with cholesterol base (blue bars) and without cholesterol base (open bars) were compared. Data compiled by Terpstra et al. (1983a).

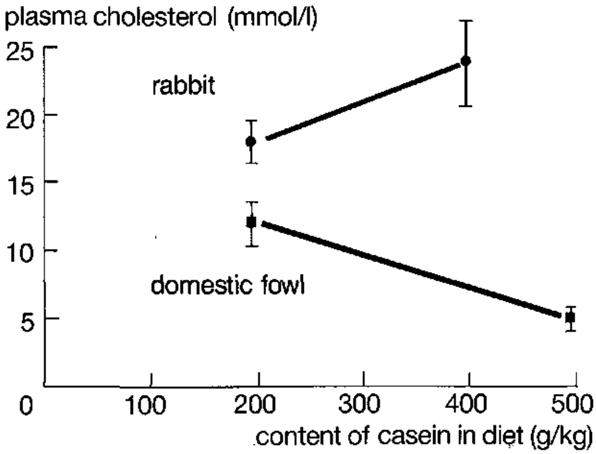

Fig. 4. Concentrations of cholesterol in plasma of rabbits and domestic fowl fed on semipurified diets containing different proportions of casein. Results are expressed as means for 10 animals. Bars indicate standard error. Data from Terpstra et al. (1982a) and Terpstra et al. (1983b).

containing cholesterol at 2.5 g/kg (Figure 4). In contrast, an increase of the amount in casein caused a decrease in plasma cholesterol in domestic fowl fed on casein diets containing cholesterol at 12 g/kg (Figure 4).

Studies in man

The ultimate aim of such nutrition research with experimental animals is to provide further insight into practical means of decreasing the concentration of plasma cholesterol in man through changes in dietary habits. A decrease in plasma cholesterol will decrease incidence of atherosclerotic diseases such as heart attacks (Lipid Research Clinics Program, 1984).

Sirtori et al. (1977), Descovich et al. (1980) and Vessby et al. (1982) have reported that intake of soya protein in contrast to animal proteins by hypercholesterolaemic patients reduced plasma cholesterol by 10 to 30%. These studies are often quoted to support the view that the replacement of animal proteins in the diet by vegetable proteins would lower plasma cholesterol in man. Further support for such a view comes from studies with experimental animals, especially rabbits. However the intake of soya protein in the studies with hypercholesterolaemic patients also involved other changes in the diet, including the elimination of dietary cholesterol and replacement

Table 1. *Effect of mixed animal proteins or casein in contrast to soya protein in the diet on* concentrations of cholesterol in plasma in man. H, healthy subjects, plasma cholesterol values ranging from 4 to 7 mmol/l; P, hypercholesterolaemic patients, plasma cholesterol values ranging from 7 to 12 mmol/l. The effect is expressed as difference: Value on animal-protein diet minus value on soya-protein diet (means; for trials with cross-over design, standard error is given). *$P<0.05$.

Authors	Type of subject	*n*	Animal protein	Difference in plasma cholesterol (mmol/l)
Carroll et al. (1978)	H	10	mixed	+0.26±0.07*
van Raaij et al.(1981)	H	25, 24	casein	0.00
Holmes et al. (1980)	P	10	mixed	+0.09
Shorey et al. (1981)	P	11, 13	mixed	−0.16
Lembke et al. (1981)	H	34, 36	casein	0.00
Lembke et al. (1981)	P	69, 58	casein	−0.12
Wolfe et al. (1981)	P	7	mixed	+0.68±0.10*
Goldberg et al. (1982)	P	12	mixed	+0.21±0.10%
van Raaij et al. (1982)	H	17, 20	casein	+0.13
van Raaij et al. (1982)	H	17, 20	casein	−0.10
Lembke et al. (1983)	H	30, 27	casein	no difference
Lembke et al. (1983)	P	57, 44	casein	no difference
Grundy & Abrams (1983)	H	10	casein	+0.08±0.17
Sacks et al. (1983)	H	13	casein	+0.03

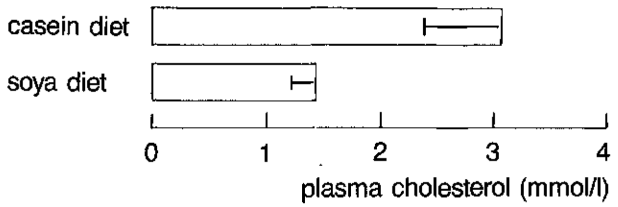

Fig. 5. Concentrations of cholesterol in plasma of rabbits fed on human diets containing 65% of the protein source as either casein or soya protein. Results are expressed as means for six rabbits. Bars indicate standard error. Data from van Raaij et al. (1981).

of saturated fatty acids by polyunsaturated fatty acids. It is thus not possible from these studies to isolate the effect of the dietary protein.

Quite a number of studies have been published in the last few years in which the type of protein was the only dietary variable. Table 1 summarizes the results of these studies. These studies reported either a small effect or no effect at all of mixed animal proteins or casein over soya protein on plasma cholesterol in healthy subjects, and a slightly larger effect in hypercholesterolaemic patients. In contrast, soya protein has been shown to have a pronounced chloesterol-lowering action relative to casein, in various animal species, especially the rabbit. When young rabbits were fed on duplicate portions of diets for human volunteers (van Raaij et al., 1981), the casein diet caused 50% higher plasma cholesterol than the soya protein diet within 2.5 weeks (Figure 5). This confirms the species-dependent sensitivity to dietary protein, and indicates that caution is warranted in extrapolating data from animals to man. In the light of the findings summarized in Table 1, it is questionable whether changes in the nature of the protein in the diet of man could really contribute to the prevention of coronary heart disease.

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Metabolic aspects of proteins for top sportsmen

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Summary

Of the three basic foodstuffs, it is generally accepted that carbohydrate and fat provide virtually all exercise energy. Although the amount of protein in the body is quite large (combustible energy about 232J), its contribution to energy supply during exercise is considered minimal. This belief is based primarily on the fact that after exercise urinary excretion of urea (major end-product of protein utilization) is unchanged. Many of these observations were made years ago and recent studies employing different and more precise techniques indicate an increased utilization of protein or its component parts (amino acids) with exercise. In the past, minimum daily protein and amino acid requirements have been determined for sedentary individuals. However if exercise increases protein utilization, these requirements could be insufficient in sportsmen. This is especially true for those whose protein needs are already high (e.g. adolescents, pregnant or lactating women) and those who may not always receive a balanced diet (e.g. students, vegetarians). Adequate protein intake is essential for elite sport performance, though excessively high protein is unnecessary and can even be detrimental because it places an increased demand on the kidney, increases the chances of dehydration, may result in decreased carbohydrate intake, or may be converted to fat and stored. When in active training, the diet of sportmen should consist largely of carbohydrate (about 60-70% of ingested energy), adequate protein (about 1.8-2.0 grams per kilogram bodyweight per day), and minimal fat. Finally, to ensure that all necessary amino acids are consumed, it is suggested that protein be obtained from complete protein foods such as lean meat, fish, poultry, eggs, and dairy products.

1. Also published in German under the title Auswirkung der Eiweisszufuhr auf die Stoffwechsel vorgänge bei Hochleistungssportlern (Deutsche Molkerei-Zeitung 1984 105 (30):978-983).

CAB descriptors: amino acids, alanine, branched-chain amino acids, endurance testing, exercise, glucose, nitrogen metabolism, protein requirement, protein sources, protein synthesis, sports, urea, protein degradiation.

Introduction

Protein degradation and subsequent amino acid oxidation is generally considered to be of minimal importance in energy metabolism during exercise (Åstrand & Rodahl, 1977). This belief may, however, need re-evaluation in view of recent evidence to the contrary (Lemon & Nagle, 1981; Young & Torún, 1981; Goodman & Ruderman, 1982). This paper will review some of this recent evidence and discuss its relevance to individuals who are chronically active.

The reader must first have an understanding of the methods used in such research. Basically, studies of protein utilization during exercise employ two techniques of measurement. One method involved nitrogen balance (difference between nitrogen intake and excretion) or, more simply, measurement of end-products of protein degradation (primarily urea). The second method utilizes radioactive or stable isotopes to trace nitrogen or carbon flow through the organism.

The metabolism underlying both procedures is outlined in Figure 1. In skeletal muscle, glucose-derived pyruvate carbon can pick up an amino radical from any amino acid (especially the branched-chain amino acids, which include leucine, isoleucine, and valine) in a process known as transamination. The result is formation of the amino acid alanine, which is released into the bloodstream in large amounts. Subsequently, the amino radical is removed in the liver, the process being deamination, and

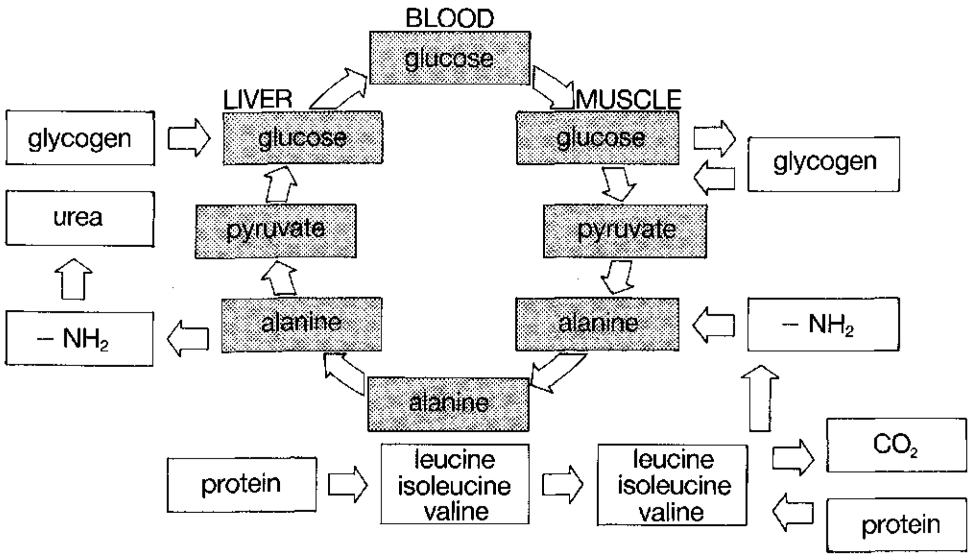

Fig. 1. Glucose-alanine cycle showing input of branched-chain amino acid (leucine, isoleucine, and valine) and output of urea. Redrawn from Odessey et al., 1974 (with permission).

enters a reaction chain (urea cycle), which ultimately forms urea. In the resting state, the resulting urea is excreted primarily through the kidney into urine. This mechanism provides a method of eliminating the toxic ammonia produced in muscle (Felig & Wahren, 1971; Odessey et al., 1974). Because urea excretion is the major form of nitrogen excretion after protein degradation, one can estimate the amount of protein broken down for regeneration of adenosine triphosphate either at rest or during exercise (Lemon & Mullin, 1980). Similar calculations can be made if one measures excretion of labelled nitrogen after injection or ingestion of an appropriately labelled amino acid. If the carbon skeleton of an amino acid is labelled (leucine, isoleucine or valine in Figure 1), protein degradation can be calculated from direct measures of amino acid oxidation. This involves measurement of labelled CO_2 in expired air and of radioactivity in tissue due to the particular compound (Lemon et al., 1982).

Evidence for protein utilization in exercise

Many studies on exercise during the past hundred years have concluded that protein does not contribute to muscular energy (Åstrand & Rodahl, 1977). Most of these studies utilized urinary excretion of urea to measure protein degradation. During the last few years, some investigations with more precise techniques, have shown that these early studies probably underestimated the contribution of protein to metabolism during exercise (Lemon et al., 1980; 1982; White & Brooks, 1981; Rennie et al., 1981; Hagg et al., 1982; Millward et al., 1982). There are several reasons for this underestimation. Although urinary urea is the major mode of nitrogen excretion at rest, skin losses (sweat) can also be very important during exercise (Cerny, 1975; Lemon & Mullin, 1980). This is probably due to decreases in blood flow through kidneys and increases in blood flow in skin during exercise. Secondly urea production during exercise may not accurately reflect total amino acid oxidation (Wolfe et al., 1982). So amino acids could provide energy for exercise that would not be detected by measuring urea. This may be the result of urea cycle enzymes being inhibited by the exercise-induced increasing concentration of pyruvate and lactate (Metz et al., 1968), by the increased concentration of several metabolic intermediated that do not yield urea during or immediately after exercise (Lemon et al., 1984b), or the increased excretion of other forms of nitrogen (Lemon et al., 1983; Deutsch et al., 1983). Thirdly, and most convincingly, some studies have observed increased oxidation of amino acids by measuring isotopes (Lemon et al., 1980; 1982; White & Brooks, 1981; Hagg et al., 1982; Millward et al., 1982).

Source of protein for energy

Unlike either carbohydrate or fat, the body does not have a storage form of protein. The amount of protein in the human body is, however, quite large (Table 1). All this protein is found in essential components, i.e. structural and enzymic protein. So it may not be as readily available as stored carbohydrate or fat. By contrast, the component parts of protein (amino acids) exist in a dynamic equilibrium (Figure 2) and

Table 1. Stores of energy in a person (body-weight 70 kg; content of fat 150 g/kg and of protein 200 g/kg) and the duration of continuous exercise they allow (assuming an oxygen consumption of 33.3 $cm^3/s \approx 1.4$ mmol/s).

Source	Combustible energy (J)	Duration (h)
Adenosine triphosphate	0.005	0.002
Creatine phosphate	0.015	0.006
Carbohydrate	8.5	3.4
Protein	232	93
Fat	390	157

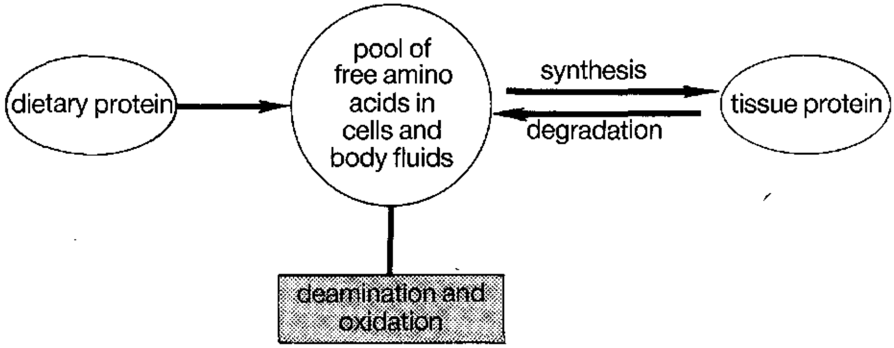

Fig. 2. Schematic representation of protein metabolism. Following deamination, energy (ATP) is regenerated during oxidation of amino acids from the free pool. This pool is constantly changing due to input of amino acids from diet and/or tissue degradation and output via protein synthesis and/or oxidation.

energy can be obtained when the amino acids from the free pool in cells and body fluids are oxidized. This pool is constantly changing by input from diet or from degradation of tissue protein and by output with oxidation or protein synthesis. Because the amount of free amino acids is extremely small (about 1% of the total), significant amounts of amino acids for oxidation can only be made available if there are acute changes in rates of protein synthesis or degradation. During endurance exercise, decreases in protein synthesis (Rennie et al., 1981; Hagg et al., 1982; Millward et al., 1982) and increases in protein degradation (Lemon & Mullin, 1980; Dohm et al., 1982; Lemon et al., 1983; Lemon et al., 1984a) have been observed. These changes would make amino acids available for energy during exercise.

Mechanism and site of amino acid oxidation

At present, the mechanism(s) and site(s) of amino acid oxidation during exercise are unclear (Lemon & Nagle, 1981; Young & Torún, 1981; Goodman & Ruderman, 1982) but some interesting information has recently been published. The oxidation of several amino acids have been investigated during exercise. The essential amino acid leucine has been most frequently studied for several reasons. Methodologically, leucine is ideal because it is a ketogenic amino acid and the decarboxylation step is irreversible. This means that production of labelled CO_2 directly reflects leucine oxidation and is not confounded by interconversion to glucose or by intermediate recycling. Also the metabolic situation in muscle, at least during prolonged exercise, is similar to starvation, where leucine oxidation is known to increase (Lemon & Nagle, 1981). The limiting enzyme in the leucine oxidation pathway (α-ketoisocaproic acid dehydrogenase) seems to exit in an active and inactive form (Randle et al., 1981) and the active form predominates when mitochondrial concentrations of adenosine triphosphate (ATP) are low. The decrease in ATP induced by exercise would therefore shift the equilibrium toward the active form of the enzyme resulting in an increase in leucine oxidation (Hagg et al., 1982). This could account for the observed increases in leucine oxidation with exercise (Lemon et al., 1980; Lemon et al., 1982; White & Brooks, 1981; Hagg et al., 1982). Whether other amino acids are oxidized to a similar extent during acute exercise and, if so, whether similar mechianisms are involved are topics that still need attention. Preliminary data suggest that chronic exercise (training) may further increase oxidation of amino acids during exercise (Dohm et al., 1977; Henderson et al., 1983; Yarasheski & Lemon, 1983). The mechanism of this apparent effect of training has not been clearly identified. However increases in palmitoyltransferase (EC 2.3.1.2.1) activity that occur with endurance training (Molé et al., 1971) could reduce the accumulation of α-ketoisocaproic acid resulting in a significant increase in leucine oxidation (Lemon & Nagle, 1981). Effects of training on protein degradation and amino acid oxidation represent another area that requires further study.

The site of amino acid oxidation during exercise has not been determined. However it is probably skeletal muscle, because this is where the large increase in metabolism occurs. The source of amino acids for oxidation is also unclear. Data of Dohm et al. (1978) indicate that both skeletal muscle and liver protein may contribute (Table 2). Let us consider the evidence for degradation of skeletal muscle first. Muscle soreness following prolonged exercise (especially eccentric exercise) is frequently reported and

Table 2. Effect of exhaustive exercise on content of tissue protein in body (i.e. mass of tissue protein divided by mass of body). Values are mean, standard error and number of observations (in parenthesis). * Significant difference ($P < 0.05$) between exhausted and rest. Data from Dohm et al. (1978).

Tissue	Content (g/kg)	
	rest	exhausted
Gastrocnemius	1.40 ± 0.06 (15)	1.18 ± .04 (16)*
Heart	1.16 ± 0.03 (15)	1.11 ± .03 (13)
Liver	5.35 ± 0.20 (14)	4.68 ± .11 (16)*

both effluxed muscle enzymes and histochemical changes in muscle (disorientation of myofibrils, mitochondrial swelling, and even degenerating fibres) have been observed (Armstrong et al., 1983; Kuipers et al., 1983). The precise role this plays in amino acid oxidation is unknown but the repair or synthesis of these components during recovery from exercise may increase protein requirement in active individuals.

Urinary excretion of the amino acid N^{τ}-methylhistidine has been used as an index of skeletal muscle protein breakdown, because it is found primarily in skeletal muscle (>90%), is not re-utilized when muscle is degraded, and is virtually all (99-100%) excreted in urine (Young & Munro, 1978). Some exercise studies have observed increased N^{τ}-methylhistidine excretion after exercise (Kasperek et al., 1979; Dohm et al., 1982). However others have observed no change or even a decrease (Décombaz et al., 1979; Rennie et al., 1981). These data should be interpreted with caution because, at least in the rat, the gastro-intestinal tract may contribute as much as 40% of urinary N^{τ}-methylhistidine by a rapid turnover of N^{τ}-methylhistidine in the gut (Wassner & Li, 1982; Rennie & Millward, 1983). This gut contribution may confound studies with N^{τ}-methylhistidine as an indicator of protein degradation especially with exercise, because of changes in blood flow that are known to occur. Let us assume that breakdown of skeletal muscle increases with exercise, leading to a 15% increase in output of N^{τ}-methylhistidine from skeletal muscle. At the same time, decreases in gut metabolism and blood flow might reduce the gut contribution by a similar amount or even a little more. The result would be no change or a slight decreasein total excretion of N^{τ}-methylhistidine with exercise, despite an increase in degradation of skeletal muscle. Although there is some evidence that the gut contribution is less in humans (Afting et al., 1981), this question must be considered in all studies with N^{τ}-methylhistidine as an index of breakdown. This problem could be overcome by measuring N^{τ}-methylhistidine across an exercising muscle, thereby excluding the gut contribution. For a further discussion of the advantages and limitations of the use of N^{τ}-methylhistidine, two reviews have been recently published (Ballard & Tomas, 1983; Rennie & Millward, 1983).

Significant changes with exercise in concentration of amino acids in both tissue and serum have been observed and it has been suggested that these indicate increases in protein degradation (Lemon & Nagle, 1981; Young & Torún, 1981; Goodman & Ruderman, 1982). This is not necessarily so, however, because most amino acids can be affected by changes in protein synthesis with no change in degradation rate. In contrast, increased concentration of unmetabolizable amino acids have also been observed with exercise and these changes indicate that protein degradation in fact increased (Haralambie & Berg, 1976).

Losses in liver protein (Table 2) and increases in hepatic lysosomal fragility (Kasperek et al., 1980; Kasperek et al., 1982) indicate that the liver may be an important source of amino acids for oxidation during exercise. Other tissues may also be involved in the exercise response. However it now seems likely that both live and muscle contribute the majority of amino acids for oxidation by skeletal muscle. Future study is necessary to confirm or deny this working hypothesis.

Magnitude and importance of protein utilization with exercise

Recent studies on exercise in both laboratory animals and man indicate that protein utilization may account for about 5-15% of energy expenditure during a single bout of exercise (Lemon & Mullin, 1980; Dohm et al., 1982; Lemon et al., 1983; Yarasheski & Lemon, 1983). Moreover, in a given individual the contribution can be even greater (Lemon et al., 1983; 1984b; Yarasheski & Lemon, 1983). Most of these studies have investigated endurance exercise but increases in excretion of urea or N^{τ}-methylhistidine have also been observed with short-term intense exercise such as weight lifting (Laritcheva et al., 1978; Dohm et al., 1982). Studies utilizing tracer methodology with weight lifting exercise are unfortunately extremely scarce, despite the common belief that muscle is broken down with this type of exercise. When completed, such experiments should help to indicate whether strength and endurance exercise differ in their effects on protein degradation. There is some evidence that the protein contribution to total energy expenditure may be related to exercise intensity at least with endurance exercise (White & Brooks, 1981; Lemon et al., 1982; Lemon et al., 1984a) and therefore it is possible that protein degradation is increased in these sportsmen as well, because of the much greater intensity during strength exercise. Although the contribution of protein to energy expenditure is clearly less than that of either carbohydrate or fat, it may be very important for performance, especially when one considers that athletic events are frequently won by extremely small margins. Furthermore oxidation of an amino acid has been reported to be as high as 90% of the minimum daily requirement during a single exercise bout (Evans et al., 1983). The minimum requirements were determined on sedentary individuals (US Food & Nutrition Board, 1980) and it is possible that active individuals have higher protein and amino acid needs unless exercise training causes an adaptation that reduces protein and amino acid utilization. If deficiencies exist, the probably occur primarily in the essential amino acids, which cannot be synthesized by the body and so must be consumed in adequate quantities in the diet. Preliminary evidence from both animals (Dohm et al., 1977) and man (Henderson et al., 1983; Yarasheski & Lemon, 1983) suggest that utilization of protein and amino acids may actually increase with endurance training. These data suggest that the chances of a deficiency are greater in endurance-trained sportsmen. Fortunately, most individuals in the developed countries are protected to some degree from this hazard, because they consume more protein than required. Despite the increased amino acid oxidation with exercise, one might argue that such a protein deficiency is unlikely in sportsmen because most consume tremendous amounts of food in order to cover their high energy output during training. This is probably true, if the content of protein in the diet remains the same as the total dietary intake increases. For example, a sedentary individual might consume about 10.5 (MJ/d). If protein supplied 16,7 MJ/kg and the diet contains 12% protein, a sedentary person of 70 kg body-weight requires 1.08 g of protein per kg body-weight per day. This is slightly above the minimum requirement of 0.9 g/kg (US Food & Nutrition Board, 1980). If this same individual began an active training program and maintained 12% protein intake while increasing total energy intake to 21.0

MJ/d, the amount of protein consumed would be about 2.16 kg body-weight per day. This should be sufficient to cover the increased need of an endurance sportsman. However with the recent trend toward high-carbohydrate diets, the same content of protein in diet (120-150 g/kg) may not always be maintained. Moreover, certain groups of individuals may be at higher risk of developing a deficiency. These include individuals that have either increased need for protein forother reasons or an imbalanced diet. Adolescents, pregnant or lactating women, individuals who employ multiple daily endurance training sessions, and perhaps weight trainers belong to the first group, while students and vegetarians belong to the second. Whether protein degradation plays an important role in the response to weight-lifting exercise is unclear. However needs for protein and amino acid are probably increased in these sportsmen because of increased protein synthesis (Goldberg et al., 1975). This suggestion is supported by the data of a study that reported a decreased cell mass in adult males who trained with isometric (static) exercise while on a diet which contained the recommended daily allowance for protein (Torún et al., 1977). In addition, other studies have successfully reversed the previously observed increased urea excretion and improved exercise performance by increasing the protein content by from 6 to 18% (Laritcheva et al., 1978). Total energy intake is also important, because if a sportman's energy expenditure exceeds intake, nitrogen balance becomes negative (indicating that protein breakdown exceeds synthesis) even at a protein intake that elicits a positive nitrogen balance when total food intake is adequate (Laritcheva et al., 1978).

Conclusions

Recent experimental evidence indicates that, contrary to classic belief, protein plays a very important role in metabolism during exercise. Although the exercise stimuli, as well as the body types of strength and endurance athletes, are drastically different, it may be that both these groups of sportsmen require more protein and specific individual amino acids than sedentary individuals. Despite inadequate study to date, the biochemical mechanisms responsible for these increased needs probably differ also. Endurance athletes have little body fat (Åstrand & Rodahl, 1977). This is clearly an advantge in their sport because it reduces the total weight that must be carried. They might also lower their body protein to a minimum, especially in non-active muscles, in an attempt to further increase speed and efficiency. If so, it is possible for this process (decreased protein mass) to continue to the point where performance or health deteriorates. So adequate intake of protein by these sportsmen is essential. Exercise-induced hypertrophy (increased muscle mass) is the result of increased protein synthesis (Goldberg et al., 1975) and so sportsmen who train with weights probably require extra protein as well. Unfortunately, it is unclear at present how much protein is optimum for either group. Until this information becomes available, recommendations must be conservative because protein intake in excess of need will not improve and may even adversely affect performance, possibly by decreasing carbohydrate intake, increasing fat deposition, or increasing dehydration.

Moreover, kidney and liver problems may result, because of the increased loading on these tissues during the metabolism of protein. It seems justifiable to recommend that sportsmen consume a diet rich in carbohydrate (perhaps 70% of energy intake), adequate protein (intake perhaps 1.8-2.0 g/kg·d) and minimal fat. This protein intake represents about twice the existing recommended requirement for sedentary individuals. Although the type of protein in the diet of sportsmen and its effects on performance has not been well studied, animal proteins may be the best source of protein, because they are more complete (contain all essential amino acids) and have higher digestibility than vegetable protein. So when animal protein is consumed, more energy can be derived from a given protein intake with less nitrogen for the liver and kidney to metabolize. Some studies on animals indicate that dietary intake of animal protein may be more atherogenic than vegetable protein (Carroll, 1982), however this may not be true for man (van Raaij et al., 1979; Holmes et al., 1980). These observed differences are difficult to explain but might be due to the type of animal protein ingested or the species studies (Terpstra et al., 1983). In any event, this is less likely in sportsmen because the protein and carbohydrate consumed in excess of minimum requirement is utilized in accelerated metabolism and is not therefore converted to fat nor stores, as would happen in sedentary individuals.

Although protein metabolism during exercise has been studied for at least a hundred years, there are still many unanswered questions for both the scientist and the sportsman. Recent information, utilizing newer and more precise techniques, appears to contradict existing conceptions. This provides an excellent reminder of the general need in science to continue to evaluate old ideas in the light of all evidence rather than to accept established beliefs. If this discussion stimulates any interest in this area of study, the effort in writing it will have been worthwhile.

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Effects of increased supply of protein on elite weight-lifters

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Summary

The favourable results are presented of a experiment with groups of elite weight-lifters, in which the effect was studies of an extra supplement of milk protein in their diet.

The effect was analysed in terms of clinical parameters, the physiological and psychological condition of the body and the actual performance in maximum lifted weights.

CAB descriptors: fatigue, protein supplements, milk protein, sports, vigour.

Introduction

Increased supply of protein for top sportsmen has attracted attention in sports medicine as a means of enhancing biological preparation and endurance during training (Strauzenberg, 1969; Gontea, 1971; Drăgan et al., 1982; 1983). Protein concentrates manufactured from milk have proved their value for this purpose, especially for strength and endurance (Drăgan, 1977; Schwarz & Teich, 1975).

In Rumania, we have tested a product called Refit®, which originated from the Melkindustrie Veghel in the Netherlands in 1978 (Hoogenkamp, 1982). This powder contains milk protein 880-900, mineral salts (Ca, P, K) 44, fat 14, carbohydrate 12 and moisture 50 g/kg. As a supplement to the diet of top swimmers, it improved athletic performance and clinical properties (Drăgan et al., 1982). The present study was designed to find its effect on top weight-lifters.

Materials and methods

Twenty elite weight-lifters had been under hard training for 4-6 h, 6 days a week, under medical supervision and with similar programme and diet for 9 months before the trial. Nutrient intakes were calculated relative to body mass to supply energy 270-315 kJ/kg·d and protein 2.2-2.5 g/kg·d. At the beginning of the trial, they fell into 8 classes by body mass: 56, 60, 67.5, 75, 82, 90, 100 and 110 kg. They were randomly assigned to two groups taking into account body mass. The trial was of double-blind placebo-controlled cross-over design. The protein concentrate was supplied at 1.2-1.5 g/kg·d as a supplement, raising the protein intake to about 3.5 g/kg·d. It was incorporated either in chocolate-flavoured milk or in yoghurt.

Group A1 received the supplement from 15 January to 15 May 1983 before an international competition on 24-27 May. From 16 May to 18 August, it received a placebo.

Table 1. Effects of increased supply of protein on elite weight-lifters (clinical symptoms). Group A1 ($n = 10$).

	Refit®		Placebo	Refit®
	1983-01-15	1983-05-15	1983-08-18	1983-10-16
Appetite	2.8 ± 1.1	3.2 ± 0.81	3.0 ± 0.72	3.1 ± 0.70
Fatigue after training	2.0 ± 0.83	3.2 ± 1.06*	2.8 ± 0.92	3.7 ± 1.14**
Personal feeling of wellbeing at the time of training	2.5 ± 0.88	3.5 ± 1.24*	3.0 ± 1.13	3.8 ± 1.21
Performance (kg)	321.42 ± 21	342.95 ± 33**	331.75 ± 31.2	359.35 ± 38**

* Change significant $P < 0.025$; ** Change significant $P < 0.05$; ±, calculated as standard deviation.

Table 2. Effects of increased supply of protein on elite weight-lifters (paraclinical parameters) Group A1 ($n = 10$).

	Refit®		Placebo	Refit®
	1983-01-15	1983-05-15	1983-08-18	1983-10-16
Lean body mass (%)	83.4 ± 4.58	88.2 ± 5.35*	86.9 ± 4.6	90.6 ± 5.22
Fat mass (%)	13.6 ± 4.1	11.9 ± 3.59	13.1 ± 3.8	12.3 ± 3.72
Scapular strength (kg)	61.75 ± 3.8	65.71 ± 5.7**	62.45 ± 6.1	67.2 ± 5.5**
Lumbar strength (kg)	177.28 ± 15.5	191.05 ± 19.2**	181.45 ± 15.2	195.25 ± 15.6**
Strength index	1.16 ± 0.15	1.307 ± 0.21**	1.05 ± 0.17**	1.31 ± 0.19**
Hb (g/l)	153.5 ± 18.1	163.9 ± 16.1	157.2 ± 16.8	166.6 ± 5.5
Protein in serum (g/l)	71.2 ± 6.2	76.8 ± 7.1**	70.6 ± 8.0**	75.3 ± 7.7**
Lipid in serum (g/l)	8.15 ± 1.60	7.08 ± 1.17	7.97 ± 1.43	7.03 ± 0.96
½ Ca^{2+} in serum (mmol/l)	4.78 ± 0.27	5.17 ± 0.61**	4.92 ± 0.36	5.33 ± 0.49*
Creatinine in serum (mg/l)	9.1 ± 3.4	11.5 ± 4.0	9.8 ± 3.5	11.0 ± 4.6
Glutamic oxaloacetic transaminase (IU/l)	74.2 ± 50.2	70.7 ± 51.7	80.2 ± 41.2	104 ± 60.4
Urinary mucoprotein (mg/d)	171.42 ± 51.32	142 ± 21**	155.4 ± 32**	118.4 ± 4.1*

* Change significant $P < 0.025$; ** Change significant $P < 0.05$; ±, calculated as standard deviation.

From 19 August to 16 October, it again received the supplement before participation in the World Weight-Lifting Championships on 22-30 October. Group A2 received the supplement only in the second period, 16 May to 18 August, and participated in other official competitions at the same time as Group A1. During the trial neither group received any drugs part from 4 vitamin tablets and 3-4 mineral tablets daily.

Clinical and performance measurements and observations were made at the start of the trial, after the first and second periods and, for Group A1 only, after the third period. They included the following:

– a questionnaire to the weight-lifters on their appetite, fatigue after training and feeling of well-being during training, classed as unsatisfactory (1), satisfactory (2), good (3) and very good (4)

Table 3. Effects of increased supply of protein on elite weight-lifters (clinical symptoms). Group A2 (n = 10).

	Placebo		Refit®
	1983-01-15	1983-05-15	1983-08-18
Appetite	3.0 ± 1.15	3.1 ± 0.96	3.5 ± 1.33
Fatigue after training	1.8 ± 0.70	1.5 ± 0.58	1.98 ± 0.67**
Personal feeling of wellbeing at the time of training	2.2 ± 0.71	2.0 ± 0.65	2.9 ± 0.88*
Performance (kg)	305.5 ± 34	315.5 ± 46	358.5 ± 58**

* Change significant $P < 0.025$; ** Change significant $P < 0.05$; ±, calculated as standard deviation.

Table 4. Effects of increased supply of protein on elite weight-lifters (paraclinical parameters) Group A2 (n = 10).

	Placebo		Refit®
	1983-01-15	1983-05-15	1983-08-18
Lean body mass (%)	84.3 ± 6,1	83.7 ± 5.8	88.9 ± 6.9**
Fat mass (%)	15.7 ± 3.2	16.3 ± 4.3	14.1 ± 3.6
Scapular strength (kg)	58.75 ± 3.5	60.50 ± 5.4	65.30 ± 5.71**
Lumbar strength (kg)	165 ± 14.7	170.5 ± 16.3	185 ± 17.5**
Strength index	1.03 ± 0.18	0.98 ± 0.16	1.15 ± 0.19**
Hb (g/l)	145.5 ± 16.2	140.2 ± 14.4	157.7 ± 16
Protein in serum (g/l)	68.5 ± 5.1	70 ± 6.6	75.5 ± 7.3**
Lipid in serum (g/l)	7.95 ± 1.45	8.38 ± 1.06	8.05 ± 1.19
½ Ca^{2+} in serum (mmol/l)	4.88 ± 0.32	5.06 ± 0.53	5.53 ± 0.65**
Creatinine in serum (mg/l)	10.5 ± 3.7	11.5 ± 4.9	10.1 ± 2.9
Glutamic oxaloacetic transaminase (IU/l)	68 ± 47.1	75 ± 50.2	78 ± 53.5
Urinary mucoprotein (mg/d)	128 ± 36.5	163 ± 45.2**	142 ± 61*

* Change significant $P < 0.025$; ** Change significant $P < 0.05$; ±, calculated as standard deviation.

– mass fractions of lean and of fat in the body (Faulkner's method as modified by Drăgan, 1974)
– strength at shoulder and thigh, expressed as maximum weights lifted as measured by a dynamic method
– an index of strength, obtained by averaging right-hand and left-hand flexor strength, and strengths at shoulder and thight, and dividing by body mass
– composition of body fluids (Manta, 1976; Richterich, 1969), including: haemoglobin in bood (Drabkin's method), protein in serum (Weichselbaum's method), lipid in serum (method of Zöllner & Kirsch), calcium in serum (flame emission spectrometry), creatinine in serum (Jaffé's method), aspartate aminotransferase (EC 2.6.1.1) (absorption spectrometry), mucoproteins in urine (Biserte Montreuil method). Values were analysed for statistical differences by Student's *t* test (Tables 1-4).

Results and discussion

In Group A1, the milk-protein concentrate significantly improved feeling about fatigue and well-being and athletic performance (Table 1). It increased body lean, strength characteristics, and protein and calcium in serum, and decreased mucoprotein in urine and lipid in serum. The same sort of trends were found in Group A2 over the period it received the concentrate. Over the whole trial, the weight lifted by Group A2 increased by 3.27% as a result of training only, in contrast to 6.69% for Group A1 with the concentrate.

Conclusion

An increase in protein supply for top athletes under hard training from about 2.5 to 3.5 g/kg·d, calculated relative to body mass, in the form of a milk-protein concentrate increases their endurance, allows quicker recovery from fatigue and increases their performance in top competitions.

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Report of plenary session B

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Milk proteins have a high nutritive value with excellent amino acid balance perfectly adapted to the different requirements for protein synthesis. This is particularly true for whey proteins, lactalbumin and lactoglobulin, but they only represent a rather small fraction of all milk proteins (17%). Caseins, constituting the main fraction of cow milk proteins, are not so well balanced as the former ones, especially because of their low content of sulpher amino acids and because of their lower biological value than the other milk proteins (70 against 94). Many studies are still undertaken to investigate the sources of variation of the nutritive value of milk proteins. These variations may arise from the protein production conditions in the animal, the conditions under which milk is processed and stored, the nature of the nutrient requirements and the proportion of proteins used otherwise than for tissue construction.

This congress session has not dealt with the first two points as they have already been thoroughly studied, especially the first one. The second one is still being investigated and research is centred on the effects of milk processing upon the physical and especially the chemical structure of the proteins and their composition, as well as on the influence of these modifications on digestibility and metabolic utilization of nutrients. On this last point, there are still many gaps in our knowledge because of the inadequacy of the physiological parameters and their biological meaning. For example, the availability of amino acids depends not only on their absorptive capacity, which can easily be measured by their disappearance from the digestive tract, and on their way of absorption, which may render them unusable for the tissues, but also on the chronology of absorption leading to an asynchronous supply to the tissues, which may be detrimental to their utilization in protein synthesis. Accordingly, it is necessary to 'sharpen' the tools we use to estimate the amount, nature and chronology of nutrients absorbed. The effect of the factor 'time' on the utilization of nutrients by the tissues should also be studied more thoroughly. This effect probably varies between animal species, as gut length affects the duration of transit and absorption and as the feeding habits (meal eater or nibbler) affects the time interval between meals. Thus we should be developing techniques to compare the qualitative and quantitative disappearance of nutrients in the digestive lumen and their concomitant appearance in the blood and portal vein as well as their uptake by the gastro-intestinal wall. Such techniques are now being applied in the pig together with new ileo-caecal fistulation methods and a technique is being used to measure the differences in the portal and asterial concentration of nutrients (furosin for heated skim-milk) with continuous recording of rate of portal flow after a meal. We have obtained valuable results with these techniques, but other aspects also need to be studied, such as the redistribution of nutrients by the liver. The hepatic balances should be measured, i.e. inputs and outputs measured by cannulation of the subhepatic veins, portal vein and hepatic artery, rate of portal and arterial flow and the chronology of renal excretion. However this type of technique often encounters problems because of difficulties in measurement of chemical components in the blood and urine, and further studies are needed. Furthermore, attention should be paid to the specific role of the large intestine in the uptake of some nutrients, a role which may be important for proteins altered by heat treatments and which we have already partly analysed. To that end, it would be interesting to use axenic or gnotobiotic animals fitted with caecal vein cannulas or caecal and colic digestive cannulas.

A major aspect of this session has been the ubiquitous role of milk proteins:

- the main role of most of them, to satisfy requirements for proteins, essential amino acids and nitrogen as well as for major elements
- the role of some of them, i.e. lactoferrin, secretory IgA, immunoglobulins and lysozyme, in defence against microbial infection
- the role of certain low-molecular milk proteins as growth factors.

These different roles have been analysed by Professor Hambraeus who emphasized the slight conflict between the classical role of milk proteins from a nutritional point of view and the physiological role played by certain proteins or protein fractions if they are not broken down in the intestines and are thus unavailable as nutrients. This diversity in the roles of milk proteins leads us to reconsider not only the possible variations in contents of the various proteins, but also factors such as the diet of the mother or the administration of drugs, and the specificity of some of these proteins. Despite the large number of studies performed for years, there is still some uncertainty about the different potentials of milk proteins and of their derivatives. Some of the aspects were not analysed in that paper, for instance the possible appearance in the stomach (during mild casein hydrolysis) of a glycomacropeptide, a substance capable of inhibiting the secretion of gastrin during digestion.

A particular aspect of the nutritional role of milk proteins was analysed in the paper of West & Beynen. It concerns the elevating effect of milk protein on plasma cholesterol and its consequences for coronary heart diseases. The studies made in different animal species show that the nature of dietary proteins may affect the concentration of cholesterol in blood plasma and the severity of arterial lesions. In rabbits, animal proteins (casein) in the diet elevated concentrations of plasma cholesterol, whereas plant proteins (soya bean) reduced them. The same results were found in rats, hamsters, pigs and rhesus monkeys. However this was not so for mice, Guinea pigs, chickens and calves. In similar experiments in man, there was no significant difference in plasma cholesterol with these two proteins. Thus, it does not seem to be necessary to change the nature of proteins in the diet of man to prevent coronary heart disease.

The last point of this session concerns the utilization of milk proteins by sportsmen. Professor Lemon emphasized the increase in exercise energy provided mainly by carbohydrate, fat being of minor importance. The contribution of protein to exercise energy has long been considered minimal, as there was no storage form of protein in the body and as urinary excretion of urea was unchanged after exercise. More recent studies, however, have shown an increased utilization of protein or amino acids with exercise. Thus athletes need protein to produce new tissues and to restore those damaged by exercise. The protein requirement as determined for sedentary individuals is not sufficient for athletes and is even less so when other requirements, for instance for growth, have to be satisfied. However too high a protein supply is unnecessary and can be detrimental. An adequate amount of protein in the diet is about 1.8-2.0 g per kilogram bodyweight per day in the athlete. The last paper of Professor Drăgan et al. demonstrates that an extra addition of milk proteins to a normal diet of top sportsmen leads to a significant improvement in physical condition and thus to a better sports performance, even when compared to a reference top level performance.

Innovative uses for milk proteins: technological and nutritional aspects

C

Recent developments in the utilization of milk proteins in dairy products

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Summary

Recent developments in dairy technology influencing the utilization of milk proteins in dairy products are discussed, with comments on recombination, ultrafiltration and utilization of whey protein, casein and caseinates. The use of membrane processes is considered the most interesting development, offering a number of interesting new ways of utilizing milk proteins, especially whey proteins. The making of cheese from milk concentrated by ultrafiltration receives special attention.

CAB descriptors: dairy products, milk protein, ultrafiltration, whey protein.

Introduction

For utilization of milk proteins, the most important dairy product has for many years been cheese. In many ways, it is still the main protein product, although fermented and preserved milk products have gained in importance.

Statistics of world-wide utilization of milk proteins in different products are hardly available. But I would like to indicate the approximate position by showing how milk proteins are utilized in different dairy products in Denmark.

Cheese and casein products are the major products as sources of protein and the utilization of milk proteins for this purpose has almost doubled in twenty years. The second largest group of products is preserved milk. The utilization of milk proteins in this kind of products has more than tripled in 20 years. The consumption of liquid and cultured milk products shows a more moderate increase. The increase in the total utilization of milk proteins for human consumption has been possible by a corresponding decrease in the amount of milk proteins for animal feeding. In the past 20 years this application has decreased from 59 to 16% of the total milk protein.

This paper discusses recent developments in dairy technology influencing the utilization of milk proteins in dairy products and comments on recombination, ultrafiltration and utilization of whey protein, casein and caseinates.

Recombination

From the Danish statistics, the fastest expanding sector seems to be preserved milk products. Closer examination of the trade figures reveals that products meant for recombination are expanding most. The estimates for 1978-1981 covering the whole world show an increase of about 17% annually, and about 14% of the world's production of milk powder is now estimated to be utilized in recombined dairy products.

Recombined milk and dairy products are usually manufactured by mixing butterfat, solids-not-fat and water in order to establish a specified ratio between fat and solids-not-fat and between dry matter and water in the final product.

The technology of the recombining process is well established, and the concern is therefore nowadays more for the quality of the raw materials, as the quality of the final recombined products depends closely on chemical composition, physical properties and microbial quality of the raw materials used.

Recombined liquid milk and fermented milk products are manufactured from traditional milk powder products, but there is also big potential for milk powder in the manufacture of cheese products. Some soft cheeses and cheese-like products can be manufactured without problems directly from a mixture of skim-milk powder, butterfat, water, starter culture and rennet. But it is more difficult by a traditional cheese manufacturing technology to produce hard or semi-hard cheeses from recombined milk mainly because the coagulation ability of the milk and the synaeresis of the curd are strongly reduced.

It may, however, be possible to overcome some of these problems. At the Danish Government Research Institute for Dairy Industry, we have recently had some promising experiences with manufacture of a traditional type of semi-hard cheese (Danbo) from recombined milk. The milk powder used was low-heat skim-milk powder, which was reconstituted and mixed with cream the day before cheese manufacture in order to give both the milk proteins and the salts of the milk time to equilibrate. Sufficiently short coagulation time and almost the same synaeretic characteristics as in normal milk were obtained by culturing the milk first. When the milk was adjusted in this way, only few changes in technique of manufacture were necessary, and the manufactured cheeses had a water content and a culturing process equivalent to what is characteristic for normal cheeses. It is often stated that the ripening of cheeses manufactured from milk powder is slow, and that both texture and consistency are atypical for the sort of cheeses in question; our experiments showed, however, that the experimental cheeses were identical with cheeses manufactured in the traditional way.

The technology of manufacturing cheese from recombined milk is at this stage far from complete but progress has been made and further development is undoubtedly possible.

Concerning other types of milk powder that could be used for recombination purposes, buttermilk powder should be mentioned. Buttermilk powder of the sweet type is suitable for many liquid and fermented recombined dairy products, such as whole milk, coffee cream, chocolate milk, yoghurt and ice-cream mix, where it can constitute 10-25% of the solids-not-fat. Buttermilk powder has a positive effect on the organoleptic quality of the final product and on the re-emulsification rate of the fat. It also increases physical stability of cultured products and so minimizes the whey synaeresis of the coagulum.

The advantages are due to the high content of phospholipids in buttermilk powder. However this makes the product susceptible to fat oxidation, which causes off-flavours in the recombined products. The keeping quality may also be lowered by lipolysis by enzymes not destroyed during heat treatment of the milk. This might be a problem especially if the powder is of the low-heat type preferred for many purposes. The only way to avoid lipolysis in low-heat products is to improve the quality of the raw materials used for the production of the powder.

Ultrafiltration

The most interesting recent technical development for milk proteins is the use of membrane processes, mainly ultrafiltration. The appearance of ultrafiltration equipment suitable for the production of food has provided the dairy industry with some new ways of utilizing milk proteins.

Ultrafiltration is a process, in which components are separated through a membrane according to molecular size (Fig. 1). For milk, this means that fat, proteins and minerals associated with the proteins are retained, whereas lactose and soluble minerals pass through the membrane. The retentate is thus a concentrate of protein and fat, and the permeate is a solution of lactose and minerals.

The protein content of milk varies through the season and with breed, and individual variations occur as well, although the variations in protein content are far less than the variations in fat content. Protein is a component of great value, and it might therefore be of interest to standardize the protein content in fluid milk, as can

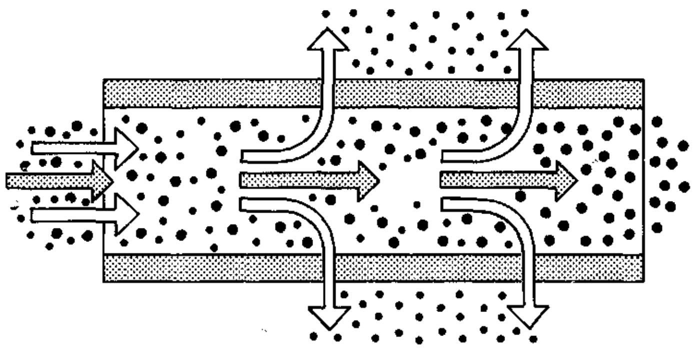

Fig. 1. Ultrafiltration through a semipermeable membrane.

be done by ultrafiltration. At our institute in Denmark, we have tried to vary the protein content of fluid milk within wide limits and found that variations from 2 to 6.5% protein do not influence the taste of whole milk and half-skim milk, while the possible variations were smaller in skim milk since there is no fat to mask the lack of protein. As fas as I know, protein content in liquid milk is not standardized commercially today, but it is an interesting possibility.

Another reason for introducing ultrafiltration in the production of dairy products is that it normally increases yield (of the product divided by input of milk) over the traditional production method, in that more whey protein is retained in the product, which is a nutritional and an economic advantage.

If ultrafiltration is introduced in the production of a traditional dairy product, the result will be a product with a slightly different composition, and it is therefore necessary to change the production process to avoid changes in the quality of the final product.

Ultrafiltration in quark production

This can be illustrated by some remarks on the production of quark, which is a cultured dairy product with a high protein content.

The traditional method of production is to separate whey from the curd at pH about 4.6, so that a lot of minerals dissolved at the low pH are removed with the whey. With the new technique, the first approach was to acidify skim milk to pH 5.7-6.0, then to concentrate by a factor 4 with ultrafiltration (Fig. 2). After this, heat was applied to the retentate, and it was fermented to pH 4.7-4.8. The product has a pleasing though somewhat acid taste in the first few days after the production, but within 2 weeks it develops an extremely unpleasant off-flavour. Probably this is due to the higher mineral content in the retentate, which means a higher buffer capacity and a higher lactic acid production before fermentation stops. The result will be a higher bacterial count and thus a higher concentration of bacterial enzymes, which will decompose more of the protein in the final product.

With this in mind, the obvious solution should be to ultrafilter at pH 4.5-4.6. When this was suggested about ten years ago it was not possible to run the process on the ultrafiltration units available at that time. Nowadays high-concentration modules are available and ultrafiltration at pH 4.5-4.6 has been introduced. By this method it is possible to make an excellent quark with a shelf-life as long or longer than that of traditional product. By now, the first industrial plants have been working with good results for some time, and there seems little reason to doubt that the problem has finally been solved.

Ultrafiltration in ymer production

Another fermented milk product I would like to mention is ymer. This is a special Danish fermented milk product with a protein content about twice that in normal milk. The traditional product is concentrated by whey drainage so that much of the whey protein is lost. With ultrafiltration, however, all whey protein is retained in the product and the yield is increased proportionally.

Today nearly all of this fermented product produced in Denmark, 35 000 tonnes per year, is manufactured by ultrafiltration; the only problem, similar to that for quark, has been a tendency to develop a bitter taste during storage. Culturing of the milk beforehand, choice of the right cultures and the proper culturing conditions have, however, now solved the problem.

Ultrafiltration in yoghurt production

Ultrafiltration can also be used in the production of yoghurt. The purpose is to con-

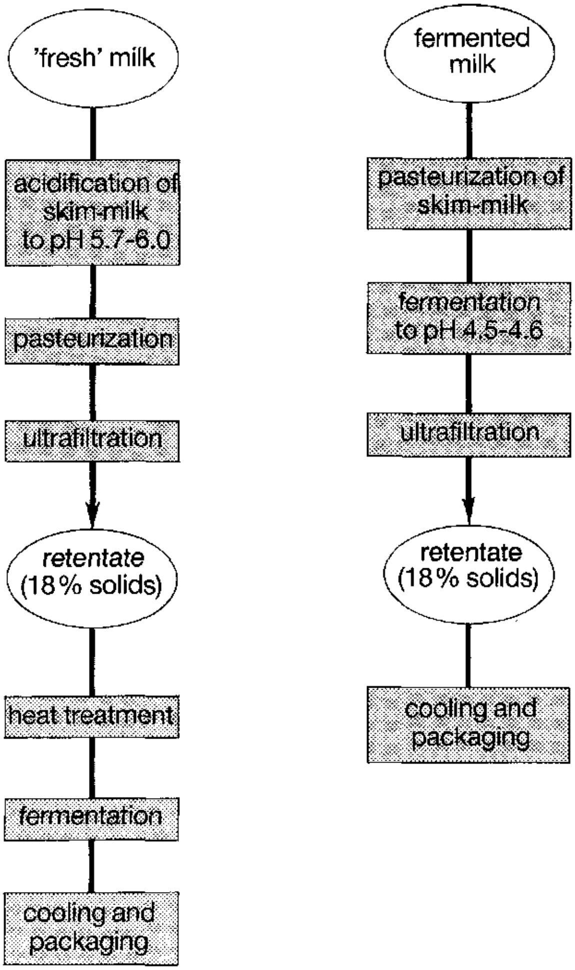

Fig. 2. Production of quark with ultrafiltration.

centrate the milk by about 10% before processing in order to stabilize the consistency of the cultured product.

Ultrafiltration in cheese production

The process of ultrafiltration is interesting for manufacture of cheese. Although a lot of research has been done on making cheese from ultrafiltered milk, the exploitation of the scientific knowledge is still in its infancy in most countries, though not Denmark.

In the early seventies, production of Feta cheese was very low in Denmark (Fig. 3). At that time, Danbo, a cheese with round eyes, was the cheese produced in largest amounts. Within less than a decade, this picture has changed completely. The production of Danbo (and other traditional Danish cheeses as well) has remained fairly constant, while the production of Feta has increased rapidly. At present, Feta accounts for about 35% of Danish cheese production – noteworthy is that some 90% of Feta is produced with ultrafiltration.

While Feta is still the only cheese produced in large amounts from milk concentrated by ultrafiltration in Denmark, others are expected to follow in the near future since the technique for some other cheeses is almost worked out and the first industrial or semi-industrial plants are constructed.

Ultrafiltered Feta is produced by two different groups of techniques (Figures 4 and 5). The product of the first-generation process as implemented in the mid 1970s has the taste and consistency of Feta cheese but lacks holes. Nevertheless, it has been produced and sold in large amounts with a yield increase of about 30%. Part of the reason for this high yield increase is that the ultrafiltered Feta cheese acquires the desired consistency at a higher water content than the traditional cheese.

The lack of holes in the first generation of ultrafiltered Feta cheese was an obstacle

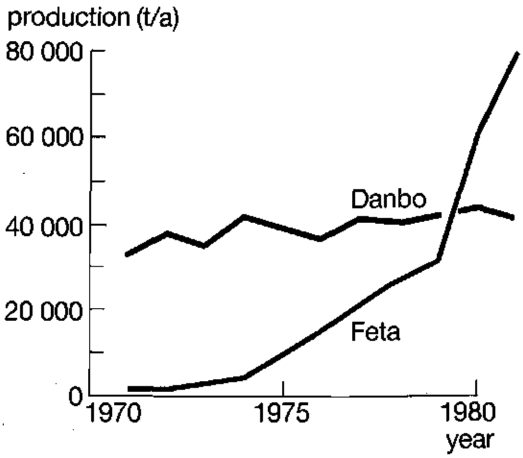

Fig. 3. Production of Feta and Danbo cheese in Denmark.

in some markets. In Greece, the product could not be sold at all or only at a price much lower than of the traditional product.

The obvious solution to this problem was to make cheese grains from the coagulated retentate and then fuse the grains as in the traditional process. Unfortunately it was not possible to obtain the desirable structure and consistency if the milk was concentrated to the solids content of the cheese as in the first-generation process. This means that we have to accept some whey drainage in the process and it is therefore important to use a rather high heat treatment in order to keep whey proteins in the curd and thus assure a reasonable yield increase (Fig. 5).

From this process emerges a product that is virtually indistinguishable from the traditional product. The yield increase is about 14% on solids basis over the traditional process.

Technologically production by first and second generation processes appears fairly straight forward. But variations are necessary in order to satisfy the demands of various markets. A great deal of know-how within this field is available today.

As Feta cheese contains about 60% water and the product is often exported to distant markets, it has been suggested to make and export a retentate in powder form with the same composition of solids as the final cheese. The transport savings would be significant, but so far no one has put such a process into operation.

At our institue, one of the main concerns in recent years has been to work out an ultrafiltration procedure for the production of Danbo cheese. Danbo has a solids content of about 55%. To obtain this, we have concentrated whole milk by a factor 2 by ultrafiltration. After addition of starter, the retentate is renneted and the curd is cut when a suitable firmness of the coagulum is obtained. After this follows a fairly traditional cheesemaking process in a vat, involving stirring, scalding and washing. In this way, it has been possible to obtain an acceptable product, but the yield increase probably does not exceed 1-2% because of the large amount of whey that has still to be expelled from the curd.

Development now seems to be directed to making semi-hard cheese from milk that is concentrated 4-5 times ultrafiltration. In this way, yield is increased significantly, but it is necessary to introduce new equipment for the coagulation and cutting, as it would not be possible to cut the coagulum in a cheese vat. These problems have not been solved satisfactorily. A combination of ultrafiltration and evaporation has been tried in the Netherlands for the production of Gouda. The results obtained showed that the ripening apparently proceeded somewhat slower with ultrafiltration than with the traditional process.

A raw material suitable for the production of processed cheese could be made with a combination of ultrafiltration and evaporation. The product often named 'Cheese Base' may have a solids content of more than 60%.

An implementation of a cheese-base process is shown in Figure 6. It is important to select suitable conditions for the ultrafiltration and diafiltration, because it is necessary to adjust the lactose concentration in order to get the correct pH in the final cheese. The factor of concentration by ultrafiltration has to be selected so that the intermediate product can be handled, and so that the fat emulsion is not damaged dur-

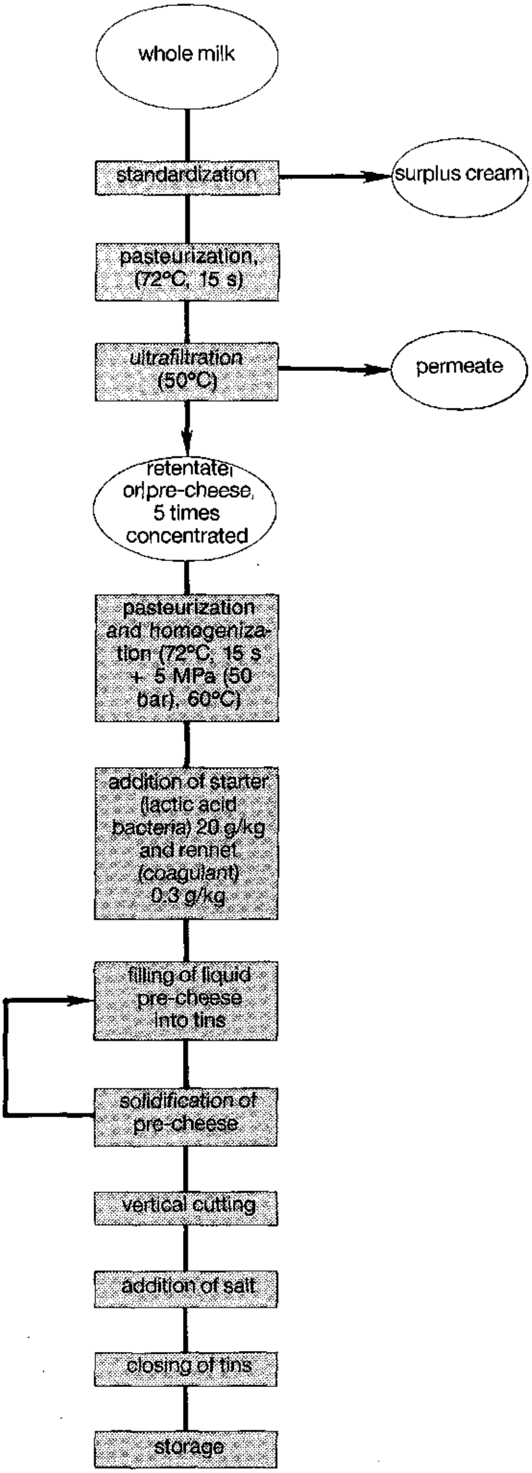

Fig. 4. First-generation process for production of ultrafiltration cheese.

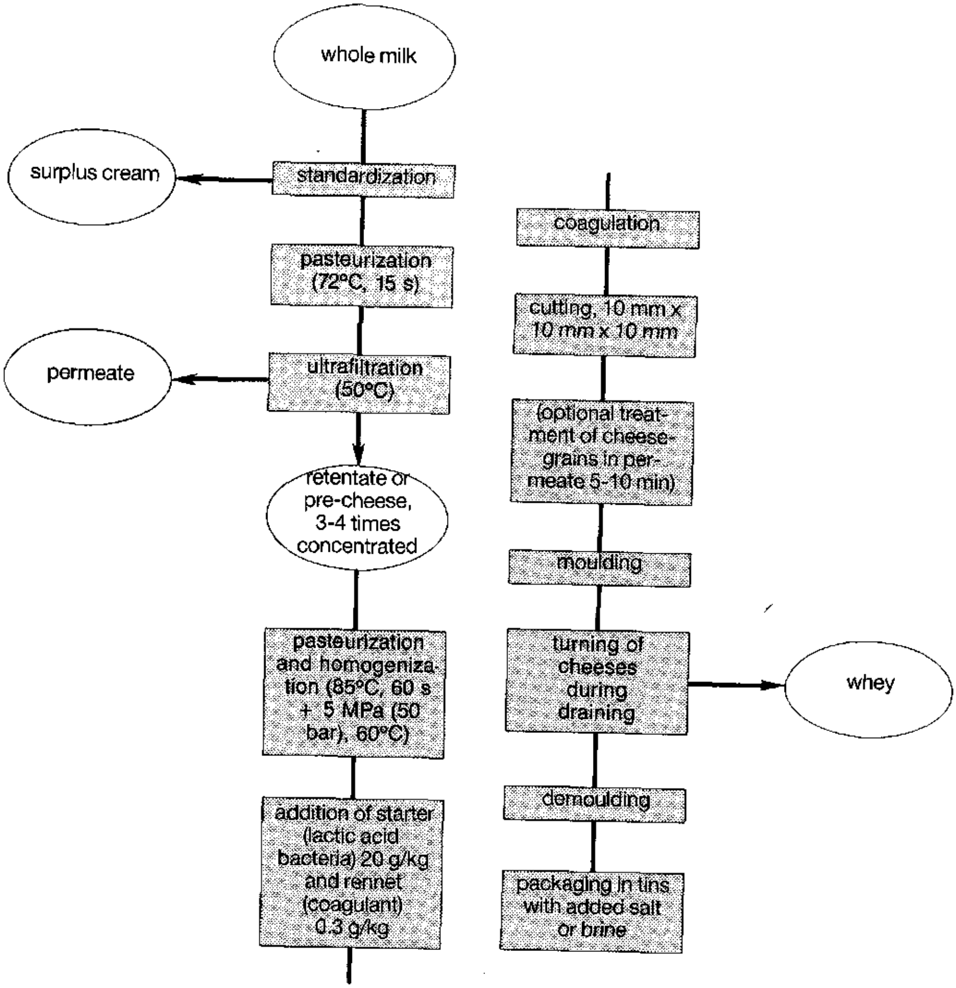

Fig. 5. Second-generation process for production of ultrafiltration cheese.

ing processing. Before fermentation, salt is added. A scrapted-surface evaporator is used for evaporation.

Although cheese base was originally intended as a substitute for barrel cheese in the production of processed cheese, it might well become a product in its own right. If the product is aged for a few months, it acquires an acceptable cheese-like flavour.

The yield increase obtained in the cheese-base process is around 18%.

Whey protein, casein and caseinates

The main reason for introducing ultrafiltration in dairy processing was to increase the utilization of milk proteins by incorporating whey proteins into traditional dairy products. However ultrafiltration can also be employed for isolation of whey proteins

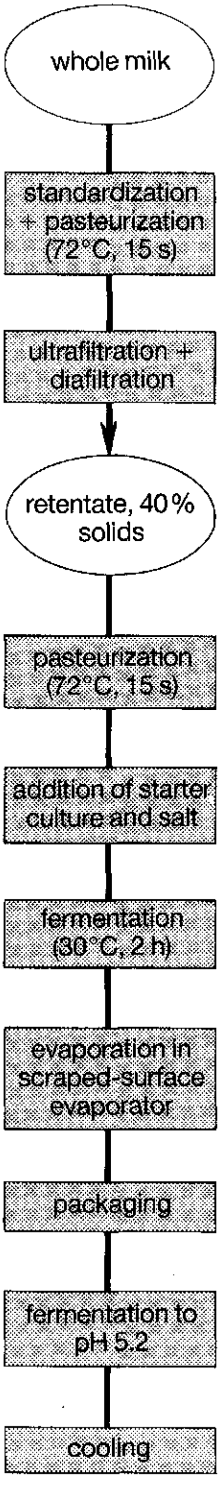

Fig. 6. Process for production of cheese base.

from whey of traditional cheesemaking. Such a whey plant is operated in Denmark with a capacity to process one million kilograms of whey per day into whey protein powders and lactose by a combination of ultrafiltration, evaporation and spray-drying.

It is, of course, also possible to produce whey protein concentrates with protein content from about 30 to 80 or 90%, depending on the application. These products are mainly used as ingredients in non-dairy products, but also to some extent in dairy products like ice cream and baby foods.

The replacement of solids-not-fat by a concentrate containing about 35% whey protein results in a satisfactory quality of ice cream. Some criteria of the quality of ice cream are the viscosity of the ice-cream mix, the overrun of the frozen mix compared to unfrozen mix, the amount of out-churned butterfat, the melting time, the storage stability, and, of course, the taste. The use of whey protein concentrate results in a mix of lower viscosity, a faster melting of the ice and a slightly sweeter and more caramel-like taste. It is not advisable to replace all solids-not-fat by whey protein concentrate because the structure of the frozen mix then becomes looser.

There seems to be an increasing interest for the use of casein and caseinates in food manufacture mainly for their functional properties, including water binding, fat binding, emulsification and viscosity. Calcium caseinate might be used in cheese manufacture. It forms stable colloidal dispersions when added to cheese milk. It affects the coagulation of the milk, which becomes much slower, but it seems to increase the transfer of fat and protein from the milk to the cheese and thus slightly increases the yield of the cheese process. Addition of calcium caseinate seems also to have a positive influence on the consistency and texture of the cheese.

Conclusions

For some years, technological development has moved in the direction of incorporating more whey protein into traditional dairy products.

Cheese production based on ultrafiltration is a certain prospect and it will represent a major advance in the utilization of the nutritionally valuable whey protein.

In the search for new markets for dairy products, the recombining process plays a major role. We need to look more closely at ways of designing new recombined products. Most of the necessary know-how is available; it is more a question of imagination and innovation.

The future development of milk-protein products is very likely to include such processes as texturization, and chemical and enzymatic modification by which the functional properties can be altered completely. At present, it is very difficult to foresee how far such developments will affect the utilization of milk proteins in dairy products and other food products.

From Atholl Brose to cream liqueurs: development of alcoholic milk drinks stabilized with trisodium caseinate

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Summary

The industrial manufacture of cream liqueur resembling the old Scottish Atholl Brose is described. Special attention is paid to some defects that hinder the marketing of such a product, for instance fat separation and gelation. The technological measures to control these effects are described.

CAB descriptors: liqueurs, manufacture, defects, separation, gelation, fat emulsions. Additional descriptor: cream liqueur.

Introduction

Old Scottish recipes describe the preparation of a luxurious drink made from whisky and cream. The whisky was first steeped overnight with coarse oatmeal, which was subsequently filtered out by passage through fine cloth. The steeping process removed harshness from the raw spirit and imparted to it a delicious nutty flavour. As an added bonus, the oatmeal was cooked with salt and milk to make breakfast porridge. Meanwhile, the treated whisky was blended with cream and heather honey to yield Atholl Brose. This concoction has much to recommend it organoleptically but must be consumed within hours of preparation. On standing, the mixture separates into discrete cream-rich and alcohol layers and, on further storage, bacterial spoilage becomes a hazard. Some 15 years ago, an attempt was made in Scotland to produce a bottled Atholl Brose, but the product turned rancid on storage. At the time of development, the oatmeal contained large amounts of lipase – nowadays inactivated by steam treatment before milling – causing hydrolysis of the fat in the liqueur with consequent spoilage of the product.

In Australia, a drink concocted from full-cream evaporated milk, sugar, alcohol and flavouring has been popular for many years. The modern cream liqueur, developed largely in Ireland, represents a combination of traditional recipes for

Atholl Brose with the technology, particularly homogenization, used in producing evaporated milk. The resultant product did not exhibit creaming, but initially suffered from a less serious, but nevertheless commercially important, effect. When the liqueur was kept at high ambient temperatures, gel formation occurred as a result of calcium-induced aggregation. Once that problem was identified, a variety of solutions were devised and are now in widespread commercial use. This paper describes the manufacture of cream liqueur, the methods of avoiding fat-separation and gelation on storage and considers the effect of changes in composition on product quality. Finally, problems associated with the formulation of milk-based drinks of lower alchol content are briefly considered.

Manufacture of cream liqueurs

The composition of commercial cream liqueurs can vary widely (Table 1) but all can be produced by the methods shown schematically in Fig. 1. The techniques can be divided into two types, depending on whether the alcohol is added before (single-stage) or after homogenization (two-stage). There are practical advantages to employing the single-stage process and these are detailed in Banks et al. (1982). In most processes, the initial step is dissolving of sodium caseinate. To the solution, sugar, cream and stabilizer are then added. Some products contain synthetic emulsifier – added with the cream – but there is no evidence that such addition is either necessary or beneficial to product quality (Banks et al., 1983). At this point, the product may be homogenized and then spirit, colour and flavour are added to give the final product. However it is preferable that the entire mix is formulated before homogenization, filtering and bottling. Cream liqueurs with diverse compositions may be prepared by either route, but it is usual to maintain the alcohol content at about 140 g/kg to prevent bacterial spoilage.

Fat separation or creaming

The milk-fat globules in cream are 1-12 μm in diameter and are emulsified by natural phospholipid (Mulder & Walstra, 1974, p. 29). Because of the density

Table 1. Composition of cream liqueurs.

	Mass fraction (g/kg)	
	optimum	range
Milk fat	160	25 - 170
Added caseinate	33	20 - 35
Added sugar	190	150 - 250
Ethanol	140	120 - 140
Total solids	400	320 - 420

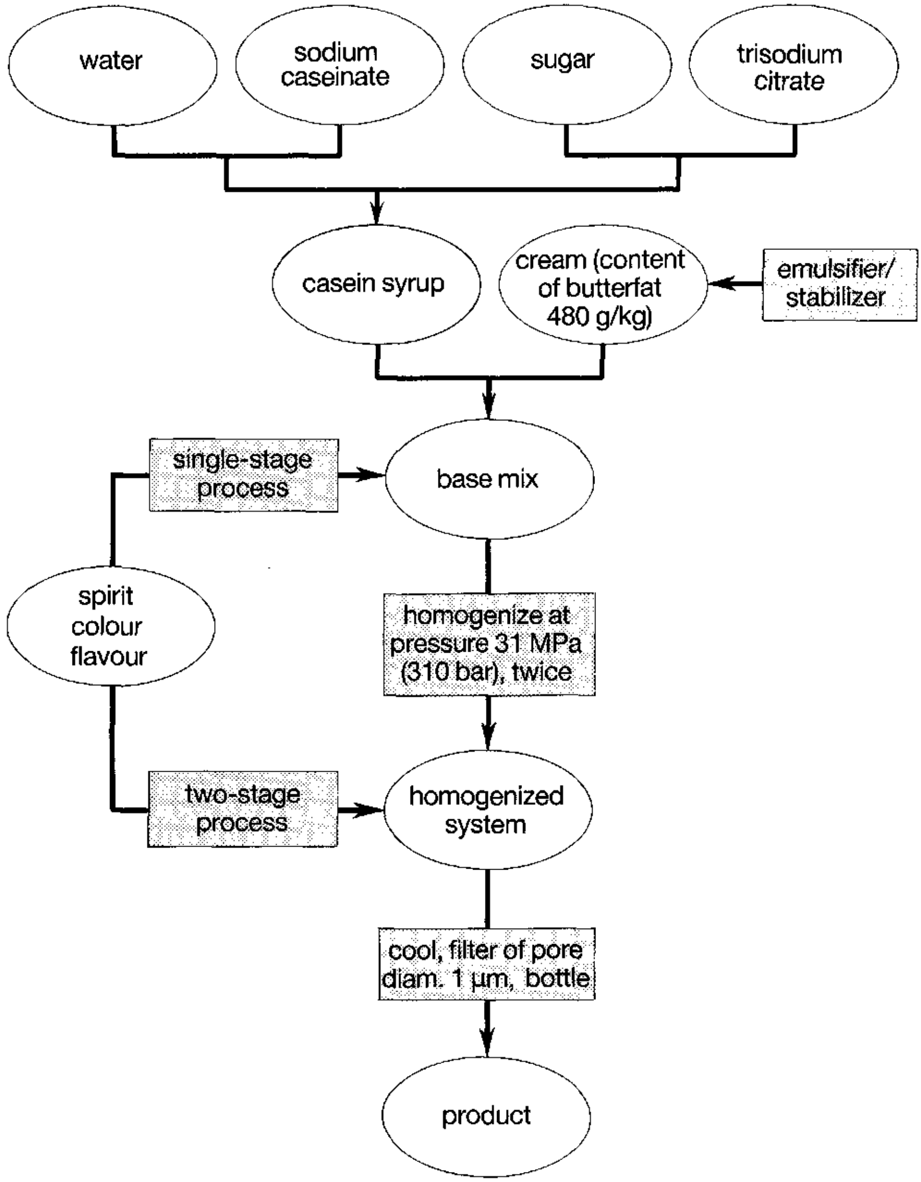

Fig. 1. Diagram of the manufacture of cream liqueur.

(volumic mass) difference between globules and milk serum, the fat rises to form a cream layer. The rate of creaming is effectively reduced if the size distribution of fat globules is reduced by homogenization: a four-fold reduction in creaming rate is achieved if the globule diameter is halved. However, during homogenization, a new fat surface is created and this must be stabilized by transfer of an emulsifier to the lipid-serum interface (Figure 2). Sodium caseinate has been found to fulfil this role

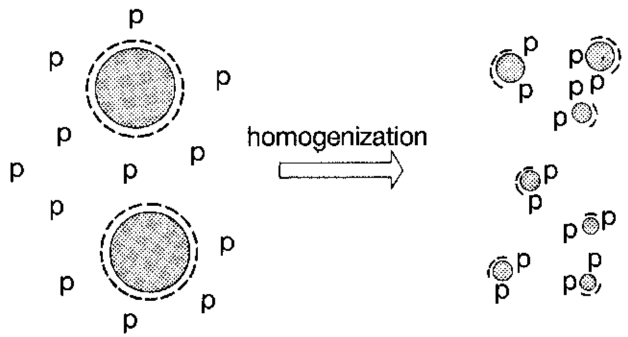

Fig. 2. Effect of homogenization on milk-fat globules. Blue, fat globules; -----, phospholipid; p, protein.

well. Alternative proteins and synthetic emulsifiers have been considered but have all shown some deficiency (Banks et al., 1983).

The effectiveness of homogenization in reducing fat-globule size depends on the temperature and pressure at which the operation is carried out and to a lesser extent on the type of homogenizer used (Mulder & Walstra, 1974, p. 169-175; Kessler, 1981, p. 119-138). Most research workers who have studies homogenization have estimated the mean globule size of the distribution of fat globules. We, however, consider that for cream liqueurs a more appropriate measure is the proportion of fat globules greater than 0.84 μm (Banks et al., 1982). This measure of effectiveness of homogenization correlates with the rate of creaming of liqueur during prolonged storage. Typical results showing the relation between homogenization pressure (at 55 °C) and this type of fat-globule size distribution are shown in Table 2. The liqueur was made by the single-stage process and contained 160 g/kg and total solids 400 g/kg. We have found that if 99.5% of the fat globules in liqueur are of diameter less than 0.84 μm, creaming is not observed during storage for up to 3 years at ambient temperature (15 °C).

Table 2. Effect of increasing homogenization pressure on the distribution of large fat globules in cream liqueur (1 MPa = 10 bar).

	Particle size distribution (%)				
	<0.5 μm	0.5-0.7 μm	0.7-0.9μm	0.9-1.25 μm	>1.25 μm
Pressure (MPa)					
13.8	82.9	2.5	3.9	6.2	4.5
20.7	90.3	1.7	2.3	3.4	2.3
31.0	95.8	0.8	0.9	1.3	1.2
41.4	96.7	0.5	0.6	1.0	1.2
31.1 (repeated)	99.5	0.2	0.0	0.0	0.0

Nevertheless, gelation may occur in cream liqueurs that have been homogenized under ideal conditions but exposed to high temperatures (> 30 °C).

Calcium-induced aggregation

Gelation in cream liqueurs is manifest by the liqueur thickening. When agitated, this gel breaks up and wheys off. Gelation in liqueurs is usually the result of calcium-induced aggregation (Banks et al., 1981a, b). We have described earlier how the newly formed emulsion is stabilized by transfer of caseinate to the fat surface after homogenization. At high temperatures, this protein interacts with ionic calcium (from the cream) to form a three-dimensional network or gel. However the gelation process can be inhibited by removal of calcium – for example, by washing cream or substituting butter oil – or by sequestration with trisodium citrate or with the citric acid ester of glyceryl monostearate (Banks et al., 1981a, b; 1982; 1983). The efficiency of these treatments is similar in prolonging shelf-life (Table 3), for all result in a significant extension of product acceptability after storage at 45 °C.

Addition of trisodium citrate is a simple measure in processing and the recommended concentration of additive (10 mmol/l) corresponds to that normally found in milk (Holt & Muir, 1979). Although the citric acid ester of glyceryl monostearate is effective both as an emulsifier and a stabilizer, it confers a slightly greasy aftertaste to the liqueur (Banks et al., 1983) and must be masked by higher concentrations of flavour additives.

Although trisodium citrate is particularly effective at pH 6.8-7.0, the effectiveness is progressively lost at lower pH as a result of the repartition of the calcium phosphate complex in cream. For this reason, cream liqueurs show some flocculation when mixed with carbonated drinks. (In particularly acid conditions, the iso-electric point of the sodium caseinate may be attained with resultant massive precipitation.) It is possible to formulate highly buffered low-fat liqueurs that are more stable when mixed with carbonated drinks, but their organoleptic properties are usually poor.

Table 3. Effect of removing solutes or adding citrate on the shelf-life of cream liqueur at 45 °C.

	Shelf-life (days)	Apparent pH
System		
control	8	6.72
anhydrous milk fat	63	6.61
washed cream	78	6.82
trisodium citrate 10 mmol/l	74	6.80
citric acid ester of glyceryl monostearate[a]	71	6.95

a. Added at a mass ratio of 0.05; 1.0% caseinate only added.

Effect of composition on the properties of cream liqueur

Fat-to-protein ratio

The ratio of fat to protein in cream liqueur can vary widely and has been considered in detail elsewhere (Banks et al., 1983). Little difference in organoleptic properties has

Table 4. Effect of mass ratio of fat to protein on shelf-life of cream liqueur kept at 45 °C. All treatments had total solids 400 g/kg and fat 160 g/kg.

	Shelf-life	
	control	stabilized[a]
Fat to protein ratio[a]		
6.02	6	47
5.10	6	47
4.44	8	76

a. Stabilized with trisodium citrate at 5 mmol/l.

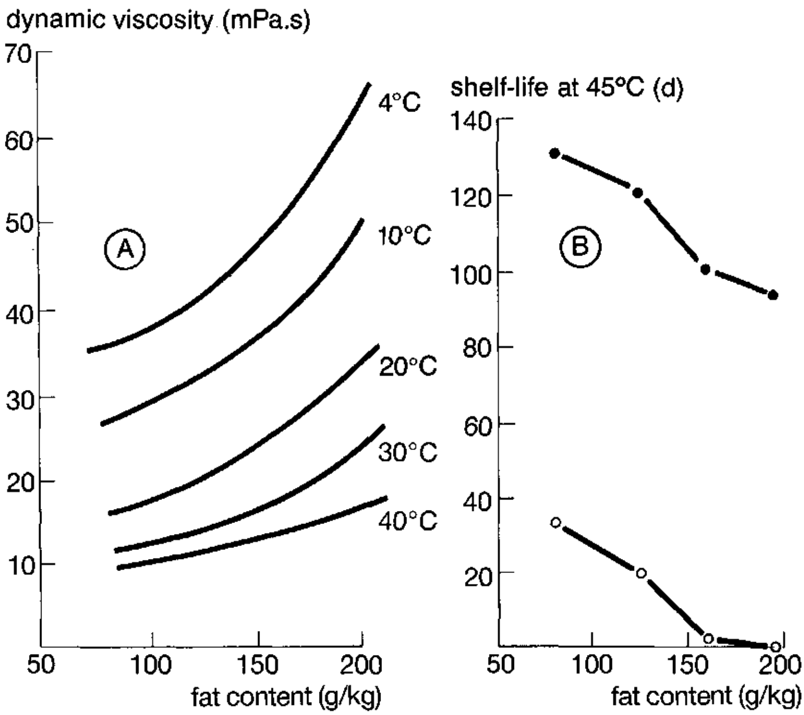

Fig. 3. Effect of fat content of cream liqueur. A. Viscosity. B. Shelf-life at 45 °C. ○, control; ●, trisodium citrate added at 10 mmol/l.

been observed when the mass ratio of fat to protein lay in the range 4.5-6.0 (Table 4). However there is an advantage in terms of overall stability if the ratio is at the lower end of this range.

Fat content

In contrast, if the fat-to-protein ratio is held constant and the fat content varied, large differences in mouthfeel are perceived even at constant total solids (Banks et al., 1981b). These differences are mainly associated with changes in viscosity (Figure 3A) but the perception of alcoholic strength also varies. As the fat content increased, trained tasters remarked that the liqueur was more alcoholic even though this compositional parameter was held constant at 140 g/kg. As the fat content changes, effects on shelf-life at 45 °C were also seen (Figure 3B). It was not feasible to make stable products containing more than 16% fat unless trisodium citrate was added.

Total solids

A similar effect was observed with mass fraction of total solids in standard cream liqueur between 375 and 450 g/kg (Banks et al., 1981b). Once more, small differences in composition resulted in large changes in viscosity (Figure 4A) and mouthfeel. The

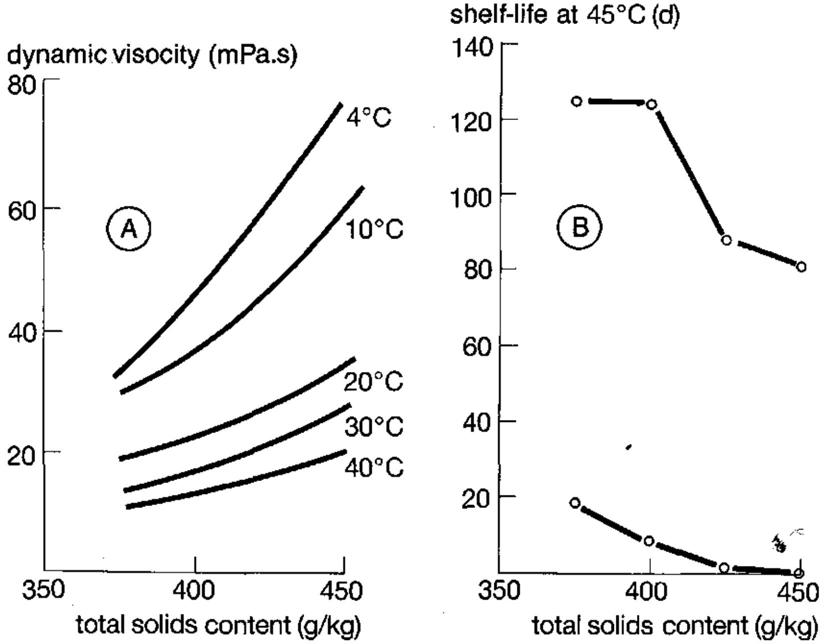

Fig. 4. Effect of varying the total solids content of cream liqueur. A. Viscosity. B. Shelf-life at 45 °C. ○, control; ●, concentration of added trisodium citrate (mmol/l).

Table 5. Shelf-life at 45 °C of cream liqueurs containing sucrose and sorbitol.

Mass fraction in carbohydrate (g/kg)		Shelf-life (d)	
sorbitol	sucrose	unstabilized	stabilized[a]
0	1000	7	35
250	750	10	35
500	500	35	35
750	250	35	35
1000	0	35	76

a. Stabilized with trisodium citrate at 10 mmol/l.

shelf-life at 45 °C was inversely related to the mass fraction of total solids (Figure 4B) but trisodium citrate was effective with contents of solids considered to assure commercially acceptable stability.

Carbohydrate component

Most cream liqueurs currently marketed contain sucrose added at a mass fraction of 0.2 (Table 1). This carbohydrate contributes sweetness and body to the liqueur, and, by reducing the water activity in the product, has a bacteriostatic effect. However liqueurs with different tastes can be produced by using sugars of various sweetness. Sorbital and glucose may be used to produce liqueurs which are less sweet than those based on sucrose (Banks et al., 1982) but we have also noted concomitant differences in the perception of alcoholic strength by trained tasters. Sorbitol also significantly increases shelf-life at 45 °C of liqueurs in which it is the predominant carbohydrate (Table 5). Sorbitol – a natural constituent of many fruits – may have a slight laxative effect for *some* individuals (Heaton et al., 1980). However for practical intakes of cream liqueurs (250 g), the physiological effects of the alcohol (and of the energy) also consumed are likely to have greater significance.

Discussion and conclusions

We have shown the principles by which a wide range of liqueurs based on cream and sodium caseinate can be formulated. The organoleptic properties can be tailored to a specific need by adjustment of content of fat and total solids, or of the type of the carbohydrate. Notwithstanding the almost infinite scope for change, two overriding principles must be observed. First, homogenization must be sufficient. Second, calcium-induced aggregation must be inhibited. Although several different methods of avoiding gelation are suggested, the addition of trisodium citrate is safe and simple.

Cream liqueurs currently marketed have an alcohol content about 140 g/kg (14%), which ensures bacteriostasis. Analyses in our laboratories have revealed that many of the organisms found in pasteurized cream survive in the liqueur. Spore-forming organisms are often found – albeit in small numbers – and, although outgrowth has never been encountered in either laboratory-produced or commercial products, the organisms can grow after dilution. The market is now well satiated by traditional cream liqueurs of the type described in this paper, and interest is turning to cocktail-like drinks based on milk and with an alcohol content of 50-100 g/kg (5-10%). Bacterial stability of such products requires some heat treatment. This can be achieved in many products by in-bottle pasteurization with no initial loss in emulsion stability. However, addition of citrate can be deleterious, for calcium citrate may precipitate after prolonged storage. Thus, the principles enunciated in this paper for traditional cream liqueurs should not be translated directly to the newer milk-based products. Long-term stability of such cocktails has to be considered on an individual basis and is the subject of on-going research in our laboratories.

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Texturizing milk proteins

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Summary

Conventional dairy products contribute a great deal to meeting the need for proteins in human diet, but the dairy industry has to ensure that its raw material, milk, also finds a place in new food products whose formulation is based on fat, protein and carbohydrate from various sources. So it is necessary to develop structurized food products based on milk, milk concentrates or milk powder. The composition of milk can readily be standardized in terms of the main constituents water, minerals, fat proteins and lactose, by simple separation techniques such as centrifugation, ultrafiltration and evaporation. For a desired composition, obtained by these separation techniques, structure can be given by means of well known procedures: enzymes, heat, extrusion. The structure-forming process for some types of product are dealt with in this paper.

CAB descriptors: milk protein, texturizing, enzymes, extrusion, heat treatment.

Introduction

Until about a hundred years ago, food was primarily based upon traditional agricultural produce, such as cereals, rice, fish, meat and milk. This produce was made into meals and products determined by cultural and social habits. Nowadays, however, technological developments make it possible to compose food by making use of the main nutritional food components, such as carbohydrates, fats and proteins. For these components, several traditional agricultural products can be used. For example, starch and sugar can be prepared from potatoes, rice, maize, wheat, sugar-beet and the like. The price and the relatively small overall differences in functionality determine which source of carbohydrate is used in manufactured foods. The same is true of fats: several sources of fat are being used as an ingredient for food products. We all know the history of substitutes for milk fat. Though milk fat is to everybody's liking because of its natural origin and delicious taste, its use is under threat because of its price.

We may wonder whether the great interchangeability, which exists between different sources of carbohydrates and edible fats, will in the long run also occur with proteins. These three components, today available via modern separation techniques, will surely make up the main part of our food of tomorrow, irrespective of the origin of the ingredients. What does this mean for milk as one of the most important traditional protein sources in our diet?

Milk proteins

Milk is a high-quality food consumed as such as well as through its conventional products, such as cheese, fermented milk and evaporated milk. All these products have gained a strong position in the food market and, together with meat and meat products, are traditionally the most important protein source in the human diet in the Western world. The question now is: What are the further possibilities of milk proteins apart from their role in traditional products? Could milk protein, outside its traditional use, aim for the same market as vegetable proteins? The answer will be determined by economic, legislative and technological factors. In fact, skim-milk powder and soya meal can be seen as competitors in the same market for certain applications. Both are based on agricultural produce, from which the fat has been removed. Skim-milk powder as such is highly suitable as food whereas soya meal, a by-product from production of vegetable oil, has been utilized as feed. In recent decades, however, the soya industry has been trying hard to upgrade soya proteins for use in food, whereas the surplus of milk production, as milk powder, is being downgraded to feed (Fig. 1).

How far these developments will continue depends on economic, political, legal and technological factors. In this contribution, I will restrict myself to technological aspects and opportunities.

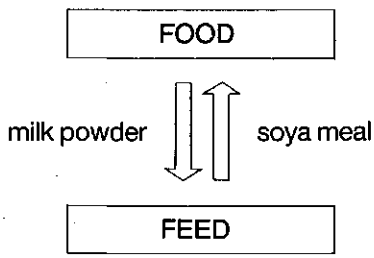

Fig. 1. Future development food proteins?

In upgrading soya proteins from feed to food, a rather complicated refining technology will have to be used to isolate the proteins and to eliminate, for example, the antinutritional factors. Antinutritional factors associated with bean proteins have been extensively reviewed by Professor Askar (1983). By contrast, milk powder holds no such antinutritional factors and is not suspect as a food component. However it will have to be presented in a convenient way. To transfer milk into new food products, simple existing technologies can be used to achieve a desired composition and texture (Fig. 2).

With existing separation techniques, milk can be separated and standardized in terms of its main components water, minerals, protein, fat and lactose. Membrane processes – available for industrial use in the last ten years – are an excellent way of separating proteins from a liquid such as milk. Every desired composition can be reached by the processes as indicated in Fig. 2.

When a certain composition has been obtained it then has to be transferred into a product by giving it structure and taste. The structure-forming properties of milk proteins can be used to give the final composition a certain structure, by rennet, heat or extrusion (English, 1981). Taste can be given to the structurized products in similar ways to those for present food products, such as fermentation, or adding spices and herbs, modification with enzymes and flavourings.

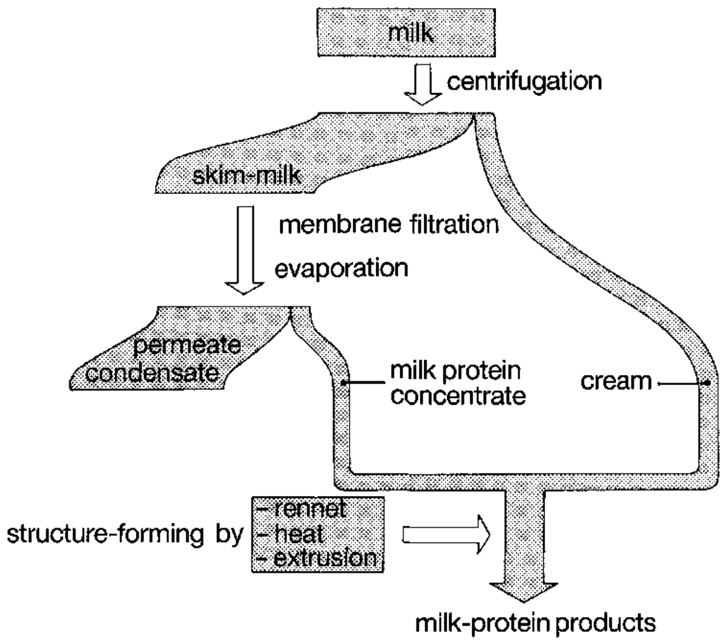

Fig. 2. Schematic process for milk-protein products.

The technological approach described is less complicated for milk-protein products than for products based on soya proteins. Other advantages of milk proteins are their blandness and the absence of antinutritional factors.

Price, nutritional value and quality will determine the success of new products based on milk protein taylored in structure and taste.

Products based on texturized milk proteins

Structure can be given to milk proteins by three principal routes using enzymes, heat or extrusion. All three structure-forming processes are being evaluated at our research institute NIZO. I will illustrate them briefly.

Structure by enzymes

A process for making semihard low-fat cheese by ultrafiltration has been developed at our institute by de Boer & Nooy (1980) (Figure 3). By different separation steps,

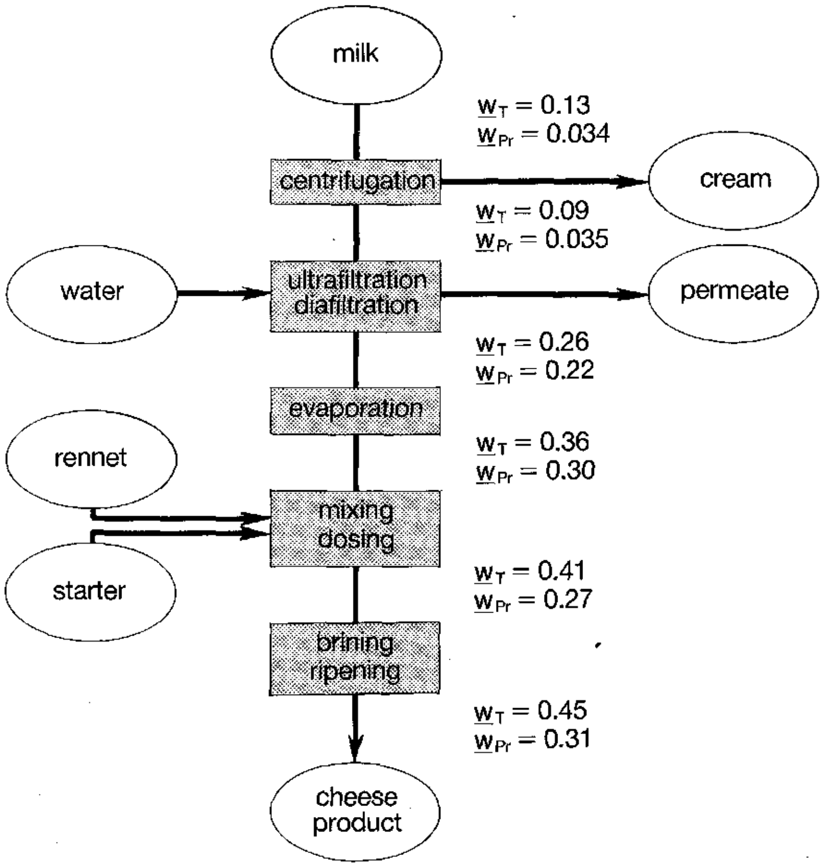

Fig. 3. Process for ultrafiltration-cheese product.

milk is converted into a viscous liquid with a composition comparable to that of the desired cheese product. When the required composition in terms of dry matter, protein, lactose and fat is reached, rennet and starter are added for structure formation and fermentation, respectively.

The composition of the final product can be varied within a relatively wide range; the figures given for dry matter and protein represent the semihard low-fat ultrafiltration-cheese currently being test-marketed. This process has substantial flexibility, not only in terms of composition but also in shape, size and addition of spices or herbs.

A characteristic difference of this ultrafiltration-cheese from traditional semihard cheese is its behaviour upon heating. Whereas traditional cheese melts, ultrafiltration-cheese either does not – or does so to a much smaller extent. This property makes it very suitable for application as the protein part of hot meals and snacks. Thick slices of ultrafiltration-cheese, as such or coated with bread crumbs and fried, go very well with a hot meal. It is also suitable for use in noodle dishes, toasted sandwiches, pizzas and the like.

The texture properties upon heating are due to the activity of the heat-settable whey proteins included in the cheese by ultrafiltration. The taste can be based on natural fermentation or a combination of spices, herbs and protein hydrolysates. Although first results look promising, a lot of work will still have to be done in developing the market.

Structure by heat setting

Another promising way of giving structure to milk proteins is by heat-setting. Whereas in ultrafiltration-cheesemaking, caseins are the structure-determining milk proteins in products with the inclusion of whey proteins, the reverse is true for heat-setting. Here whey proteins are primarily responsible for the structure of the product in which the caseins are enclosed. The type of structure we get depends on dry matter content, content of whey proteins in dry matter and the process used. Some preliminary work has been published by de Wit (1983) of our institute. A structure that can be sliced, spread or squeezed can be achieved by de Wit's system. These products are made of skim-milk solids, milk fat and added whey proteins. A rough composition is indicated, the remaining solids consist of lactose and salts from the milk.

The implementation of taste in such a product can be done along the same lines as mentioned for enzyme-induced structures with spices, herbs or protein hydrolysates.

Quite a lot of development work has still to be done in optimizing the products in texture, taste and cost. We are, however, convinced that milk solids can find application in new dairy-based products and thus can aim for the same market as soya proteins.

Structure by extrusion

Texturized food products, made by extrusion-cooking of carbohydrates as well as of proteins are commonly used in food processing. It is therefore logical that by analogy with soya proteins, work has also been carried out on texturizing milk proteins by extrusion-cooking (Markh et al., 1982; Poznánski et al., 1980; Szpendowski et al., 1983; Tuohy et al., 1979).

The results of preliminary work published so far show, however, that structure formation of milk proteins is rather different from that of soya proteins. So far, the possibilities have not yet been exploited in great depth; enzymic modification of the proteins, adjustment of the composition by ultrafiltration – such as salt balance, content of lactose, content of dry matter – and addition of other food components open many opportunities for the use of milk solids in new types of product. However we must let well defined marketing targets set the course when looking into technological possibilities.

For example, an interesting concept has been indicated by Russian research workers (Markh et al., 1982), who extruded a combination of milk-protein concentrates and wheat flour in the shape and appearance of rice grains. Such products resemble conventional food, having a nutritionally balanced composition in terms of proteins and carbohydrates. For application purposes, it is not necessary to isolate the milk proteins, but one should start off from skim-milk concentrates or skim-milk powder, either with or without modifications in composition, heat or enzymic treatment. But a lot of work still has to be done. Many applications for milk proteins have not yet been explored. We at NIZO have started work in this field and will contribute to future developments.

Final remarks and conclusion

Milk is traditionally converted into conventional dairy products, which have a strong position on the food market. These conventional dairy products contribute a great deal to the need for proteins in the human diet. However, over the years a great deal of food has been formulated based on the major nutritional components fat, protein and carbohydrates of various sources rather than on one single agricultural product. The dairy industry has to ensure that raw material, milk, also finds a place in the new food products. It will have to keep its place as a source of protein in food.

There are two approaches to this. The first is to isolate the milk proteins from milk and use them in various food formulations. The second is to make new products based on skim-milk concentrates without much purification.

The first approach has already gained a strong position in the market. The application of different types of caseinates and whey proteins, by their functional properties in several food formulations, is well known. The extent of use of technical ingredients in the different food formulations, however, is rather low, very often not more than a few percent. In the second approach, new products based on skim-milk concentrates present the opportunity for using a larger proportion of milk dry matter for food products.

It will be a challenge to exploit the new technologies of ultrafiltration followed by texturization for better utilization of skim-milk powder, the excess of which at present is being downgraded to feed. This challenge could be the start to a range of new dairy-based products. Price and quality, however, will determine the final result.

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Recombined and reconstructed dairy products: nutritional aspects and marketing

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Summary

The worldwide demand for milk products is increasing, but in developing countries the increase of local milk production is normally unable to cope with the drowing demand. Therefore recombined dairy products play a large part in milk supply in these countries. The marketing of recombined products is compared with that of retail milk powder. The setting up of a local recombined milk industry also offers a way of marketing a lot of other milk products. Some remarks are made about the nutritional value of recombined milk.

CAB descriptors: dairy products, developing countries, marketing, nutrition, recombination, reconstitution.

Introduction

Over the past 20 years, 3DC, of the Danish Dairy Federation has run recombination dairies in Kuwait and in Bahrain, and recently also in Jordan and Qatar. Consequently we have closely observed the spectacular development of the recombination industry.

Let me first explain the words recombination and reconstitution. Both processes include mixing of milk powder with water in order to obtain a liquid with the qualities of the original milk. During the recombination process, skim-milk powder and fat are mixed with water in the original proportions. During the reconstitution process, whole milk powder is mixed with water. There is no material difference between recombination and reconstitution. However traditionally and because skim-milk powder has better keeping qualities, skim-milk powder has been used in most dairies. So I shall only be using the term recombination in the following.

Though my subject includes both nutrition and marketing, I shall concentrate on marketing and leave other speakers to deal with details of nutrition.

Nutritional aspects

I shall limit myself to two important nutritional conditions for recombined products: first, the position of the milk as a food source containing large amounts of essential amino acids; secondly, the nutritional value of recombined milk compared with that of fresh milk.

Milk as a protein source

As a protein source, milk is especially important in countries where an effort is made to improve the population's state of nutrition, very often by encouraging a change in diet. Often resistance is found towards a change. However it will be possible to obtain a positive effect by promoting the consumption of milk as this is a product people like and traditionally consume.

A major contribution to nutrition is the milk protein rich in essential amino acids and so of higher biological value than most vegetable proteins.

In most developing countries, the diet's content of protein is acceptable and is similar to that in industrial countries, 10-12%. However energy intake is often minimal, so that proteins are used as an energy source, limiting their availability for building up enzymes and for tissue restructure.

Furthermore, cereals, especially wheat, maize and rice, are the staple food in many developing countries. They contribute up to 90% of the protein intake and are all rather low in essential amino acid lysine so that their biological value is low.

Animal proteins are rich on lysine, but the price of meat is usually so high that the need for animal proteins can only be partly met with meat. So milk comes into the picture as a strong competitor as a cheaper source of animal protein. For instance with the price relations between milk and meats prevailing in developing countries, the price of protein consumed in the form of milk is 60-100% of the price of protein consumed in the form of meat.

Therefore the best use of milk protein in the developing countries will be as a supplement to the cheaper vegetable proteins in order to exploit the milk protein's richness in essential amino acids. This will enhance the nutritional value of the total diet, as the milk proteins supplement the nutritionally poorer proteins in the cereals in a synergetic way, as this mixed diet is of higher nutritional value than the sum of the individual components. Consequently inclusion of milk products can improve the diet in developing countries.

Recombined milk compared to fresh milk

The contents of fat, protein, milk sugar and minerals in recombined milk are almost the same as in standardized fresh milk products.

The major deviation is found in content of vitamins, especially water-soluble vitamins, as the extra pasteurization and the powder-production process cause a loss (Table 1).

Table 1. Relative loss (%) in vitamin content in recombined milk compared to fresh milk with extra heat treatment and with spray-drying. Data from Renner (1977) and Thompson (1968).

	Pasteurization	Spray-drying	Aggregate
Vitamin			
thiamin	10	10	20
biotin	0	10	10
B-12	0	20	20
C	10	20	30

The vitamins B-12 and C, and thiamin and biotin are lost to a significant degree. The major loss is during drying, but more than 70% of the amount of vitamins most affected is recovered in the recombined products.

Marketing of recombined milk products

The part of the world that we deal with in recombination of milk is essentially South and Central America, Asia and Africa. They are mainly developing countries or newly industrialized countries, characterized by a large increase of population. Often the growth of population is larger than the rise in domestic food production and individual demand may even increase for some of the food articles in question.

Milk is a commodity for which local supply cannot meet an increasing demand. Growth in domestic production is bound to happen so slowly that it is long necessary to import milk products, often milk powder. In spite of an increasing milk production in these areas, import of milk powder has experienced a strong increase during the period 1971-1981. Noteworthy is the large increase in imports from 1975 to 1980.

Traditionally the imported milk powder has been distributed to the consumers as powder and only mixed with water just before consumption. This resulted in a relatively undifferentiated product that replaced only whole milk and no other products.

For many years, imported milk powder has been used for local production of condensed milk products, products which were traditionally imported. This had a double purpose: to reduce transport by the decreased water contents and to establish local processing industry.

Over the past 20 years a considerable increase in range of products has occurred, these products are produced from milk powder and especially during the past 10 years production of these products has experienced a rapid growth.

Products concerned

I have limited myself to the part of the recombination industry that produces the products, in Europe referred to as liquid milk products. It is not possible to make a

Table 2. Product range of Danish Bahrain Dairy Company, Manama, Bahrain, 1984. Sources: Product specifications for Danish Bahrain Dairy Company, 3DC.

	Number of flavours	Packaging size (l)
Product		
whole milk	1	22½, 1, ½
flavoured milk	4	22½, ¼
buttermilk	1	¼
yoghurt, stirred	5	⅕
yoghurt, plain-set	1	⅕
labneh, plain	2	⅕, ½
whipping cream	1	¼, 1
sour cream	1	¼
ice cream - basin	9	5, 1, ½
ice cream - other	9	cone, stick, cups

clear-cut distinction: quark products and ice cream are included in part: cheese and condensed products have been excluded.

As an example of the variety of products, Table 2 shows the range of products of the Danish Bahrain Dairy Company, a dairy of which 3DC is co-owner.

The range of products is similar to that found in most European countries.

A more representative picture of a range of products from a recombination dairy, the Danish Jordanian Dairy Company, of which 3DC is co-owner, is restricted to whole and flavoured milks, plain yoghurt, a quark-like product and a few ice cream varieties.

Marketing of recombined products

The major differences in marketing parameters of the recombination industry from the traditional export of retail milk powder are indicated in Table 3. They include price level, product properties and adaptation to local taste. The requirements on the distribution facilities are much stricter, and the promotion message tends to be more sophisticated for recombined products than for retail milk powder.

From the differences, we can draw out the requirements for expansion of recombination industries in many countries and for an increased market share over retail powder:

- positive trend in income
- improvement in recombination technology to suit local customs and preferences
- continuous development of infrastructure.

The fulfilment of these requirements favours the recombined products:

- it equalizes the importance of the price difference
- it allows for the production of more attractive products
- it diminishes the distribution problems and allows for the use of more sophisticated promotion.

Table 3. Major differences in marketing parameters between recombined milk products and retail milk powder.

	Recombined milk	Retail milk powder
Price	relatively high	relatively low
Product	– wide product range – single portions – harmonization with local tastes – perishable	– narrow product range – multiple portions – little harmonization with local tastes – imperishable
Distribution	heavy demands on: – frequency – conditions – space	less demands on: – frequency – conditions – space
Promotion	– easy to use – abundance of products – 'natural' form – locally produced – new product	– multiple portions – manufactured by experts – well proven product

Market size and potential

Evaluations of the size of the recombination industry suffer from the fact that the countries that have a recombination industry lack adequate statistical information. It is therefore a distinct advantage to follow the development in some of the best known markets and, speaking for 3DC, that means markets where we are involved in dairy production. An example of this is the change in the amount of powder used and in the purpose for which the powder has been used in the recombination in Kuwait and Jordan. There has been a continuous increase in the amount of milk powder used in the recombination industry.

Notable too is that a considerable and steady growth has also taken place in the consumption of retail milk powder. So recombined milk products seem to be a supplement to retail milk powder and seem to contribute to a more rapid increase in the consumption of milk powder.

In trying to evaluate the development in the production of recombined products in the whole world, problems are encountered in collection and reliability of data. With reservations for the accuracy of the following evaluation, an effort has been made to give a rough estimate of the size of the recombination industry world wide.

As basis for this estimate, 15 countries have been chosen – countries that in 1981 imported the largest amounts of milk powder – exclusive of internal trade in the European Community, and of trade in Spain and the Soviet Union. These countries were found, from various sources and cross-checks, to produce about 0.8×10^9 l recombined milk in 1978 and 1.3 in 1981. Assumed that these countries are representative in the proportion of powder being used for recombination, an estimate of the recombination industry for all powder-importing countries in 1981:

- production of milk for consumption by recombination processes 2.4×10^9 l
- proportion of the world's milk production 0.5%
- amount of milk powder used in recombination processes 240 000 t
- proportion of the world's trade in milk powder 13.5%
- rate of increase during the period 1978-1981 17% per year.

If this growth rate is continued until 1990, the amount of recombined milk products will be four times as much as now.

This production requires 10^6 t of powder per year, equivalent to about half the European Community's production of skim-milk powder in 1982.

Conclusion

There seems to be good prospects within the recombination industry and 3DC considers this an advantageous way of marketing milk products.

When establishing recombination dairies, the result is that large amounts of milk powder that would have been sold as bulk powder is converted into highly manufactured products, to be sold as competitive branded goods.

This results in a steady and stable export of milk powder and consequently an improved economy in production.

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Protein quantity and quality in infant feeding

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Summary

Proteins in human milk are compared with those of cow's milk. There is a substantial difference in the casein-whey ratio and the content of lactoferrin and lysozyme.

Probably not all the protein in human milk is nutritionally available for the infant.

The amino acid profiles of human milk and infant formulas in use today still differ significantly even when the latter have been adapted.

As to the whey protein content, the protein requirements of normal term and preterm infants are discussed. On some points current recommendations have to be re-evaluated. For infants with a very low birth-weight, attention is drawn to enriched human milk.

CAB descriptors: milk, human milk, infant feeding, protein, requirements.

Introduction

For centuries of human existence the main source of nutrition for the infant has been mother's milk.

Prior to the twentieth century most newborn infants did not survive unless breast milk could be provided. The first efforts of providing artificial feeding was focused on improving the bacteriological safety of cow's milk, since the major reason for the high mortality rate of artificially-fed infants was diarrhea caused by contaminated cow's milk. The first good analyses of milk protein came in the end of the century at which time the relatively low concentration of protein in human milk was established. This lead to further modifications of cow's milk such as reducing curd tension

1. The contribution of Professor Räihä is republished with permission from Rooth/Saugsted, 1984. The rise of perinatal medicine. Georg Thieme Verlag, Stuttgart.

in order to improve digestibility, lowering the protein level by dilution and the addition of sugar. Further refinements were made in milk formulas during the 1920s and 1930s but it was not until the second world war that comercially produced formulas became available.

The question related to the protein requirement of the newborn infant has been a controversial one among pediatricians around the world for most part of the century. There has been disagreement among nutritionists, pediatricians and among the industrialists who attempt to provide us with the formulas to feed our babies. In 1959 the distinguished American pediatrician Emmett Holt writes: 'In view of our ignorance, what is the best way to play safe as far as feeding protein to infants is concerned? Are we safer with 2 or with 3 gm per kilogram or more? I shall answer this question very simply by saying, I don't know and I don't know of anyone who does know' (Holt, 1959). The question is still, 25 years later, a controversial one.

With the increased survival of smaller and smaller pre-term infants the nutritional problems of today are becoming even more complex. There is growing awareness that nutrition early in life may exert significant consequences on later well-being. In this respect protein intake is of critical importance. The following discussion will deal with various new aspects of protein quantity and quality as they affect neonatal nutrition.

Human milk proteins

Much new information on the human milk proteins have accumulated during recent years. The protein content of human milk is often quoted as 1.2 g/100 ml when expressed as total nitrogen × 6.38 (Fomon, 1974). However, recent studies have shown that mature human milk from well-nourished mothers has a mean true protein content of only about 0.9 g/100 ml (Hambraeus, 1977; Räihä et al., 1976). All of this protein in human milk is probably not nutritionally available for the infant since recent studies indicate that secretory IgA, lactoferrin and lysozyme are resistant to proteolytic enzymes and the major part of these proteins are excreted unabsorbed (Räihä, b). Thus, the nutritionally available protein concentration of human milk may be as low as 0.6-0.7 g/100 ml.

The caseins represent a group of milk-specific proteins that are characterized by ester-bound phosphate, a high proline content, few or no cystine residues and low solubility at pH 4 to 5. They are present in the form of complex particles of micelles with calcium and inorganic phosphate. The primary function of caseins is nutritional, since they are readily attacked by proteases and serve as a source of amino acids as well as calcium and phosphorus (Jenness, 1979a).

In human milk, caseins account for only 18 to 20% of the total nitrogen content, having a concentration of only 0.25 g/100 ml (Hambraeus, 1977). Human caseins are electrophoretically heterogenous and the fractions are comparable with α, β and κ-caseins of cow's milk (Jenness, 1979b). β-Casein is the predominant casein in human milk, and its concentration is about half that of bovine milk. The phenylalanine and methionine content of human β-casein is different from that of bovine β-casein (Blanc, 1981). Furthermore, there are physiochemical differences between bovine and human caseins that affect curd formation, which in turn increase gastric emptying and intestinal transit time.

The concentrations of noncasein protein or whey proteins in human milk are presented in Table 1 (Hambraeus, 1977). When caseins are precipitated from milk by acid at pH of 4 to 5, the whey proteins remain.

These whey proteins represent more than 70% of the total proteins in human milk (Hambraeus, 1977). In human milk the whey proteins consist of five major components, α-lactalbumin, lactoferrin, lysozyme, the immunoglobulines and serum albumin. In addition a large number of other proteins are present in low concentration such as enzymes, growth modulators and hormones.

α-Lactalbumin is a milk protein which appears to be present in milk of all species that contain lactose. This protein is a part of the lactose- synthesizing system (Jennes, 1979a). It is the dominant whey protein in human milk. Lactoferrin is the second most abundant whey protein in human milk. It is present in bovine milk in only trace amounts. Lactoferrin is a milk-specific, iron-binding protein which is related to transferrin and consists of a single polypeptide chain (Bezkorovainy, 1977). In human

Table 1. Protein and non-protein composition of human milk and cow's milk (Hambraeus, 1977).

	Human milk g/100 ml	Percentage	Cow's milk g/100 ml	Percentage
Protein (g/100 ml)				
Total proteins	0.89	100	3.30	100
Caseins	0.25	35	2.60	79
Total whey proteins	0.64	65	0.70	21
α-lactalbumin	0.25	17	0.12	3.5
β-lactoglobulin	–	–	0.30	9.0
lactoferrin	0.17	17	trace	
serum-albumin	0.05	6	0.03	1.0
lysozyme	0.05	6	trace	
– IgA	0.10	11	0.003	3.0
– IgG	0.003		0.06	
– IgM	0.002		0.003	
– others	0.07	8	0.15	4.5
Non-protein nitrogen (mg N/100 ml)				
Total	50		28	
urea	25		13	
creatine nitrogen	3.7		0.9	
creatinine nitrogen	3.5		0.3	
uric acid nitrogen	0.5		0.8	
glucosamine	4.7		?	
α-amino nitrogen	13		4.8	
ammonia nitrogen	0.2		0.6	
other nitrogen components	?		7.4	

milk the iron saturation of lactoferrin is only 2-4% (Fransson & Lönnerdal, 1980), and it may play an important role in the process of iron absorption in the intestine in addition to its bacteriostatic effect. The lactoferrin concentration of milk has been found to be higher in iron-deficient women as compared with well-nourished mothers; thus, milk lactoferrin may be a means to protect the infant from such deficiency (Fransson, 1983). Lactoferrin may not be absorbed itself and its nutritional importance is thus questionable (Hambraeus, 1984). Human milk contains a much higher concentration of lysozyme than most other milks (Bezkorovainy, 1977). Lysozyme and human α-lactalbumin have identical amino acids at 49 positions and seem to be derived from a common evolutionary protein (Dayhoff, 1976). Lysozyme catalyses the hydrolysis of glycosidic bonds in the cell membrane of microorganisms and may function as an antibacterial agent in the gastrointestinal tract (McCelland et al., 1978). Furthermore lysozyme is resistant to many digestive enzymes and can pass through the digestive tract (Lönnerdal, 1984). Its nutritional importance thus may be limited. Bovine milk contains only trace amounts of lysozyme.

Both human and bovine milk contain a fairly constant concentration of serum albumin, about 50 mg/100 ml. Its role is mainly nutritional. Bovine serum albumin may produce hypersensitivity in the human.

Human milk contains the immunoglobulins IgG, IgM and secretory IgA (SIgA) and a little IgD and IgE. The dominating immunoglobulin is SIgA (Hanson, 1961). The ratio between milk and serum IgA is about 8, indicating a local synthesis of IgA. The milk SIgA antibodies are directed against a large number of antigens, often antigens found in the intestine such as food components and microorganisms. The infant will thus be provided with specialized antibodies for mucosal defence against the various microbes present in the same milieu as the mother, to which the newborn is exposed after birth (Hanson, 1961). SIgA is very stable at low pH and also resistant to the action of proteolytic enzymes and more than three-quarters of the ingested SIgA is excreted in the infants stool (Hanson et al., 1984; Ogra et al., 1977).

Human milk is characterized also by a high content of non-protein nitrogen (NPN), about 25% of the total nitrogen content. Urea is the major component of this fraction, comprising about 50%. Other components include creatinine, creatine, glucosamine and free amino acids (Fransson, 1983).

Formula proteins

Casein-predominant formulas are made with non-fat milk solids, a mixture of fats, carbohydrates, and vitamins and minerals are added. The newer, 'adapted' formulas, however, are made by mixing milk base with demineralized bovine whey protein in order to modify the proportions of whey proteins to caseins from the 18:82 ratio of bovine milk to the 60:40 of 70:30 ratio of whey-predominant human milk. Three different techniques are used to demineralize bovine milk whey protein for the use in infant formula: ion exchange, electrodialysis and ultrafiltration.

Ultra-filtration removes both minerals and lactose, and the true protein content of ultrafiltered whey is higher than that of demineralized whey since NPN is also lost through the membrane during ultrafiltration.

During the industrial manufacture and storage of formulas, the side chain of some protein bound amino acids can react chemically together or with other molecules present in the milk. The following reactions have been noted: protein to protein interactions, destruction of amino acids, and reaction of proteins with reducing sugars (Maillard reaction). The involved amino acids are lysine, methionine and tryptophan which all are essential. The two chemical reactions of any nutritional importance that can occur in milk are the Maillard reaction and, to a lesser degree the formation of lysino-alanine. The extent of the Maillard reaction during the processing and storage of proprietary formulas can be quantified by measuring the degree of lysine units which are 'blocked' using the furosine method which indicates the presence of lactose-lysine (Finot et al., 1981). About 5-15% of the lysine residues are blocked in infant formulas, so that this will not normally be of nutritional significance.

The amino acid composition of human and formula milk proteins have striking differences due to the characteristic amino acid compositions of caseins in relation to whey proteins. The amino acid profiles of human milk and infant formulas in use today still differ considerably, even when adapted to be whey-predominant (Table 2) (Järvenpää et al., 1982b).

Table 2. Concentration of protein, amino acid and taurine in human milk and formulas (Järvenpää et al., 1982b).

	Human milk	Formula 1.5 (60:40)	Formula 1.5 (18:82)
Protein (g/l)	9.6	15.0	15.0
Taurine and amino acids (mmol/l)			
taurine	26.6	1.9	0.8
glutamate	11.50	21.96	22.77
proline	8.36	12.34	14.25
leucine	7.97	13.34	12.04
aspartate	7.42	12.77	9.84
lysine	5.15	9.92	8.96
valine	4.66	8.71	8.20
serine	4.60	9.32	9.42
alanine	4.42	7.97	5.84
isoleucine	4.18	7.16	5.79
threonine	3.98	8.23	6.04
lycine	3.33	4.39	4.26
yrosine	3.26	4.19	5.08
henylalanine	3.07	4.54	5.02
arginine	2.32	2.98	3.62
cystine	2.01	1.90	1.07
histidine	1.57	2.38	2.58
methionine	1.07	2.28	1.81

The low cystine content of caseins results in a very low methionine/cystine ratio in human milk (1/2), as compared with bovine milk (3/1). A methionine/cystine ratio of less than 1 is seen only in vegetable proteins and in human whey proteins. In adapted and in unadapted infant formulas the ratio is modified from that of unprocessed bovine milk but is still greater than one. Another difference is the content of the phenolic amino acids, phenylalanine and tyrosine, which is much lower in whey proteins, and thus in human milk as compared with casein-predominant milk. Threonine has a high concentration in whey proteins (Järvenpää et al., 1982b).

The NPN of milk contains a number of free amino acids including glutamic acid, glycine, alanine, valine, leucine, aspatic acid, serine, threonine, proline and taurine. Glutamic acid is the predominant amino acid at a concentration of 170 μmoles/100 ml and taurine, which is almost absent from the milk of the dairy cow is the second most abundant amino acid in the NPN-fraction of human milk with a concentration of 30 μmoles/100 ml (Rassin et al., 1978). The technique used tot demineralize bovine milk whey protein will affect the NPN-fraction in an adapted formula. Ultrafiltration will remove most of the NPN-fraction, and there are also differences in whey preparations produced by electrodialysis and ion exchange. Thus, the taurine concentration in formulas can vary depending on the processing technique used, but it is never more than 10-15% of that of human milk (Rassin et al., 1978).

Protein requirements of the normal infant from birth to 6 months

It has been assumed on teleological grounds that the milk of a given species is best adapted to the nutrient requirements of its young; thus, it is generally agreed that a normal human infant breast fed by its healthy mother is the nutritional norm for the growth and development of such an infant. The milk must represent a compromise between the need to maintain optimal nutrient intake of the young and the need to minimize the nutritional drain of lactation on the female. Nutrient levels in milk, therefore, will meet, but not much exceed, the requirements of the offspring. As mentioned above, the mature breast milk from well-nourished mothers has a true protein content of only about 0.9 g per 100 ml (Räihä et al., 1976), although the individual variation of the protein concentration is fairly large (Hibberd et al., 1982). Due to the doubtful nutritional value of SIgA, lactoferrin and lysozyme the nutritionally-available protein in mature human milk, may be even less than 0.9 g per 100 ml and could be as low as about 0.7 grams per 100 ml.

Recommendations for feeding normal infants in Scandinavia stress the importance of breast feeding for up to 6 months of age. According to recent studies the intake *ad libitum* of breast fed infants decreases from 160-180 ml/kg/d during the first month to 120-130 ml/kg/d during the 3rd month and to 115 ml/kg/d during the 5th month (Butte et al., 1984; Hofvander et al., 1982). If the nutritionally-available protein content of mature human milk is accepted as 0.7 g/100 ml these intakes correspond to a protein consumption of 1.1-1.3 and 0.9 g/kg/d during the first and the third month of life only from breast milk. Supplementary foods, such as strained fruits and vegetables are usually introduced at 4 months and fish and meat mixes are introduced at 5 months. When such supplementary food are introduced during one feeding per day the protein intake is increased by about 0.8 g/kg/d resulting in a protein intake during the 5th month of about 1.6 g/kg/d. According to recent estimations using the factorial method it has been suggested that a term infant has a mean protein requirement of about 1.3 g/kg/d (Pohlandt & Kupferschmid, in press).

Our own studies have shown that term infants fed *ad libitum* from birth to three months with formula containing 1.5 g/100 ml of protein with a mean intake of 2.7 g/kg/d receive a protein load much in excess of their requirements when compared with breast-fed infants. Blood urea concentrations and the branched-chain amino acids, valine, isoleucine and leucine are significantly elevated in the formula-fed infants as compared with those breast-fed (Järvenpää et al., 1982a; Järvenpää et al., 1982b). These differences suggest that formulas now in common use provide a protein intake in excess of requirements during the first 3 months of life. Further studies have indicated that term infants fed with an adapted formula containing only 1.2 g/100 ml of protein with protein intakes of 1.5 to 1.7 g/kg/d have significantly lower blood urea nitrogen concentrations during the three first months of life when compared with infants fed an adapted formula containing 1.6 g/100 ml of protein, and a protein intake of 2.3 to 2.7 g/kg/d (Moro et al., 1984). No differences in growth rate of serum albumin concentration were found.

Follow-up formulas and milk cereals which are often used in Europe for infants between 3 to 6 months of age contain even higher protein concentrations (1.9 to 2.7 g/100 ml) than regular starting formulas. Infants fed such follow-up formulas in addition to supplementary foods during the 4th and 5th month also show evidence of an excessive protein load when compared with infants fed with human milk and the same schedule of supplementary food introduction (Borulf et al., 1984). It is thus evident that the current recommendations for protein intake in normal infants up to 6 months of age need to be re-evaluated (ESPGAN, 1977), especially with regard to protein intake. Infant feeding practices in different parts of the world vary considerably, and protein-rich supplementary foods may be introduced much earlier and would further increase the excess protein load and produce metabolic and renal overloading and perhaps irreversible mal-adaptations in the metabolic machinery resulting in later disease.

Thus, normal term infants should be fed breast milk for up to 6 months of age with the gradual introduction of supplementary foods during the fourth and fifth month. If formula is given the protein composition should be adjusted to supply approximately the pattern of amino acids found in breast milk and the protein quantity should not much exceed that supplied by adequate volumes of human milk.

Protein requirements of the low-birth-weight infant (LBW)

During the first half of the century human milk was used widely as the only nutrient of the premature infants who survived. However, in the late 1940s, Gordong and coworkers (Gordon et al., 1947) showed that preterm infants fed a skimmed cow's milk formula at 6 g of protein per kg per day gained weight more rapidly than those fed human milk. Subsequent studies (Omans et al., 1961; Young et al., 1950) supported Gordon's findings that infants fed intakes of between 4 and 8 g/kg/d of cow's milk protein gained weight better than infants fed less than 2.5 g/kg/d. As a result of these and other studies premature infants were fed formulas very high in protein concentration for many decades. Thus, Young and coworkers in 1950 (Young et al., 1950) write: 'Premature infants should be given 6 g protein per kg per day' and further, 'they should be given diets which contain enough protein and minerals to exceed their needs'. The question of how the quantity and quality of protein given affected the metabolism of the preterm infant was not investigated before the mid 1970s (Räihä et al., 1976).

There are three major considerations affecting the quantity and quality of protein to be given to a low-birth-weight baby. These are: requirements for normal growth and body composition, development of protein and amino acid metabolism, and renal function.

A number of different techniques have been used to estimate the requirements in adults, for example, nitrogen balance, body compositions, amino acid turnover, fractional nitrogen excretion, and calorimetry. The application of these methods to the problem of determining the protein requirement of the small preterm infant is very difficult, because the optimal rate at which preterm infants *ex utero* should grow and accumulate protein has yet to be determined.

The classical factorial method has been used to estimate protein requirements. The results suggest that the amount of protein in human milk and in many formulas designed for normal term babies is inadequate. The calculations assume that the *in utero* growth rate remains optimal *ex utero* and that the body composition of the developing fetus is adequately known. Recently, however, Pohlandt & Kupferschmid (in press) has revised the estimation of protein requirement by the factorial method and has thus achieved different results from those of Ziegler et al. According to Pohlandt's calculations the protein requirement is at its maximum at 29 to 31 weeks of gestation being appr. 2.7 g per kg body weight per day.

In any case, it is not sufficient merely to estimate protein requirements on the basis of theoretical calculations from *in utero* accumulation rates or to administer large quantities of protein in order to attain high weight gain in the immediate extrauterine environment. The biochemical immaturity of the human preterm infant makes him nutritionally very vulnerable, and the margin between an adequate protein intake and protein undernutrition or overnutrition with possible adverse effects is small. There is an incomplete development of several amino acid metabolic pathways in the newborn infant, especially in the very-low-birth-weight infant (Räihä, 1980). Thus, many of the amino acids previously thought to be nonessential, for example, cystine and taurine, may be essential, at least for the immature organism, and must be supplied in the diet. Also, amino acid catabolism is incomplete, and an administration of protein in quantities which exceed the needs for synthesis stress the infants metabolic machinery for disposing of excess nitrogen and results in hyperaminoacidemia, metabolic acidosis, hyperammonemia and high serum urea concentrations. Recent reviews have been published (Malloy & Gaull, 1979; Räihä, 1980). Few of the classic studies which showed that preterm infants gained weight better with high-protein cow's milk formulas than with human milk measured metabolic effects.

The question concerning the adequacy of human milk for the very-low-birth-weight (VLBW) infant still creates controversy in the pediatric literature (Tyson et al., 1983). There is reasonable agreement that moderately LBW infants (>31 weeks gestational age) thrive and achieve intrauterine growth rates on adequate volumes (185-200 ml/kg/d) of human milk (Davies, 1977; Järvenpää et al., 1983a; Järvenpää et al., 1983b), however, for VLBW-infants (<31 weeks and <1500 g) human milk alone may not be adequate and the nutrient intake most appropriate for the growth, development and health of these infants has yet to be defined.

As previously mentioned, the protein content of breast milk has usually been estimated tot 1.2 g/100 ml, however, today we know that the true protein of human milk is only 0.9 g/dl and nutritionally available protein may be even lower. The advisable protein intakes for the VLBW-infant, as estimated by the factorial method can thus, not be achieved with reasonable volume intakes of mature human milk. The minimum intake of 2.25 g/kg/d recommended by the American Academy of Pediatrics' Committee on Nutrition could, however, be achieved by feeding over 200 ml/kg/d. Intakes of 185 to 200 ml/kg/d are common practice, and there is evidence showing that moderately LBW-babies (31-36 weeks) achieve an intrauterine rate of weight gain without signs of metabolic stress (Davies, 1977; Järvenpää et al., 1983a; Järvenpää et al., 1983b) on such volumes of human milk. For the VLBW-infant this may however not be sufficient. Two recent reports suggest that VLBW-infants may benefit in terms of weight gain from preterm milk, presumably because of its somewhat higher protein content (Gross, 1981; Pearce & Buchanen, 1979). This interesting finding requires confirmation and further evaluation.

Formulas specially designed to meet the requirements of the VLBW-infant have been developed the last decade. These formulas usually have a higher protein content and also a somewhat higher caloric density than normal infant formulas. The protein varies from 1.8 to 2.4 g/100 ml and the caloric density from 75 to 81 kcal/100 ml.

Formulas specially designed for VLBW-babies require thorough study and evaluation before routine use is justified, but the following guidelines may be helpful. There is today documented experience of feeding VLBW-babies with formulas containing 1.5 g protein/100 ml (1.9 g/100 kcal) (Räihä et al., 1976), and thus, there is at present little justification for designing a formula for VLBW-infants which containes less protein than this. Since many infants thrive on such formulas, it is suggested that the lower limit for protein content be set at 1.5 g/100 ml or 1.9 g/100 kcal. When fed at the level of 130 kcal/kg/d, such formula will provide 2.5 g/kg/d of protein. This is in close agreement with the theoretical requirement estimated by Pohlandt & Kupferschmid (in press). If the upper estimate reached by the factorial method (Ziegler et al.) of 4 g/kg/d is accepted, then at the level of 130 kcal/kg/d it implies a protein/energy ratio of 3.1 g/100 kcal. A number of formulas are available with such a protein/energy ratio, but detailed documented experience, particularly data on metabolic tolerance (e.g., plasma concentration of ammonia, amino acids, urea, hydrogen ion, urinary concentration) is very limited.

Formulas with protein content greater than this, for example, 3.8 g/100 kcal, 3 g/dl/78 kcal, 4.5 g protein/kg/d are associated with high plasma concentrations of aromatic amino acid ammonia and hydrogen ion, particularly if the proteins are casein-predominant (Räihä et al., 1976, Rassin et al., 1977). Although it is not established conclusively that such metabolic abnormalities are harmful, neither can it be said that they are safe. Formulas with a higher whey/casein ratio are associated with lower plasma aromatic amino acid concentration (Rassin et al., 1977). Formulas for LBW-babies should contain predominantly whey protein. This will ensure an intake of cysteine at least equal to that of the breast-fed baby. Babies who receive dietary taurine, for example, in breast milk or added to a formula, excrete taurine in the urine (Rassin et al., 1983) and have a higher taurine to glycine ratio in their bile acids (Järvenpää et al., 1983c). Formulas designed for VLBW-infants should be supplemented with 30 moles/100 ml of taurine.

In early life especially of the VLBW-infant when the protective factors (McCelland et al., 1978), growth modulators, enzymes and hormones of human milk (Räihä, a) may be of great value for the developing organism it is considered by many that human milk should be given even though it theoretically may provide suboptimal concentrations of many nutrients. For this reason 'human milk formulas' or enriched human milk has been developed to meet the special needs of the VLBW-infant (Hylmö et al. (in press); Lucas et al., 1980). Human milk enriched with human milk protein or bovine whey protein in addition to minerals and calories may in the future be an alternative to commercial special formulas which do not provide the many biologically active components present in human milk.

Acknowledgement

Studies mentioned in this paper have been supported by grants from the Swedish Medical Research Council B84-19X-6259-0313, by Wyeth Laboratories and Nestlé Nutrition.

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Milk protein in the diets of those of intermediate years

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Summary

The protein intake in developed and developing countries is discussed. In the former countries, it usually exceeds the recommended values. Milk proteins substantially contribute to the daily protein intake. The intake of the large amounts of protein are discussed in relation to calcium balance. The consumption of milk protein is viewed in relation to the serum cholesterol level. In developing countries where the protein intakes are inadequate, protein-energy malnutrition can be considered a major problem of public health. Milk proteins in the form of dried milk and caseinates are recommended in the treatment of such malnutrition.

CAB descriptors: milk protein, intake, calcium, blood serum, cholesterol, energy, protein-energy malnutrition.

Intake of milk protein

Intake of milk protein is high in developed countries for a number of reasons, including the availability at competitive prices of a wide variety of dairy products, including liquid milks, cheeses and other fermented products. These products are convenient, organoleptically attractive to the consumer, and, besides high-quality protein, they contain many vitamins and minerals in nutritionally significant amounts. Furthermore, milk and cheese have a long-established cultural acceptance in many countries.

Milk protein makes a considerable contribution to total intake of protein in many developed countries. In Ireland in 1981, the average consumption of milk protein per person was about 20 g/d, about 20% of total protein. The protein intake of the vast majority of the Irish population exceeds the recommended dietary allowance of 44 and 56 g for female and male adults, respectively. Milk protein is also a good source of the amino acid tryptophan (Paul & Southgate, 1978), which has niacin activity.

Table 1. Average consumption per person of milk protein in Ireland (IE), United Kingdom (GB) and France (FR) in 1983. Data on food consumption from IDF (1983) and on food consumption from Paul & Southgate (1978).

<table>
<tr><th rowspan="2">Food</th><th colspan="3">Protein consumption (g/d)</th><th colspan="3">Contribution to protein (%)</th></tr>
<tr><th>IE</th><th>GB</th><th>FR</th><th>IE</th><th>GB</th><th>FR</th></tr>
<tr><td>Liquid milk</td><td>16.6</td><td>11.9</td><td>7.0</td><td>85</td><td>64</td><td>30</td></tr>
<tr><td>Cheese</td><td>2.4</td><td>4.2</td><td>12.4</td><td>12</td><td>22</td><td>54</td></tr>
<tr><td>Yoghurt</td><td>0.3</td><td>1.0</td><td>1.3</td><td rowspan="2">3</td><td rowspan="2">14</td><td rowspan="2">16</td></tr>
<tr><td>Other</td><td>0.3</td><td>1.6</td><td>2.3</td></tr>
</table>

Milk protein contributes 6 mg of niacin activity (33% of the recommended·dietary allowance for adults) to the average Irish diet.

Consumption statistics for milk and milk products published by the International Dairy Federation (IDF, 1982; 1983) show that average consumption of milk protein in Ireland is fairly representative of Western European and other developed countries. For example, consumption of milk protein in 1981 in the Unifed Kingdom and France was about 19 and 23 g/d, respectively (Table 1). However comsumption of milk protein is much lower in many other countries and it has been estimated that 8-10% of protein intake comes from milk in India and Pakistan, and only 1-2% elsewhere in Asia (Smith, 1970).

Liquid milk and cheese are the two principal dietary sources of milk protein in most countries and the relative contribution of these foods to consumption of milk protein differs markedly from country to country. In Ireland, 85% of milk protein is from liquid milk and 12% from cheese; in the United Kingdom, the proportions are 64 and 22%; in France, most milk protein is consumed in the form of cheese (about 54%) with 30% from liquid milk (Table 1).

There has been a steady decrease in the consumption of milk protein in Ireland in 1971-1981, and protein consumption from milk and milk products decreased by about 13%. This was primarily due to a decrease in consumption of liquid milk over this period. Protein intake from liquid milk decreased by 22% and this was only partially offset by a rapid increase in consumption of cheese and yogurt. Between 1971 and 1981, there was little overall change in consumption of milk protein per person in the United Kingdom; there was a gradual increase in consumption in France (IDF, 1982).

Milk protein in calcium balance

A potentially adverse effect of the high protein intakes observed in developed countries is increased losses of calcium in urine, resulting in increased calcium requirements. Studies with purified proteins have shown that when intake of protein, as an isolated nutrient, increased, urinary calcium increased proportionately (Margen et al., 1974; Johnson et al., 1970; Walker & Linkswiller, 1972; Chu et al., 1975). Doubling of protein intake increased urinary calcium by a factor 1.5 (Heaney et al., 1982). A similar effect on urinary calcium excretion has been observed with increasing levels of sodium intake (Madden et al., 1983) but this increased urinary excretion of calcium is accompanied by increased intestinal absorption of calcium mediated by parathyroid hormone and 1,25 $(OH)_2$-D_3 (Breslau et al., 1982). This normal physiological adaptation might occur in response to increased urinary losses of calcium with high intakes of protein. Though such an effect has not been observed (Heaney & Recker, 1982; Allen et al., 1979), further detailed studies are required to clarify this.

The increased urinary excretion of calcium resulting from high intakes of purified proteins can be decreased by increased intake of phosphate within the normal dietary range (Hegsted & Linskwiller, 1981). This is a significant finding, since many food proteins occur naturally in association with phosphate. No systematic studies on the effect of milk protein on urinary excretion of calcium have been carried out. However since milk protein is associated with significant amounts of phosphate, normal intakes are unlikely to have any adverse effect on urinary excretion of calcium. Furthermore, milk protein is unique in that it is associated with significant amounts of calcium, which can be readily absorbed (Renner, 1983).

Milk protein and serum cholesterol

Recently attention has been directed towards the effect of dietary protein on serum cholesterol in man, because of the association of high serum cholesterol with atherosclerosis. Studies on experimental animals have shown that the replacement of soya protein by casein in semi-purified diets increases serum cholesterol. When young rabbits were fed with casein or soya protein in semi-purified diets for 28 days, there were striking differences in concentrations of cholesterol in serum, casein-fed rabbits having 5.72 mmol/1 and rabbits receiving soya protein having 1.76 mmol/1 (Huff & Carroll, 1980). When rabbits were fed on soya protein, serum cholesterol remained low; substituting casein for the soya protein resulted in a significant increase in the concentration of serum cholesterol (Terpstra et al., 1982). Similar results have been observed in rhesus monkeys, a species more akin to man (West et al., 1983).

Studies in man have shown that the dietary substitution of soya protein for animal proteins reduces the concentration of plasma cholesterol in individuals with varying degrees of hypercholesteraemia by 10-25% (Sirtori et al,, 1977; Descovich et al., 1980; Vessby et al., 1982). However in all these studies, the change from the habitual mixed-protein diet (mainly animal protein) to the soya-protein diet involved a marked increase in the ratio of dietary polyunsaturated fatty acids to saturated fatty acids (P/S ratio) in diet or a decrease in cholesterol in diet. The soya diets were also relatively rich in complex carbohydrates and dietary fibre. Such dietary changes are known to lower plasma cholesterol. Changes in these dietary factors and not the soya protein could be responsible for the lowering in plasma cholesterol.

More carefully controlled studies, in which dietary fat, cholesterol and P/S ratio were controlled have shown little or no difference in the effect of these proteins on plasma cholesterol (Holmes et al., 1980; Shorey et al., 1981; Goldberg et al., 1982; van Raaij et al., 1981; 1982). For example, van Raaij et al. (1981; 1982) carried out studies on young adult and middle-aged volunteers who consumed a diet containing either soya protein isolate or casein as the predominant protein source for a period of 28 days. The fat and cholesterol contents and P/S ratios of the two diets were identical. Soya protein, when compared with casein, had no effect on plasma cholesterol in these people. Thus the striking effects of dietary casein and soya protein on serum cholesterol in animals have not been shown to occur in man with carefully controlled studies.

Use of milk protein in developing countries

Protein intakes in developing countries are much lower and generally of a poorer quality than in developed countries. These protein intakes are often inadequate, especially in vulnerable groups, such as young children, and pregnant and lactating women, whose dietary requirements for protein are relatively high. Protein-energy malnutrition is a major hazard of public health in many developing countries and is a major cause of illness and death, with children in the age group 1-5 years most commonly affected (Davidson et al., 1979).

Nutritional rehabilitation of children with such malnutrition requires a diet adequate in high-quality protein (Koppert, 1977). Milk proteins in the form of dried skim-milk and caseinates, because of their high biological value and the ease with which they can be incorporated into therapeutic diets, is widely used in treatment (Davidson et al., 1979).

Protein-energy malnutrition is usually associated with poor weaning practices e.g. weaning onto diets based on foods with low ratios of protein to energy or with poor-quality protein (Alleyne et al., 1977). The supplementation of weaning diets with a high quality protein source such as dried skim milk can greatly improve the quality of such diets and help prevent PEM (Hiel et al., 1982). This also facilitates better use of indigenous foods since milk protein has a relative surplus of the essential amino acid lysine and thus complements cereal proteins which have a relative deficiency of lysine (King et al., 1972; Garza, 1978).

Food aid in the form of dried skim-milk is at present provided to poorer countries by various non-governmental agencies and international organizations to alleviate malnutrition. In particular, it is useful as a temporary protein supplement to the local diet for young children in helping to prevent malnutrition and promote rehabilitation after infectious illness, as well as in the diets of pregnant and lactating women.

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Feeding the elderly

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Summary

In the diet of the elderly, with their differing capabilities and needs, milk proteins play an important role combining nourishment with ease of swallowing, digestion, assimilation, absorption, acceptability, low cost, availability and ease of preparation. In the United Kingdom, nutrition surveys indicate that dairy products contribute about a fifth to the protein consumed by the elderly. Promotional activity might increase the frequency of consumption of these foods.

CAB descriptors: milk protein, institutional catering, old age, protein intake, protein requirement.

Introduction

In practice most old people in the United Kingdom consume a variety of animal and vegetable foods to meet their protein needs. However in countries with bread as the staple food, there is rarely a shortage of protein, even on an uninteresting diet, because 12% of the energy of bread comes from protein.

Nevertheless for som elderly men and women, there may be special circumstances that raise the need for protein above normal requirements. To take a few examples:

– extra proteins may be needed during convalescence from illness, especially after trauma such as surgery, or with fever, fractures or burns

– extra proteins may be needed to replace reduced muscle tissue after a period of self-neglect or semi-starvation, e.g., through mental or physical incapacity, chewing difficulties, bereavement, loneliness, or apathy in old age

– extra proteins may be needed if expensive animal proteins have been passed over because of their price.

For such diverse reasons, milk proteins – of high biological value and relatively inexpensive – have a major role in the nutrition of the elderly.

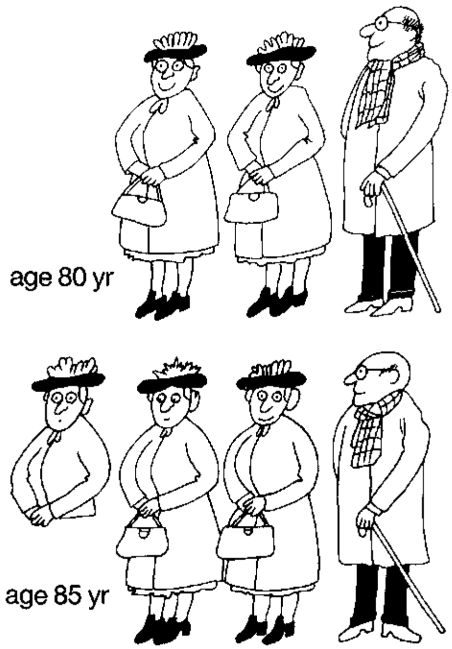

Fig. 1. Ratio of men and women at retirement age.

As in many other countries, numbers of men and women surviving to old age are increasing, especially the very elderly, who may be in extra need of nutritional and social support through increasing frailty.

More women than men are reaching very old age. In the United Kingdom, the ratio of women to men is 2:1 at the age of 80 and nearly 3:1 at age 85.

Those are the statistics, but we must look at the people behind the statistics. The 9½ million elderly men and women in the United Kingdom (17% of our total population) share a chronological age, but in all other aspects they are differing individuals. The significance of milk proteins in their diet, will therefore, vary widely.

The elderly in hospital

For the hospitalized (fewer than 3% of our total elderly) milk foods supply protein and other essential nutrients and must be easy for swallowing, assimilation, absorption and acceptability. For enteral feeding, proprietary milk-based products can meet the total protein needs. In most hospital menus in Britain, it is customary to serve savoury and dessert milk dishes as well as a constant supply of beverages, including endless cups of tea (which in Britain are served with milk). At night, comforting milky drinks may even act as substitutes for hypnotics.

For the elderly in residential homes (again fewer than 3% of the British elderly), consumption of milk proteins is relevant. The Gerontology Nutrition Unit in which I work identified 26 nutritional risk factors in residential homes (Davies & Holdsworth, 1979; CPA, 1983a). One striking example was a disproportionate expenditure between foods in the financial budget of homes. The relative expenditure suggested by the Department of Health and Social Security for England and Wales was given publicity in a Homes Advice Broadsheet written by the Gerontology Nutrition Unit and distributed to homes for the elderly (NCCOP, 1980):

- animal proteins 50%
- fruits and vegetables 20-25%
- energy foods 25-30%

However the Unit found that too much was spent in some homes on the cheaper 'fill-up energy foods' rather than on the more expensive animal proteins. In one home of 25 residents, we counted 152 packets of biscuits in their store cupboard, which was frequently replenished.

One of the problems with menu planning in the homes was a lack of variety. The Unit designed recipe idea cards, which included a reminder of popular dishes, many using milk and dairy products (CPA, 1983b).

The officers-in-charge and the cooks in such homes need to be taught that milk proteins are of high biological value. Relative to the average for all foods, they are one of the most valuable of the animal proteins (i.e. nutritional value divided by cost): eggs 1.65; cheese 1.62; milk 1.59; pork 1,01; beef 0.93; bacon 0.77 (National Food Survey, 1983).

The protein quality of the residents' diets can easily be improved at only a small cost by the addition of cheese, milk or eggs, which have a high rating for nutritional value for money. In other words, they would get 59% more protein for their money spent on milk than if they spent that money on other general foods, which have an index of 100. Similarly, cheese would give them 62% more protein for their money, whereas meat and bacon would give them far less.

Fig. 2. Pushing plate away.

This nutritional value for money is relevant in hospitals, nursing homes and other institutions budgeting for large-scale catering.

The elderly in the community

However, the vast majority of old people are not in institutions: in Britain over 94% live at home, either on their own or with one or more members of their family or friends. That is not to say that all of them are fit; about 3% of them are recognized to be at special nutritional and social risk, and therefore need meals delivered to them at home. Such meals are generally delivered by van or car, and so are known as meals-on-wheels.

In a survey on meals-on-wheels recipients, a clear indication of a generally poor diet was a low vitamin C intake combined with a low intake of milk, and less than 8 protein meals in a week.

The daily protein recommendation for the elderly in the United Kingdom ranging according to age, is 54-60 g for men and 42-47 g for women (DHSS, 1979a).
It has been recommended (Exton-Smith & Stanton, 1965) that a lunch for old people at a local centre or a delivered meal should provide at least 25 g of protein, that is about half the recommended daily amount. The mean supply of protein in 200 meals-on-wheels examined in the survey conducted by my Unit (Davies, 1981) was 28 g, which would appear to be satisfactory. However the amount of protein eaten ranged from 8-58 g. In fact, 37% of the delivered meals contributed less than the recommended 25 g of protein to the day's diet. These were mainly meals which economized by serving only small portions of the expensive sources of protein: roast meats. Certainly these meals were amongst those most popular with the diners. So instead of replacing these roast meats by cheaper less popular dishes, we recommended that in these meals, particular attention must be paid to the other protein components of the meal. For instance, a thin slice of delicious roast beef needs to be accompanied by a generous portion of traditional Yorkshire pudding, made with milk, eggs and flour. Give different nationalities the same ingredients and what do you get: Dutch pancakes, French crêpes and English Yorkshire pudding!

The Unit is formulating nourishing milk-based soups, which, it is hoped, can be introduced to augment meals-on-wheels.

So far, I have concentrated on the elderly at greatest nutritional risk. However age itself does not necessarily bring ill health or apathy. You are as old as you feel, and many old people make determined efforts to maintain good health into old age.

It is nog true to say that old people are set in their ways and will not change their choice of foods. In a survey we conducted (Bilderbeck et al., 1981) on subjects aged 60 years and over, all had changed some foods. For instance, over a third had changed the type of milk they were using – mainly to a less creamy milk, for health reasons or weight reduction.

Whereas milk is looked upon as a food only for infants or young children in some countries, it is considered a good food for the older generations as well as for other age groups in the United Kingdom.

Of course there is the bonus of the present regular delivery with its aspect of care. In many areas, the milkman is the old people's most regular caller, and frequently helps them or summons urgent outside help in a crisis. Moreover, many milkmen now deliver to their door a variety of foods, including cheese, yoghurt, cream, fruit juices, ham, bacon, eggs and bread, as well as milk. This helps them to buy without having to queue or carry.

The National Food Survey demonstrates that the elderly in the United Kingdom buy more milk than other age groups, despite many claims of reduced food intake per person with increasing age of the housewife:

- all ages 0.326 l/d
- 65-74 years 0.356 l/d
- 75 years or more 0.364 l/d.

Advertising, of course, plays a major role in maintaining consumption. For the elderly, milk consumption could even be increased. Many of them still only use milk for tea and coffee. One can, therefore, recommend milk for cooking, emphasising the versatility and ease of use in every meal of the day (Davies, 1971; 1979).

Many retired men and women enjoy going to special cookery classes for the over 60 s, where they are encouraged to maintain a nourishing attractive diet; after a morning of cooking, they eat their lunch together.

In order to maintain the popularity of cheese, one has to aim for ease of digestibility by encouraging grating and light cooking. Digestibility is of more concern to old people than concentration of cholesterol in blood. It is generally acknowledged that they have adapted to their cholesterol concentration.

Milk and dairy products are highly recommended for their contributions of potassium, riboflavin and calcium. The lack of some nutrients, e.g. vitamin C, can be overcome by using milk and yoghurt as a vehicle, e.g. blackcurrant syrup stirred into cold milk (Davies & Holdsworth, 1978; National Dairy Council, 1971).

To encourage the intake of yoghurt and other 'new' milk protein foods for an 'old' generation, proper marketing is essential. Marketing in small one-portion packs has undoubtedly promoted such foods.

Our current research, part-funded by the European Community, is a nutritional survey on men and women before and after the age of retirement from work. This

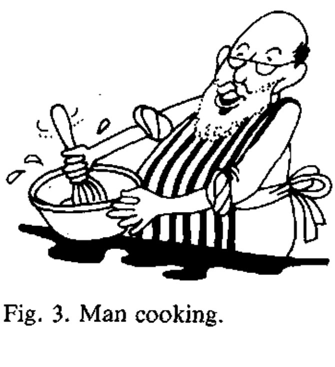

Fig. 3. Man cooking.

extensive study examined health, socio-economic background and diet, and emphasized the ease of cooking with milk and cheese. Extension in the project used demonstrations, leaflets and books (Davies & Holdsworth, 1983).

When we examined the diets of a sample of men and women before retirement, liquid milk contributed 9.4% of total protein intake; cheese contributed 6.3%; the total from all milks and dairy products was 19.0%. This is similar to the finding by the Department of Health & Social Security on an older sample of men and women in six areas of Great Britain (DHSS, 1979b) that milk and dairy products contributed 20% of the protein in their diet.

As a final comment: for our retirement survey, we have designed frequency of consumption lists; foods are graded as eaten daily, weekly, fortnightly, monthly, occasionally, rarely or never. We have found that several of the milk and dairy protein foods are coded 'eaten occasionally' rather than 'never', indicating that the foods are liked rather than avoided. Such information could help in identifying where promotion might increase the frequency of consumption of these foods (Davies & Holdsworth, 1984).

Acknowledgments

The current retirement survey conducted by the Gerontology Nutrition Unit is funded by the National Dairy Council of England and Wales, together with the European Community in Brussels. The part-funding by the European Community is part of the Community Programme under Regulations (EEC) 2935/79 and 271/82.

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Conclusions of plenary session C

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Cheese, casein products and preserved milk are major outlets for milk proteins.

Recombined of milk powder into a variety of products offer a fast growing outlet for milk powder. The annual growth rate is approximately 17%. Research results obtained on manufacture of cheese from recombined milk may offer an additional opportunity.

Simultaneously with the growth of recombination, the retail milk-powder market in the same countries has grown. Thus recombination can be considered as a supplement of the retail market of milk powder.

Ultrafiltration offers new possibilities for the use of milk proteins. Examples are fermented milk products such as quark, ymer and yoghurt with increased protein content. Another example is the application of ultrafiltration in cheese making. Feta cheese based upon ultrafiltration has found a large market. Other cheese types based upon ultrafiltration are still in their infancy.

Specific milk proteins, isolated either from the casein fraction or from the whey protein fraction offer – by their functional properties – a potential for growing applications in a variety of dairy and non-dairy foods.

The successful development of cream liqueur is a neat example of the innovative and creative application of scientific knowhow, avoiding fat separation and gelation, which leads to a new outlet of milk components.

Instead of downgrading milk proteins into feed components, it is recommended to upgrate milk proteins into food components. The results are dependent upon economic, political and technological factors.

By separation techniques, such as centrifugation, evaporation and ultrafiltration, milk-protein concentrates can be prepared, which may find new applications after structure-forming by enzymic action, heat-setting or extrusion.

The addition of relatively small amounts of milk proteins to the dairy diet in developing countries will increase considerably the nutritional value of these diets.

Milk proteins may be used specifically during recovery from protein-energy malnutrition.

Infant formulae, although composed carefully, are different in several aspects from human milk. The major differences concern milk protein content and amino acid composition.

High-protein diets in general increase the urinary excretion of calcium. It is not established yet whether this is compensated for by increased absorption. However the high phosphate content of milk proteins should counterbalance any increase in calcium excretion.

Under special circumstances, elderly people need additional and good-quality protein. The high nutritional value for money of milk proteins as compared to other proteins is justification for use of milk and dairy products. The proper approach of nutritional education is essential.

Milk proteins in non-dairy products

D

Manufacture, functionality and utilization of milk-protein products

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Summary

The importance of milk protein products stems from their high economic value and their recognized nutritional and functional value in manufactured food applications.

Government price support, regulations on use and related programs exert a major role in influencing the production, distribution and utilization of milk proteins on a national and international scale.

Data on annual production of casein are given and on the potential for manufacturing whey proteins. Processing schemes are described for the major products of milk protein, with emphasis upon ultrafiltration and ion-exchange adsorption methods for manufacture of whey-protein concentrates and upon new methods for manufacture of total milk proteinate. Alternative processes for manufacture of whey protein concentrates with modified composition and functionality are also discussed. The general and functional properties of milk protein products are listed and considered in terms of their basic physico-chemical properties and also how processing treatments alter these basic properties and functionality.

Utilization patterns for the major products of milk proteins in the United States are reviewed in terms of their ability to be replaced by non-fat dry milk and soya proteins. Examples are dicussed where recent government regulations now permit the use of whey proteins in frozen desserts and processed meat products. Projections are made for increased utilization of whey protein concentrates in carbonated beverages, fruit juices and infant formulas. Strategies for further improvement in whey protein utilization in human foods in general and in specific food products where proteins are not now being used are considered. The need of additional research to improve the functional properties of milk proteins and to expand their utilization is discussed.

CAB descriptors: milk protein, casein, whey protein, ultrafiltration, food, ion-exchange processes, milk processing, dairy technology.
Other descriptor: physico-chemical properties.

Introduction

Milk-protein products, e.g. caseins, caseinates, coprecipitates, whey protein concentrates, lactalbumins and the recently developed total milk proteinates, are important to the dairy and food industry for their economic value, by-product utilization, waste treatment and recovery, utilization of seasonal surplus milk, and governmental price-support programmes (Morr, 1984). In addition, these products represent a tremendous resource in terms of their functional and nutritional value as ingredients in processed, formulated food products.

World production of milk protein

An estimated 220-226 thousand tonnes of casein products are manufactured in the world annually, most of which is produced in New Zealand and Australia (80 thousand tonnes), the European Community (108 thousand tonnes) and Poland (30 thousand tonnes) (USDA, 1983; USDA, 1981). There are about 85 million tonnes of cheese whey produced annually in the world. This 'ocean' of whey contains an estimated 607 thousand tonnes of whey proteins, which are only partially recovered and utilized. There is also the potential for manufacturing an additional 45-50 thousand tonnes of whey proteins from the whey that results from commercial casein manufacture.

General requirements of milk proteins

Milk-protein products, which are generally recognized as safe food ingredients, must meet general requirements (Morr, 1976; 1979a; 1979b). These general requirements include: freedom from toxic factors such as natural food toxicants, pathogenic micro-organisms and their toxins, and processing-derived toxic factors such as lysinoalanine; minimal off-flavors and odours from processing and storage; a high protein content with minimal lactose, minerals and fat; high nutritional quality; compatibility with other ingredients and processing conditions in the formulated foods; and abundant availability at prices competitive with alternative sources of protein. Milk proteins generally compare favourably with most alternative protein products on the market today.

Functional requirements of milk protein products

Milk protein products must also meet critical functional properties, which determine their ultimate value as ingredients in various formulated food products (Table 1) (Morr, 1976; 1979a; 1979b). For example, milk protein products are added to formulated foods to emulsify fat, expand and stabilize foam, for viscosity, to control crystallization, gelation and texturization, and for freeze-thaw stability, dehydration stability and heat stability. The composition of the food product in terms af acidity and calcium ion content, and the processing conditions strongly influence the ability

Table 1. Functional requirements of food protein products.

Sensory	Flavour, odour, texture, colour
Appearance	Turbidity, colour, grain formation, precipitate
Hydration	Dispersibility, solubility, viscosity, gelation
Surfactant	Emulsification, foam expansion and stability, gas and air entrapment during baking
Structural	Aggregation, gelation, texturization
pH stability	Isoelectric or specific-ion precipitation
Heat stability	No precipitation during heat processing
Drying stability	Rehydration after drying

of the milk-protein products to provide optimum functionality.

Each of the casein and whey-protein products provide specific functional properties in formulated food products. There is as yet no reliable method to predict the functionality of milk-protein products in a formulated food product. Research is under way on the relationships between physico-chemical properties of proteins and their functionality in food products. The relative concentrations of each of the milk-protein components, previous processing, methods of isolation and manufacture, and conditions of storage all influence their functionality in food products (de Wit, 1983; Morr, 1979a; 1982). Manufacturers of milk-protein products are devising and using various proprietary processing and protein-modification treatments to produce protein products with improved functionality for specific requirements.

Physicochemical and functional properties of milk-protein products

The caseins, which represent about 80% of the proteins in milk, are composed of three major subunits: α_s-casein (55%); β-casein (30%); and κ-casein (15%). These subunits possess molecular weights in the range 20 000 to 25 000 (Morr, 1979d; 1982; 1983). They possess unique conformational structures in terms of amino acid composition and sequence, degree of phosphorylation, glycosylation and content of thiol group. The caseins are present in milk as highly organized and structured aggregate particles, commonly called micelles, with substantial amounts of colloidal calcium phosphate. The caseins are readily precipitated and isolated from milk by adjusting the pH to their isoelectric point of 4.5-4.7 with acid, or by treating milk with rennet.

Whey proteins, which account for about 20% of the total skim-milk proteins, are composed of four major components: β-lactoglobulin; α-lactalbumin; bovine serum albumin; and immunoglobulins, plus the minor proteose-peptone components, which range in molecular weight from about 8 000 to 200 000. The whey proteins are generally believed to be compact globular conformational structures sensitive to denaturation by heat and related processing treatments, which reduce their solubility and functionality in food products. Since whey proteins are not precipitated by acidification to their isoelectric points or by treatment with rennet, in contrast to caseins, they must be isolated from whey by one or more relatively costly and sophisticated processes, including ultrafiltration, ion-exchange adsorption, gel filtration or specific-ion precipitation (Morr, 1976; Marshall, 1982).

The importance of physico-chemical properties of milk proteins for controlling the functionality in food product applications has been considered (Morr, 1979d; 1982; 1983; de Wit 1983). These considerations are critical for design of processes for milk-protein isolation and manufacture. For example, treatment of milk proteins with acid, heat, alkali, agitation, whipping, drying and enzymes alter their physico-chemical properties sufficiently to influence their functional properties favourably or unfavourably. For example, it is extremely important to remove residual fat from whey protein concentrates to provide a protein product with optimum foaming and gelation properties. Rennet treatment of casein, which causes specific hydrolysis of the κ-casein subunit, renders it virtually insoluble in the presence of calcium ions. Lactalbumin and coprecipitate, both of which are isolated by a combination of acid and heat, are only slightly soluble and therefore provide only limited functionality in most food products. The relatively new total milk proteinate (TMP), which has also been isolated by a combination of pH adjustments and heat treatments, also offers special and unique physico-chemical and functional properties, which have yet to be reported (Food Development, 1981; Connolly, 1983; data of Lankveld, Workshop 1).

Heating of milk and whey, as in the manufacture of coprecipitates and lactalbumin, causes irreversible interactions among the various proteins and, with colloidal phosphate, activation of thiol groups in whey protein and the Maillard browning reaction involving the proteins and lactose. All of these chemical and physico-chemical reactions are considered detrimental to the production of milk-protein products in terms of meeting the general and functional requirements.

Milk protein product manufacturing processes

The caseins and caseinates are manufactured by treating skim-milk with acid or rennet (Fig. 1). Details of these processes are provided by Fox (1970) and Muller (1982). The acid and alkali treatments used in manufacturing acid casein and the caseinates completely dissipates the micellar structures described above. Casein subunits exist in these casein products as randomly associated aggregates with size distribution that is dependent upon the calcium concentration and pH of their environment (Morr, 1975). Rennet casein is composed of enzyme-modified casein micelles, which more closely resemble those in skim-milk in conformational structure, except that they have lost virtually all their solubility in the presence of calcium ions. Coprecipitates represent a complex of caseins and whey proteins that are generally manufactured by heating skim-milk to temperatures of 90 °C or more to denature and complex whey proteins with caseins. Upon acidification to pH 4.5-4.7, the protein complex is precipitated at the isoelectric point.

The composition of acid casein and the sodium, potassium and calcium caseinates is given in Table 2. These products typically contain at least 90% protein and have correspondingly low contents of fat, lactose and minerals. Although coprecipitates

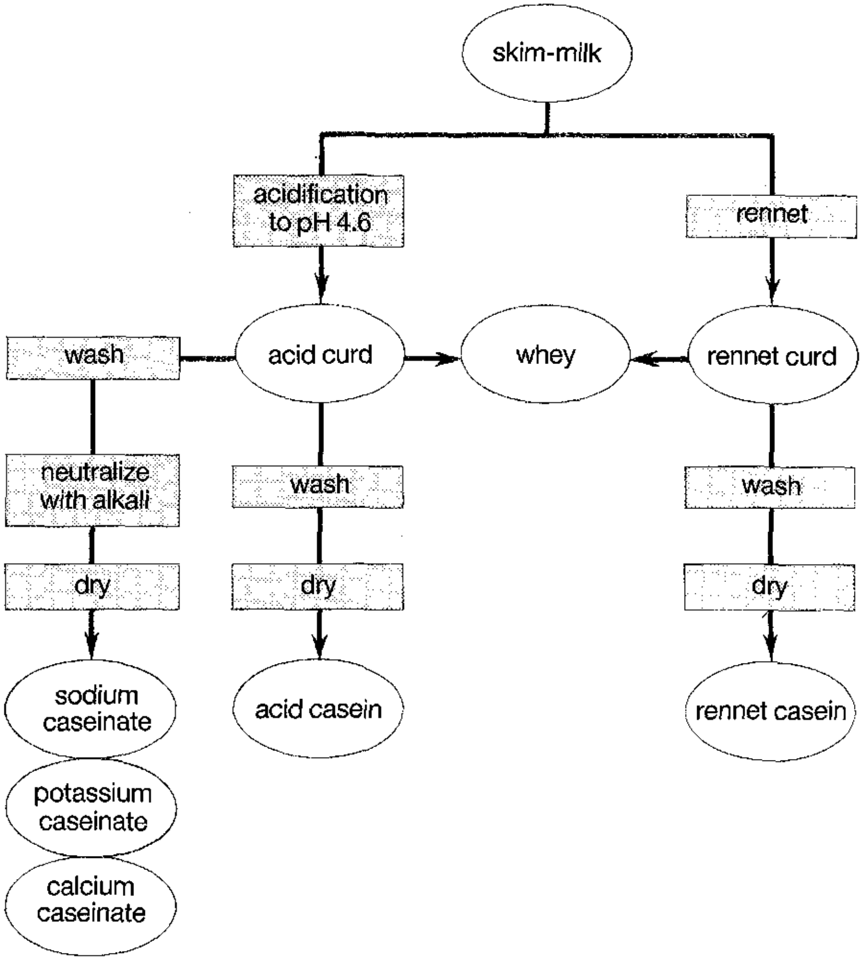

Fig. 1. Scheme for manufacture of caseinate, acid casein and rennet casein. RO, reverse osmosis; UF, ultrafilter.

are generally similar in chemical composition to caseins and caseinates, their protein composition in terms of casein and whey protein content, is obviously different. Also, coprecipitates exhibit vastly different protein solubilities and functional properties, because of the drastic heat treatment.

Details of the various manufacturing processes for whey proteins are provided by Marshall (1982) and Fox (1970). The composition of liquid whey is given in Table 3. The major requirement for all of the different processes for recovery of whey protein is to overcome the serious limitations due to the low protein content of the initial whey and also to concentrate and recover these sensitive proteins with a minimum of denaturation, which would impair their solubility and functionality. Ultrafiltration has emerged as the preferred process for recovering whey proteins (Figure 2). Major advances are being made in the design of the equipment and in processing conditions (Wesley, 1981). Whey is commonly first treated to remove as much of the residual lipids and minerals as possible before the ultrafiltration process to recover the proteins (Morr, 1979a; de Wit et al, 1978). Typical compositional data for whey concentrates are given in Table 4. The protein content of these whey-protein products ranges from about 35 to 80% on a dry basis, depending upon the extent of fractionation and the functional requirements of the products. There is also some interest in developing

Table 2. Composition of caseins and caseinates, expressed as contents (g/kg). From Morr (1982). –, no data.

	Sodium caseinate	Calcium caseinate	Acid casein	Rennet casein
Protein, (min. N × 6.38)	940	935	950	890
Lactose, max.	2	2	2	–
Minerals, max.	40	45	22	75
Fat, max.	15	15	15	15
Moisture, max.	40	40	100	120

Table 3. Composition of liquid and dry whey, expressed as contents (g/kg). Sweet whey from Cheddar cheese manufacture and acid whey from cottage cheese manufacture. Data from Morr (1984).

	Liquid		Dry	
	sweet	acid	sweet	acid
Protein	8	7	120	120
Lactose	49	44	733	687
Minerals	5	8	79	115
Fat	2	0.4	13	8
Lactic acid	2	5	17	46

Table 4. Composition of whey-protein concentrates (WPC), expressed as content (g/kg). Data from Wesley (1981).

	35% WPC	70-80% WPC
Protein, min. (N × 6.38)	350	760
Lactose, max.	400-600	80
Minerals, max.	20-200	30
Fat, max.	24-45	80
Moisture	40	40

special whey-protein concentrates with hydrolysed lactose, low in sodium, low in cholesterol and with other unique properties (Andres, 1982a; 1982b; 1982c). Permeate fractions from the ultrafiltration process, which contain the lactose and minerals, are further processed to recover lactose, lactose hydrolysate, ethanol, yeast protein or wine (Texieira et al., 1983).

There has also been some interest in the possibility of developing suitable ion-exchange adsorption processes to recover whey proteins. However, since the limitetd number of literature reports on this subject are contradictory (Burgess & Kelly, 1979;

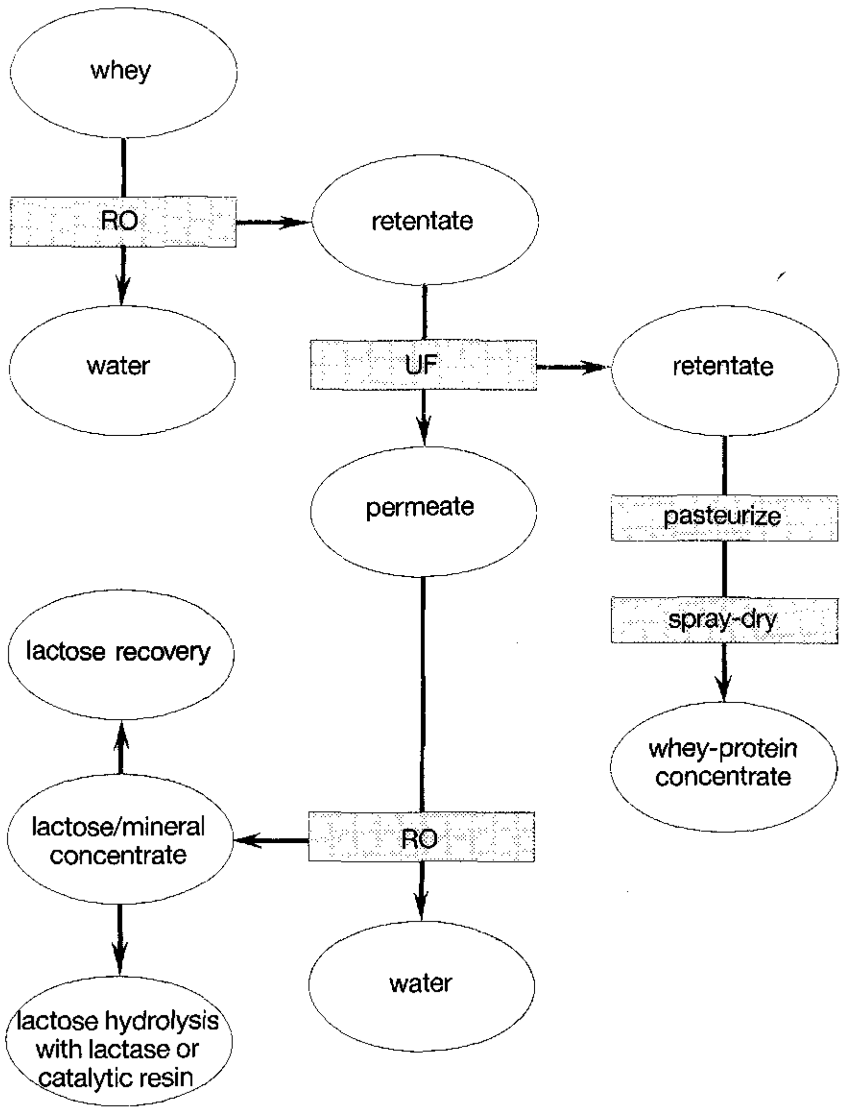

Fig. 2. Scheme for ultrafiltration and reverse-osmosis processing of whey.

Table 5. Processing conditions, yield and composition of total milk proteinate. Data from Lankveld, Workshop 1.

	Soluble lactoproteinate process TMP[a]	New Zealand TMP[b]
Processing conditions		
pretreatment pH	7.5	10/2.5
pretreatment temperature (°C)	96	55
precipitation pH	4.6	4.6
precipitation temperature (°C)	40	55
Yield and composition		
protein yield, proportion of total protein (%)	95	95
protein content, dry basis (g/kg)	950	950
mass ratio of whey protein to casein	0.163	0.163
Ca content, dry basis (g/kg)	1.3	1.2
solubility, at pH 6.7[c] (%)	97	97

a. Soluble lactoproteinate process, NIZO, Ede, Netherlands.

b. New Zealand Milk Products, Inc., Petaluma, CA, US.

c. Nitrogen Solubility index (American Oil Chemists' Society, Champaign, IL, US).

Palmer, 1982; Nichols, 1984), we must await more definitive research findings before we can evaluate the process.

A recent development in the manufacture of milk-protein products that offers excellent potential is the total milk proteinate (TMP) process, which reportedly isolates all of the skim-milk proteins in an undenatured and functional state (Food Development, 1981; Connolly, 1983; data of Lankveld, Workshop 1). Details of this process indicate that the skim milk is adjusted to alkaline pH, warmed to solubilize the proteins, acidified below isoelectric pH to complex the caseins and whey proteins and then adjusted to isoelectric pH to precipitate the complex. A newer process has been developed (Table 5), termed the soluble lactoproteinate process (SLP), to produce total milk proteinate with a composition identical to that from the above process (Food Development, 1981; Connolly, 1983). This newer process (Lankveld, Workshop 1) and the former process result in a product close in properties to traditional coprecipitate. However, the one major difference between these two types of product is the degreee of denaturation and the resulting solubilities and functionalities of the protein. Total milk proteinate is reportedly completely soluble away from the isoelectric pH and exhibits excellent functionality also. Additional research is obviously warranted in this development area to characterize the physico-chemical and functional properties of these new products.

Utilization of milk protein

Whey proteins are used in the form of dry whey solids, whey protein concentrates, lactalbumin, partially delactosed whey and partially demineralized whey in a number of food product applications including icing and confectionary frozen desserts, processed meat products, bakery products and salad dressings (Whey Products Institute, 1983). About 60% of the total 355 thousand tonnes of whey protein products in the United States are used in human food. About 97% of the total of 8 thousand tonnes of whey protein concentrates designated for human food products is accounted for in protein blends and dairy products. There is a significant trend toward increased utilization of whey protein concentrates and partially delactosed and partially demineralized whey in human food applications. Whey protein concentrates are more suitable as replacement for non-fat dry milk than dry whole whey in those food products where low lactose and mineral contents are required. There are also legal limits on the amount of whey protein products in certain foods, such as processed meat and frozen desserts in the United States. Whey protein concentrates, due to lack of functionality, would probably not replace casein and caseinate in formulating coffee whiteners, imitation cheese and dessert toppings. The availability of the newer whey protein concentrates, such as the low-cholesterol, low-lactose, and low-sodium whey protein concentrates (Andres, 1982a; 1982b; 1982c), may improve utilization of whey protein in food products.

About 60% of the annual total of 58.1 thousand tonnes of casein and caseinate are used in human food in the United States (USDA, 1983; USDA, 1981). These proteins are used for their excellent functionality and nutritional quality. The largest amounts of casein and caseinate are used for manufacturing imitation cheese (33%) and coffee whitener (10%). Major non-food uses of caseinates and casein include industrial products, e.g. glues, adhesives, paints, rubber products, leather products, paper sizing, cleaning agents and lubricants. About 13% of the total casein and caseinate are utilized in pet foods.

Users of caseins and caseinates were surveyed and asked to indicate whether they could substitute other proteins for caseins and caseinates in their food and non-food applications (USDA, 1981). Results of the survey indicated that about 16.5 thousand tonnes (28%) of the casein and caseinates could be substituted for by soya proteins, about 30.6 thousand tonnes (53%) could be replaced by non-fat dry milk or non-fat milk, but about 11 thousand tonnes (19%) could not be replaced by any other protein source.

Alternative protein sources

As indicated above, substantial amounts of casein and caseinate can be replaced with soya and other alternative protein sources. The same situation would likely be found for replacers of whey protein products in certain food and non-food uses. The relative competitiveness of the various protein sources is dependant upon such factors as cost, availability, general and functional properties, and nutritional quality.

Soya protein isolates and concentrates are probably the most competitive alternative proteins available at this time. Soya protein products suffer from several major disadvantages that are generally recognized through the food industry. The disadvantages include rather poor nutritional quality in terms of essential amino acids, off-flavours and off-odours, high content of green and yellow pigments, phytate and phenolic compounds, potentially toxic compounds and enzyme inhibitors, and limited solubility and functionality for certain food applications (Morr, 1979c). Although newer and improved isolation processes are available for manufacture of soya protein products with improved general and functional properties, the soya protein manufacturers have been somewhat slow in adopting these processes. They must recognize that the added cost of implementing such process modifications might further increase the price of the protein product, so that they may no longer be competitive with milk proteins and other protein sources.

Proposed strategy for increasing utilization of milk protein

There are at least 50 United States companies manufacturing whey protein concentrates. Their production capacity exceeds the demand for their product by a factor of at least two to three. A similar situation is likely to prevail in the European Community, New Zealand, Australia and Poland. Strategies are therefore needed to increase the utilization of whey protein concentrates and the other milk protein products. Efforts are needed along the lines of further refinement of protein isolation and manufacturing processes to improve their general and functional properties so that they can better compete with alternative protein sources and will be acceptable in a wider range of formulated food products. Also, efforts should be continued to develop new milk-protein products, such as the total milk proteinate product, with new and interesting possibilities for improving their utilization. Appropriate modifications to processing could be introduced to produce whey protein and casein products with better functional properties. These latter modifications might include chemical, enzymic and physical treatments of the proteins. Additional research is needed tot develop new and innovative processes for processing the lactose-enriched permeate fractions from ultrafiltration resulting from whey-protein isolation and manufacture. These improvements should result in a more favourable economic relationship for all of the protein products produced from whey (Texieira et al., 1983). Research and development must be directed towards divising new end-products for milk proteins and lactose, such as in carbonated beverages, fruit juices, meat products, bakery products and confectionery products (Zall, 1983). Greater emphasis is needed upon efforts to acquaint the food-processing industry with ways of using milk protein products in present and developed food products.

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New approch to the functional characterization of whey proteins for use in food products

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Summary

Attention is paid to the unknown relation between the properties of whey proteins in aqueous solutions and those in food systems. The functionality of whey protein is now approached from the opposite direction and along the following lines:
– typical characteristics of some food products should be surveyed on the basis of properties of their original proteins and of substituted or fortified proteins
– suitable model systems should be selected to allow to predict the performance of whey proteins in final food formulations, according to representative processing steps
– empirical results should be compared with results from model systems with the functional properties of whey protein concentrates obtained in aqueous protein solutions
– results should be interpreted on the basis of structure-function relations of whey proteins in terms of denaturation or controlled thermal, physical or enzymic modifications.

Some results of this procedure are discussed, as derived from a comparative study of industrially prepared whey protein concentrates produced according to quite different isolation techniques.

CAB descriptors: milk protein, whey protein, functional properties, food processing, protein quality.

Introduction

Functional application of whey proteins in food products requires a thorough knowledge of protein properties under the widest range of thermal, physical and compositional conditions. This includes both the history of whey protein fractionation and the conditions governing application of such proteins in food products. In particular, detailed information on the state of whey proteins in terms of their denaturation or alteration induced by several processing steps is important for reliable prediction of their functionality.

Many attempts have been made to establish a number of functional whey protein properties in aqueous solutions (Kinsella, 1976; Cheftel & Lorient, 1982). However, the lack of generally accepted, standardized techniques for the determination and evaluation of such properties impedes effective use of the information thus gathered.

The general procedure for the production and characterization of whey protein concentrates (WPCs) is shown schematically in Fig. 1. Starting from whey as a byproduct of either cheese production or casein separation, a WPC can be obtained by a variety of fractionation techniques. Some of these techniques may also result in physical or compositional alterations of the whey protein fraction itself.

The resulting WPC is subsequently characterized on functional properties by arbitrarily chosen techniques. Well known functional properties of WPC systems are solubility and colloidal stability, viscosity and gelation, emulsifying and foaming abilities, and finally the fat- and water-binding properties. The majority of these properties, however, give information on the processing history of the WPC, without sufficient relation to protein functionality in actual food systems. In Fig. 1, this is indicated by 'known properties' and 'unknown properties', respectively.

Thus there is an urgent need for a study that relates functional properties more closely to food products and which takes the food system itself as the starting point for the procedure of functional evaluation of whey proteins. Some years ago, we

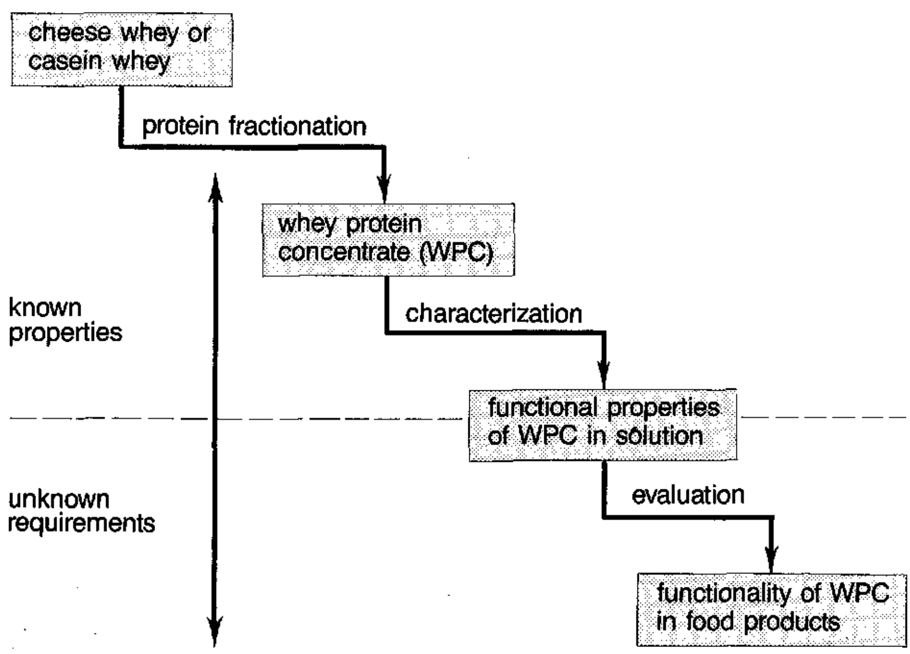

Fig. 1. Classical method for functional characterization of whey proteins.

started such a study on both pure isolated whey proteins and industrially prepared WPCs (de Wit et al., 1983). To carry out this study, we selected WPCs produced by widely different fractionation techniques on an industrial scale.

A few results of the study are discussed in the present paper, in order to illustrate our evaluation procedure for functional properties of whey proteins.

Fractionation and composition of some industrially prepared WPCs

The WPCs used in our study were isolated or fractionated from both cheese whey and casein whey, according to three different fractionation techniques:
- membrane processes such as ultrafiltration and diafiltration;
- ionic-exchange processes based on resins from Sphérosil (Mirabel, 1978) and Vistec (Palmer, 1977)
- whey desalting and desugaring processes, as used by some lactose manufacturers.

For the purposes of this paper we have selected some characteristic WPCs obtained by membrane processes and by Sphérosil ion-exchange techniques.

The composition of four industrially WPCs is shown in Table 1. Ultrafiltration and diafiltration are fractionating techniques that yield a preferential concentration of proteins, fat and bacteria at the expense of low-molecular whey constituents, such as water, minerals and lactose. The WPC shown in line 1 of Table 1 was obtained by ultrafiltration of whey to a relatively low protein content and, consequently, a high lactose content on total solids. Line 2 gives the results of a highly concentrated whey protein product, obtained by a process of ultrafiltration and washing (called diafiltration) during fractionation. This WPC has a high protein content, a low lactose content and a fairly high fat content. Both products were concentrated and dried at pH of about 6.5, which led to a protein denaturation of the order of 20%.

Protein denaturation was determined by nitrogen solubility index (NSI) at pH 4.6 (de Wit et al., 1983).

Table 1. Composition, pH and degree of denaturation (fraction of protein denatured) of some industrially prepared whey protein concentrates.

Preparation process	pH in solution (100 g/l)	Denaturation (%)	Mass fraction in total solids (g/kg)			
			protein	lactose	ash	fat
UF[1] WPC	6.5	16	370	515	74	37
UF/DF[2] WPC	6.4	22	830	54	28	71
Sphérosil 'QMA'-WPC	4.0	21	900	33	19	10
Sphérosil 'S' WPC	6.0	65	970	1	19	10

1. Ultrafiltration.
2. Diafiltration.

The composition of WPCs obtained by the Sphérosil ion-exchange processes is shown in lines 3 and 4 of Table 1. Such WPCs are characterized by a very high protein content and low contents of lactose, ash and fat. The Sphérosil 'QMA' process is based on resins consisting of porous silica provided particles with positively charged quarternary methylamino groups.

The whey proteins in sweet cheese whey, which carry a predominantly negative charge, are bound at pH 6.5 and, after washing, are desorbed by diluted acid at pH ≤ 4.0. The resulting whey protein solution is concentrated and spray-dried at the same low pH, without serious consequence in protein denaturation (Table 1).

A much more denatured WPC results from the Sphérosil 'S' process for acid (casein) whey and this may be explained by the process history. The Sphérosil 'S' process is based on adsorptions onto porous silica particles provided with negatively charged sulphonic groups. The positively charged whey proteins are bound at pH 4.6 and, after washing, are desorbed by ammonia at pH above 8. Whey proteins, however, are extremely sensitive to thermal damage at high pH through increased activity of their sulphydryl groups (Hillier et al., 1980). In particular during the drying process, this may account for significant alterations determined as protein denaturation. During the drying stage, however, the ammonia disappears, causing the pH to drop to 6.0, and thus masking an important step in the overall process.

In the following sections, we will show that the differences in composition and properties (Table 1) underlie a differentiation in how these four WPCs can be used in food products. The price of these WPCs depends on their protein content and ranges, for the last three (high protein) types mentioned in Table 1, between 65 and 130% of the average price of dried white of egg.

Method for evaluation of functional properties

Our approach to a procedure for functional evaluation of WPCs is summarized in Figure 2 (de Wit, 1984). Starting from the left, this requires firstly a thorough knowledge of the realization of typical and protein-related properties in different food systems. A second requirement is the formulation of suitable model products containing the main ingredients of the food product, for testing the performance of whey protein concentrate during and after representative processing steps.

All information thus obtained is empirical and should be related to functional properties well defined in aqueous solutions, which are more appropriate to theoretical explanations based on the structure-function relation of whey proteins.

Most of the studies on functional properties of WPCs published so far are limited to results obtained in aqueous solutions. Discussions on the function of proteins in food products are speculative and are derived from protein properties in well defined protein solutions (Kinsella, 1982).

In this paper, we will adopt a procedure for functional evaluation that works the other way round, starting with the complex food product and gradually simplifying to a system for studying the structure-function relation of the whey proteins in aqueous solution. Compared to vegetable proteins, we will thus be at an advantage

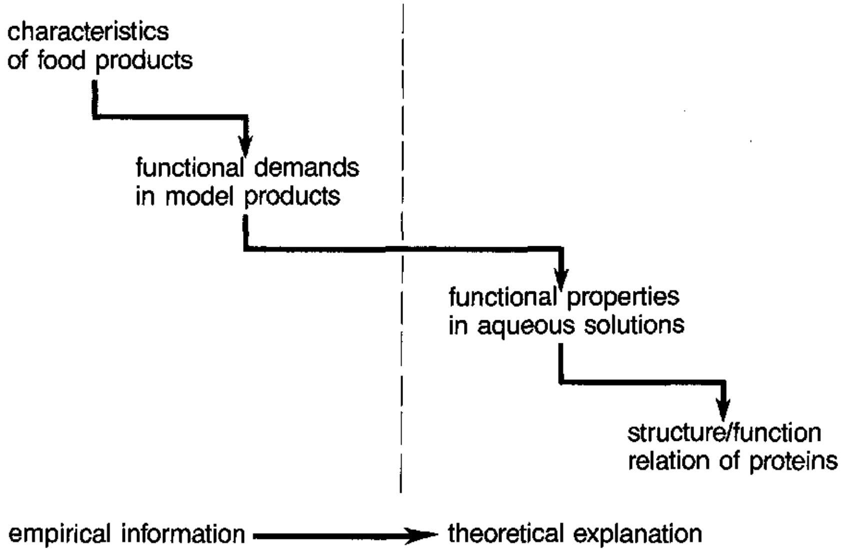

Fig. 2. Systematic evaluation of functional properties.

in that a great deal has already been elucidated on the structure and properties of the various isolated whey proteins.

Characteristics of some food products

Figure 3 shows some food products functionally suitable for use of whey proteins. They have been grouped together as beverages, confectionary goods, bakery products, and cheese and egg products.

The main characteristics relating to the protein fortification or stabilization of beverages are governed by high demands on organoleptic qualities, combined with good solubility or colloidal stability under various conditions. In the soft drink (shown on the left), this applies to pH between 2.5 and 3.5 in the presence of sugar, organic acid and small amounts of flavour emulsions. In fruit juice, there should be no flocculation with the solids from the juice in pH between 3.5 and 4.5. For a chocolate milk, one must prevent sedimentation of cacao particles and ensure adequate stability of the milk proteins during sterilization at pH of about 6.8.

Confectionary goods impose severe demands on the aeration and structure-forming properties of proteins. In this group we distinguish such products as meringues, light foam work and marshmallows, in which egg-white proteins and sugar induce an aerated structure after whipping and heat-setting. A second group includes fondants, chocolate centres and, for instance, nougat bars, whose palatability is improved by incorporating a highly aerated sugar-glucose syrup obtained by whipping with less than 5.9 of a whipping protein per kilogram syrup.

The bakery products include high-ratio cakes, in which the amounts of sugar and egg-white proteins exceed the amount of flour. The 'Dutch split' cookie 'Bokkepootje' presented on the left is an example of such a product. The aerated structure of this product is mainly based on a protein foam stabilized by sugar during baking.

The product in the middle is a sponge-like cake prepared from whole eggs, sugar and flour. The aerated structure of this product is mainly based on a phospholipoprotein type of foam from egg white and egg yolk. This type of foam is different in structure and properties from the pure-protein foam of the high-ratio cake. Some differences between the protein type and the phospholipoprotein type of foam are described by Richardson & El-Rafey (1948). Finally there is the Madeira-like cake shown on the top far right, and consisting of four main ingredients: whole egg, sugar, flour and butter. Aeration of this sort of cake is started in the fat phase and, during the melting of the fat, the air bubbles are stabilized by the egg lipoproteins and transferred to the aqueous phase (Shepherd & Yoell, 1976). So the functional demands on proteins in various aerated bakery products are quite different and not so easy to relate to the foaming properties of proteins in an aqueous solution.

The last product group involves pure protein-induced structures, as found in (soft) cheese and boiled eggs. In a boiled egg, this structure is largely based on the heat-induced gelation properties of the egg proteins. The cheese structure is obtained by

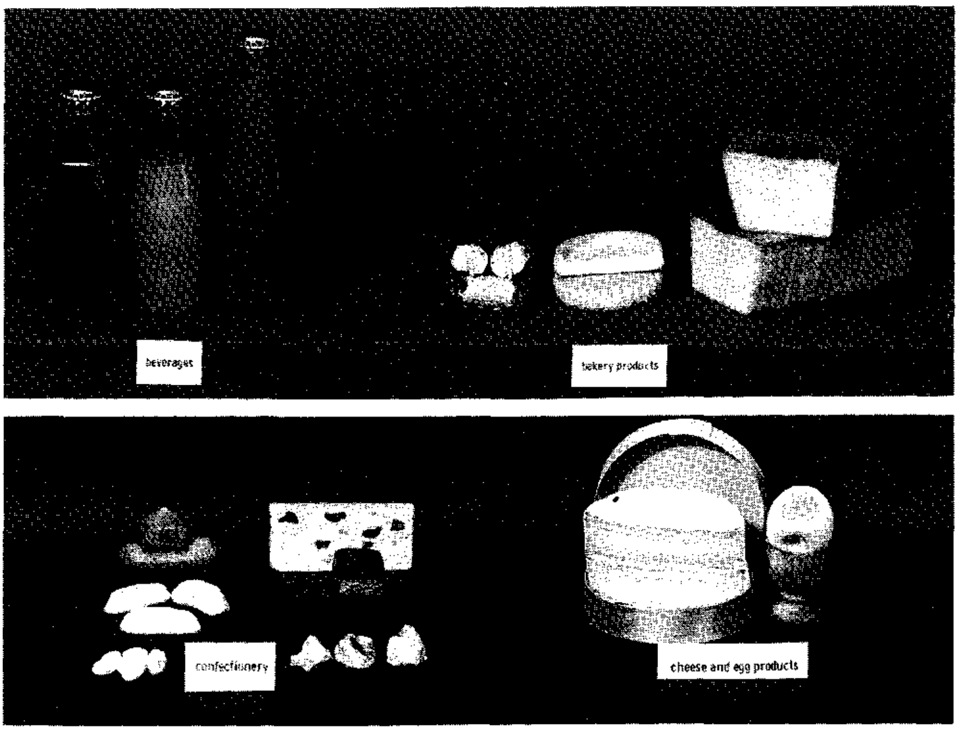

Fig. 3. Characteristics appearance of some protein-containing food products.

enzymically promoted gelation of the caseins. However identical structures are obtained by the heat-induced gelation of whey proteins, and heat-induced interaction bonds between whey proteins, fat and caseins. This will be discussed in our next section on model products.

Functional properties of whey proteins in model products or aqueous solution

So prediction of the contribution of WPC to some specific and desired product characteristics is virtually impossible without model products. We shall exemplify this by a few model products in which some of the previously discussed industrially prepared WPCs are incorporated as protein substitute or fortifier.

A bland taste and good solubility are requisites for the application of whey proteins in beverages. Undenatured whey proteins have proved to be suitable for that purpose (Kosikowski, 1979). However note well that not all beverages are appropriate for use of whey proteins without problems (Figure 4). For comparison both protein-fortified fruit-juice samples are accompanied by centrifuge tubes in which the solubility of the WPCs was measured at the same pH of 4.2 in water. For this particular fruit-juice, it was found that the most soluble WPC caused sedimentation of the fruit particles, whereas the least soluble WPC induced gelation.

Thus protein solubility as a functional property in an aqueous solution does not always coincide with solubility as a functional property in a beverage.

Another functional demand imposed on whey proteins is their suitability for use in making or stabilizing aerated products. This property is often identified with the foaming ability of WPCs in aqueous solution. It is generally known that the presence of fat in a WPC is detrimental to its foaming properties and this is also clearly shown by the meringues in Fig. 5A. Only the meringue prepared from 'QMA' (Fig. 5A-3)

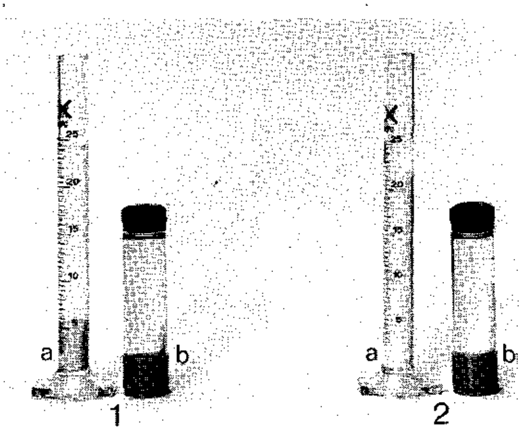

Fig. 4. Solubility of whey protein fairly undenatured (Sph. 'QMA'-WPC, 1) and more heavily denatured (Sph. 'S'-WPC, 2) incorporated at 30 g per litre in a citrus fruit-juice concentrate (a), and determined by centrifuging in an aqueous solution (b). pH = 4.2.

is of the same structure and appearance as the reference prepared from egg white (Fig. 5A-1). The meringue prepared from ultrafiltration whey protein concentrate (Fig. 5A-2) was reduced to a flat biscuit during drying, because of the presence of fat.

Another functional demand for meringues is the heat-setting property of the whey proteins. This property is very poor for the denatured whey protein concentrate Sph. 'S', so that this type is also unsuitable for meringues and light foam.

Fig. 5B shows a quite different result for sponge-like cakes, in which whole egg is replaced by WPC.

It appears now that by the presence of fat the ultrafiltration WPC gives better results than the defatted 'QMA' concentrate. As mentioned in the previous section, this is explained by a different type of foam: a phospholipoprotein foam of the ultrafiltration WPC appears to be more compatible with the wheat flour during the

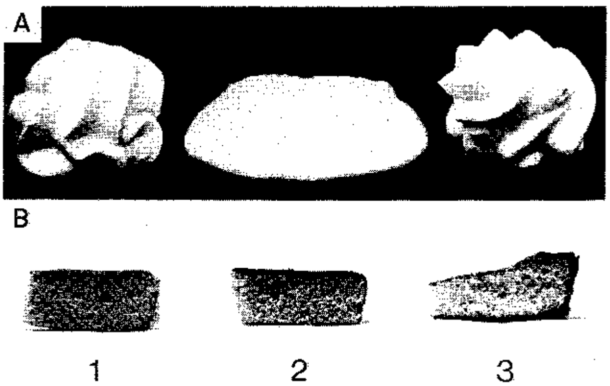

Fig. 5. A. Meringues prepared from sugar and egg-white (1), ultrafiltration-whey-protein concentrate (2) and the whey-protein concentrate Sph. 'QMA' (3). **B.** Sponge cakes prepared from sugar, flour and whole egg (1), ultrafiltration-whey-protein concentrate (2) and the whey-protein concentrate Sph. 'QMA' (3).

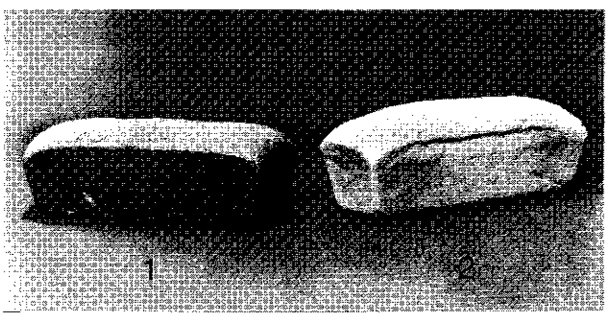

Fig. 6. Madeira-like cakes prepared from equal amounts of wheat flour, sugar, fat and ultrafiltration-whey-protein concentrate (1) or the concentrate Sph. 'QMA' (2), as complete substitutes for whole eggs.

whipping and baking process than a pure protein foam, although the results are still not good.

This, then, is a second example of the reverse relation between functional properties in water and the same properties in an actual product.

The discrepancy is even greater in a Madeira-like cake, where the emulsifying or fat-binding properties of the whey proteins are much more important than their foaming qualities.

One can prepare Madeira-like cakes with WPC as a complete substitute for whole egg and other additives, according to a modified procedure (de Wit & Hontelez-Backx, 1981). The presence of lactose in the WPC has effects on the colour of the cake, because of Maillard reactions (Fig. 6). Over 50% lactose in the ultrafiltration WPC (Fig. 6-1) was too much, but 3% lactose in the concentrate Sph. 'QMA' (Fig. 6-2) was too little, both for colour and taste.

The major functional demand on whey proteins is their heat-induced gelation and

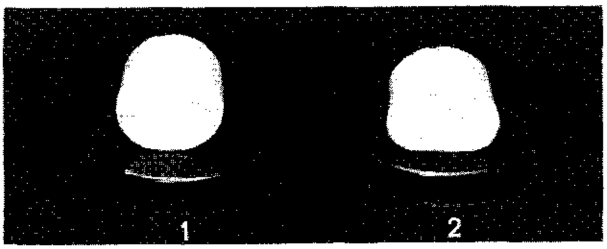

Fig. 7. Cheese-like model products, obtained with heat treatment of an emulsion of 100 g fat per litre caseinate emulsion after addition of 80 g whey proteins from Sph. 'QMA' (1) and Sph. 'S' (2).

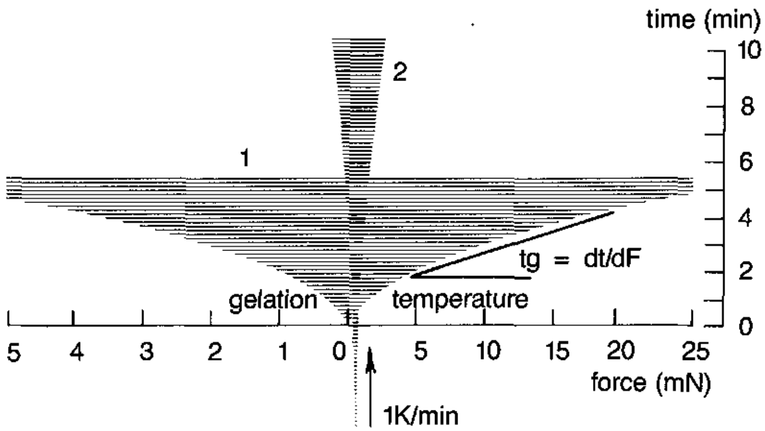

Fig. 8. Structure-forming characteristics of the cheese-like products shown in Fig. 7. Gelation temperature: 76 °C. Gelation rate (d*f*/d*t*): Sph. 'QMA' (1), 1×10^{-4} N/S; Sph. 'S' (2), 2×10^{-6} N/S. Gel strength: Sph. 'QMA', 2 N; Sph. 'S', 0

structure-forming quality. An important requisite for this quality is that the whey proteins should remain predominantly undenatured during the preceding processing steps. This is illustrated by Fig. 7, showing cheese-like model products prepared by heat treatment of a fat-in-caseinate emulsion in the presence of whey proteins from WPC. The structure obtained with the least denatured concentrate Sph. 'QMA' (Fig. 7-1) was much firmer than that obtained with the more denatured concentrate Sph. 'S' (Fig. 7-2).

The distinction is even more evident in Fig. 8, which reflects the rate of structure forming measured at the gelation temperature of both these model products.

The results in question were obtained with an Instron Universal testing machine, using a bulb probe in the oscillating mode for non-destructive measurements.

When the gelation temperature is reached, heating is stopped and the structure-forming rate determined by the reciprocal value of tg α (de Wit, 1984). The concentrate Sph. 'QMA' (Fig. 8-1) gives by far the best structure-forming results.

Structure-function relation of whey proteins

The following data form the point of departure for theoretical explanations based on the structure-function relation of whey proteins.

Recurrent phenomena discussed in the preceding pages were the heat denaturation and heat gelation or structure forming of whey proteins. Let me, therefore, conclude my paper with a schematic representation of the molecular changes which occur during denaturation and gelation of β-lactoglobulin, the most important whey protein.

The left hand part of Fig. 9 shows a model of undenatured β-lactoglobulin, which is actually a globular molecule with a diameter of 3 nm (3×10^{-9}m). This molecule includes 162 amino acid residues, illustrated as property-marking beads.

Through the presence at the globular surface of charged amino acid residues (indicated as black and dark beads), this molecule is soluble in aqueous solutions over a broad range of pH and salt concentrations.

The water-insoluble hydrophobic amino acid residues (indicated in light) are mainly hidden inside the undenatured molecule.

When β-lactoglobulin is heat-denatured, it unfolds and exposes the poorly soluble hydrophobic amino acid residues to water. This unfolding is partly blocked by two disulphide bridges (shown as beads with white dots) and generally not as complete as suggested by Fig. 9 (right) (Tanford, 1968; de Wit & Klarenbeek, 1981). However, the result after severe heat treatment at pH about 5.0, is always flocculation (as shown in the plastic bag on the right) and consequently loss of important functional properties (de Wit, 1981).

When the pH of the β-lactoglobulin solution is increased beyond pH 5.0, flocculation is promoted by heat-induced thiol-disulphide exchange reactions and by cross-linking through thiol-oxidation (β-lactoglobulin contains one thiol- of free -SH group).

In particular, heat treatments at and above pH 6.5 promote disulphide exchange reactions to the extent that at higher protein concentrations flocculation (without

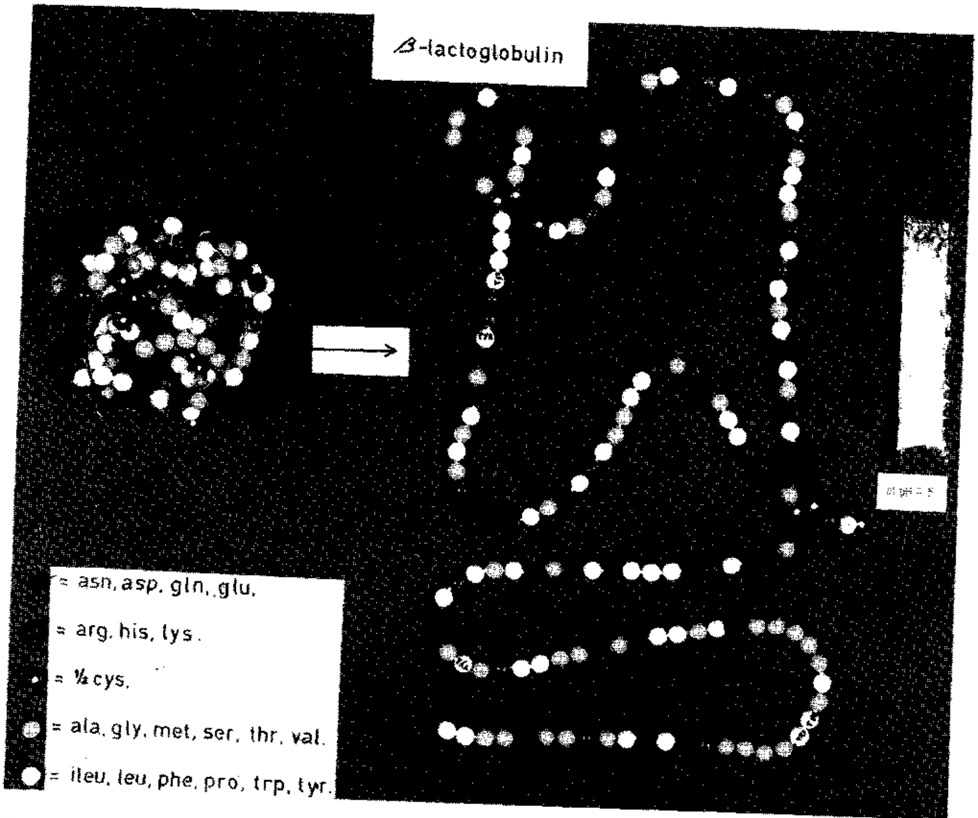

Fig. 9. Schematic model of the denaturation (unfolding) of β-lactoglobulin and the appearance of an aggregated β-lactoglobulin solution at pH 5.0 (right).

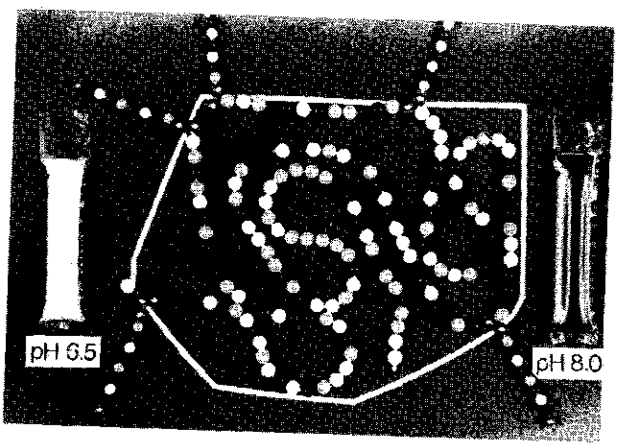

Fig. 10. Representation of the gelation of β-lactoglobulin between pH 6.5 and 8.0. The white encircling line encloses one molecule of β-lactoglobulin.

gelation) is dominated by protein gelation. This is illustrated by Fig. 10, which shows a gel structure identical to that of boiled white of egg in the plastic bag on the left. When, however, the same heat treatment is given to β-lactoglobulin solutions at pH 8.0, we observe a transparent gel, as shown on the right. The latter gel is completely soluble in β-mercapto-ethanol, a chemical solution that breaks down all disulphide bonds. So gelation of β-lactoglobulin is mainly based on the formation of intermolecular disulphide bonds, as presented schematically in the centre of Fig. 10 for protein concentrations exceeding 50 g/l.

Instead of β-lactoglobulin, other proteins containing thiol or disulphide groups, such as casein and other whey proteins, may be involved in the structure-forming or gelation process. This is how we try to explain a number of features in a given food product through a simplified system relating to that product.

Conclusions

Our approach to functional characterization of whey proteins for food products comprises the following steps.

1. Make an inventory of protein-related characteristics relative to a number of food products.
2. Formulate suitable model products to predict the behaviour of WPCs.
3. Compare empirical results with functional properties in aqueous solutions.
4. Assess these functional properties against basic data on milk proteins.
5. Feed back basic data on proteins, as obtained under representative conditions, to observations made in actual food products.

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Casein and caseinates: manufacture and utilization

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Summary

A short description is given of the preparation and properties of the milk proteins casein, caseinate, whey protein and coprecipitate.

Special attention is paid to casein and caseinates, and to the preparation of new types of coprecipitate (total milk protein) where high temperature heating is avoided and most of the whey protein is recovered along with the casein in a soluble and functional form. A survey is given of the food products containing milk proteins. In the manufacture of the soluble caseinates, it is possible to modify the properties of these products to highlight particular functional characteristics or alter the nutritional profile. Caseinate products are remarkably versatile.

Development of newer and modified forms of caseins and caseinates, and of new products such as total milk protein increase the range of options for the user.

CAB descriptors: milk protein, casein, caseinates, protein quality, food processing.

Introduction

In June 1967, at an IDF seminar on casein and caseinates in Paris, Mr A.E. Poarch of Western Dairy Products, San Francisco stated, and I quote, 'We are experiencing a revolution in the milk-protein usage field'. He was referring of course, to the increasing utilization of casein and caseinates in foods and the rapidly declining use of casein in industrial products such as wood adhesives, paper coatings, paints, and plastics. This 'revolution' in casein usage patterns has been worldwide and in some markets, over a period of about 20 years, there has been a total reversal in the propor-

3. Also published in German under the title Casein und Cadeinate-Herstellung and Anwendung (Deutsche Molkerei-Zeitung 1984 105(18): 1374-1379).

Table 1. Composition of milk proteins on mass fraction basis (g/kg).

	Protein	Moisture	Fat	Lactose	ASH
Nonfat dry milk	360	40	8	512	80
Lactic/acid					
Casein	870	95	11	1	19
Caseinate	910	40	11	1	38
Rennet casein	810	110	5	1	78
Coprecipitate	910	35	10	6	40

tion of casein used for edible and industrial purposes. The increased use of casein in edible food preparations has required that casein manufacturers invest substantially in sanitary plant and equipment to enable the production of edible-quality casein and caseinates on a consistent basis. This shift to edible use has also required significant on going investment in research, to develop innovative new types of casein and caseinate to meet the specific requirements of the food-processing industry. The revolution in casein use patterns has therefore had some far-reaching effects.

In any discussion of casein manufacture and utilization, we must first consider the raw material, which is fluid skim-milk. Fluid skim or non-fat milk, as it is known in the United States, has protein at a content of about 37 g/kg. About 80% of the protein is casein and 20% whey proteins. Casein is a phosphoprotein, which is insoluble at its isoelectric point, pH 4.6.

In all countries with developed dairy industries, significant amounts of fluid skim-milk are produced as the major byproduct of the butter industry. In many of these countries, fluid skim-milk is used to make products such as cottage cheese, non-fat yoghurt and a variety of low-fat or reduced-fat dairy products. Surplus fluid skim-milk is usually dried to produce skim-milk powder, which also finds some use in the food industry, particularly in baking and meat processing. While the price of skim-milk powder, which can vary significantly from country to country, is a major consideration in its use as a food ingredient, there are some other constraints to use of skim-milk powder in formulated food systems. Table 1 shows the composition of skim-milk powder, or non-fat dry milk as it is also known, as compared to the composition of some of the milk-protein products under discussion in this session. Skim-milk powder contains protein at about 350 g/kg together with all of the lactose which is present in fluid skim-milk. This significant lactose content can cause problems in processing foods containing non-fat dry milk, since lactose is a reducing sugar that will brown under certain conditions of heating. Also, in many formulated food systems, the presence of lactose will dilute the functional effect of the protein in the skim-milk powder. Excessive lactose also has some undesirable effects in foods formulated for special dietary purposes.

In view of the limitations on the use of skim-milk powder in formulated foods, be they economic or otherwise, it is not surprising that over the past 20 years, processes have been developed and refined to isolate and modify the different types of protein from skim-milk. Figure 1 shows the basic types of milk-protein product derived directly or indirectly from fluid skim-milk. The four primary protein products from skim-milk are acid casein, caseinates, rennet casein, and milk-protein coprecipitates. Secondary products include lactalbumin and whey-protein concentrate, which may

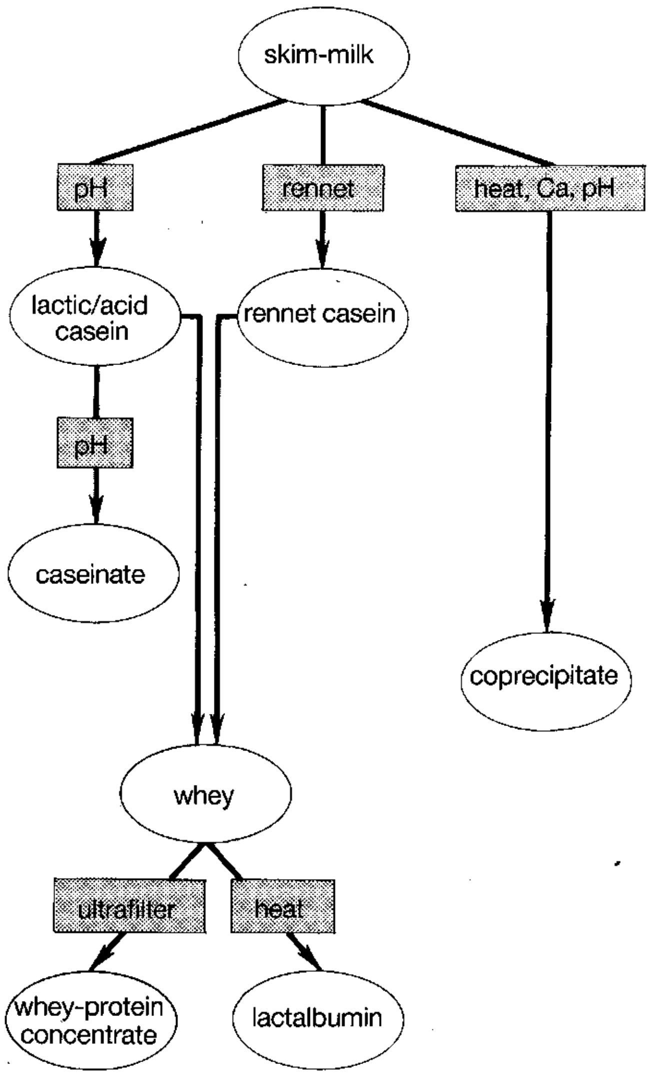

Fig. 1. Milk-protein products from skim-milk.

be derived from the whey byproduct of casein manufacture. Without doubt, casein is the most common protein product derived from skim-milk and I would like to discuss its manufacture in some further detail. The basic steps in the process for manufacture of casein are shown in Figure 2. The first step of the process involves

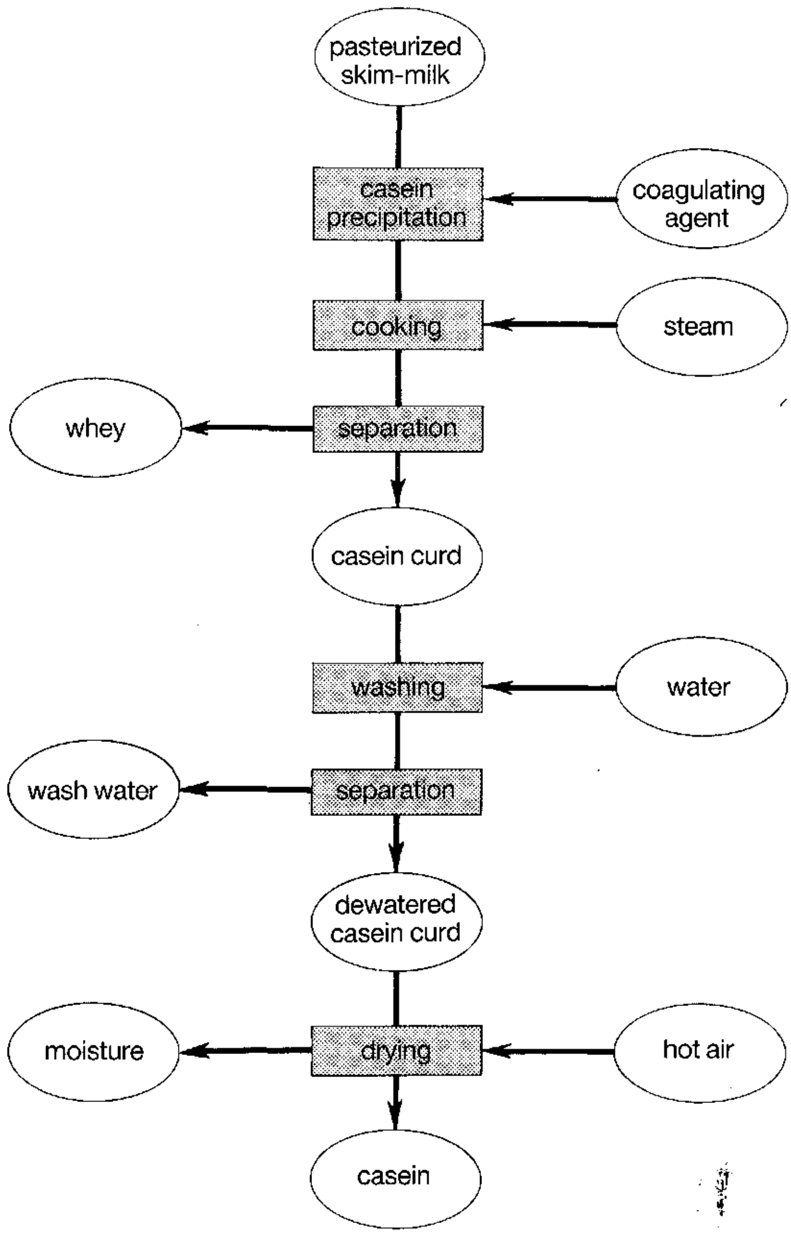

Fig. 2. Processing operations in casein manufacture.

the precipitation of casein curd, where different types of coagulating agents are used to destabilize the casein micelle in fluid skim-milk. After precipitation, the mixture of casein curd and whey is cooked in order to cause the curd to agglomerate and become sufficiently firm to withstand subsequent mechanical processing. After the cooking operation, the curd and whey are separated and washed with a countercurrent flow of water. After three or four washing cycles, the curd is separated from the wash water with a roller press or a horizontal solid-bowl centrifuge. These mechanical dewatering devices are capable of reducing the moisture content of the washed curd to within the range 500-600 g/kg. The dewatered curd is then conveyed to the drying system. Traditionally a vibrating-screen fluid-bed dryer has been used to dry casein curd, which is subsequently ground, but more recently pneumatic conveying ring-dryers or attrition-dryers have been used to reduce particle size and dry the curd in one operation.

The different types of casein which are prepared commercially are:

- acid-precipitated
    - lactic
    - hydrochloric
    - sulphuric
- rennet-precipitated.

Acid casein is often described by the type of acid used to reduce the pH, for example, lactic casein or hydrochloric casein. In the manufacture of lactic casein, a starter culture is inoculated into the skim-milk, which is incubated until the pH of the milk has fallen to about 4.6 forming a coagulum in the silo. By contrast, in the manufacture of hydrochloric or sulphuric casein, dilute acid is usually injected directly into skim-milk by means of a nozzle to achieve thorough mixing and reach a pH of about 4.6. After precipitation, the casein curd is cooked, de-wheyed, washed, dewatered and dried as previously described.

The basic properties of acid caseins are as follows:

- insoluble at pH 4.7
- low in calcium and phosphates
- solubilized by increasing the pH
- very good flavour stability
- heat stable
- very good nutritive value (per 2.5)

Acid casein is insoluble at its natural pH 4.6-4.7, but it can be rendered soluble at pH 7 by treatment with an alkali or an alkaline salt, forming caseinate. The caseinates are usually spray-dried but sometimes roller-dried to form white free-flowing powders, which are soluble or form stable colloidal dispersions in water. Caseinates are used in a wide variety of food products, where they provide supplementary nutritional value or play an important functional role in emulsification, thickening or film formation.

The other major commercial type of casein is rennet casein. In this process, skim-milk at its natural pH is inoculated with calf rennet or with a microbial milk-clotting enzyme preparation. After 20-40 min, the milk clots and is ready for further processing as described previously for acid casein. In the manufacture of rennet casein, the milk must be sweet, with no developed acidity; otherwise the quality of the resulting rennet casein will be adversely effected. The basic properties of rennet casein are as follows:

- insoluble at pH 7.1
- high in calcium and phosphates
- solubilized by sequestering the calcium
- excellent flavour stability
- heat stable
- very good nutritive value (2.5)

Rennet casein, unlike acid casein, is insoluble at pH 7 but it can be solubilized by a calcium-sequestering agent such as sodium tripolyphosphate, sodium hexametaphosphate, or trisodium phosphate. Rennet casein has an inherently bland flavour and demonstrates excellent flavour-stability during storage. For this reason, it is commonly used in the preparation of flavour-sensitive food products, such as cheese substitutes. Rennet casein has a nutritional value similar to acid casein, both products having a protein efficiency ratio of 2.5. The action of heat on skim-milk will help to induce complex interactions between casein and the whey proteins, mainly the β-lactaglobulin. This phenomenon forms the basis for the commercial preparation of another group of casein products, namely the milk-protein coprecipitates. Traditionally, the coprecipitates are manufactured by heating skim-milk to a temperature of about 85 °C, which will induce casein-whey-protein interactions and will allow coprecipitation of the proteins by subsequent reduction of pH or addition of inorganic calcium salts to the hot skim-milk. These coprecipitates are available with varying levels of calcium, which affects the solubility of the base product at pH 7. The amount of whey protein coprecipitated along with the casein varies in the tradi-

Table 2. Protein efficiency ratios of various food proteins. PER, protein efficiency ratio; USRA, United States Recommended Allowance.

	PER	USRA (g/d)
Vegetables proteins		
soya	1.4-2.2	65
maize	1.1-2.0	65
wheat	0.8-1.4	65
peanut	1.1-1.8	65
Milk proteins		
non-fat dried milk	2.7-2.9	45
coprecipitate	2.7-2.9	45
total milk protein	2.7-2.9	45
casein	2.5	45
caseinates	2.5-2.6	45
whey-protein concentrates	3.0-3.2	45
lactalbumin	2.8-3.0	45

tional process from about 40 to 60% of the total whey protein present in the milk. In more recent developments, new types of milk-protein coprecipitates have been manufactured, where high-temperature heating is avoided and most of the whey protein is recovered along with the casein in a soluble and functional form. These milk-protein isolates are now commercially available in various functional forms. They have a nutritional value superior to caseinate. The nutritional value of the range of milk-protein products discussed so far, together with some other milk and food proteins, is set out in Table 2. The superior quality of milk protein is evident and the possibilities for routine use to upgrade vegetable-protein quality are clearly indicated.

In the manufacture of the soluble caseinates, it is possible to modify the properties of these products to highlight particular functional characteristics or alter the nutritional profile. The functional versatility that can be built into caseinate products is evident in the following list:

- high solubility
- bland flavour profile
- high opacity
- excellent suspension-stability
- calcium sensitivity
- high foaming stability
- high emulsification capacity
- heat stability
- high dispersibility
- low viscosity
- high viscosity
- increased acid stability
- water/fat binding

Though no single caseinate product will exhibit all the characteristics listed, the best product for a particular purpose can usually be selected from the range of caseinate products now commercially available. A recently published United States Food Ingredients Standard describes caseinates as white to cream in colour and granular or powdery in form, being soluble or dispersible in water, and being prepared by treatment of casein with food-grade alkalis, neutralizing agents, enzymes, buffers or sequestrants. A standard of this type, if widely adopted, would give the milk-protein manufacturers considerable flexibility in formulating caseinates with widely differing physical and functional properties, while working with safe and suitable ingredients in accordance with good manufacturing practice. In many food applications, the properties of other proteins may well be complementary to those of the caseinates and so a mixture of protein types may be considered in any food application where a protein is required for both a nutritional and functional purpose. Alternatively, a coprecipitated milk protein may be the most appropiate material to obtain the correct balance of nutritional quality and functionality in a particular food system.

Applications in food

In view of the number and versatility of the milk protein products prepared commercially from skim-milk, it is probably not surprising that milk proteins are so widely used in formulated and prepared foods. A list of the generic food products known to contain milk protein is catalogued below:

coffee whiteners
custards
frozen desserts
pies
imitation cheese
cookies
pet foods
acidic beverages
pasta
breakfast cereals
soups
cream liqueurs
breakfast bars
imitation cream cheese
high-protein diet powders
luncheon loaves
Quiche
extruded snack foods
imitation milk
whipped toppings
dips
cake mixes
biscuits
wafers
cheese sauce
cocoa mix
pudding
hams
yoghurt drinks
doughnuts
diet wafers
nougat
pet foods

If you consider the utilization of milk proteins in all of these food products, you will note that the milk proteins have been used not only for nutritional purposes but also to thicken, emulsify, stabilize or bind water in the various food systems. For example, in cheese substitutes, the milk-protein system not only provides nutrition and helps to hold the vegetable oil in a stable emulsion, but being a thermoplastic protein it is almost indispensible in preparing a cheese substitute with the melting characteristic of a natural or processed cheese. Similarly, in a whipped topping, a caseinate will act as an emulsifer and film-forming agent and will help to impart the required freeze-thaw stability to this type of product. In the meat-processing industry, caseinates are used for emulsification and water-binding in those products where there is a deficiency of the soluble and functional natural meat protein, myosin. In some applications, where milk proteins are used predominately to boost the nutritional quality of the food, the protein ingredient must not be allowed to cause a change in the textural or organoleptic properties of the food system. For example, in the fortification of pasta, it is necessary to use a particular form of milk protein compatible with the pasta dough system. Similar requirements apply in other applications, such as snack foods, bakery products, breakfast cereals and cooked dough products, where the milk protein is used primarily for nutritional fortification.

In the food applications I have covered in brief, casein, caseinates or milk-protein coprecipitates are not simply used as substitutes for skim-milk solids. While some of the end-products may well simulate traditional food products prepared from milk or egg, the use of the milk-protein ingredient offers the consumer an equally nutritious food that is usually cheaper than the traditional counterpart. The availability of the concentrated milk proteins offers the food processer considerable flexibility in formulating a food product to meet specific nutritional and organoleptic requirements. As you well know, protein concentrates or isolates from other sources such as soya and wheat can be similarly used in food systems for functional purposes, although I would venture to say that the milk proteins continue to have several advantages over the vegetable-protein products. This may not always be so but casein provides a strong foundation for the development of new milk-protein derivatives that will continue to have wide application as specialized food ingredients.

Perspective casein and caseinates

In closing, I would like to offer a perspective on the economic and practical realities that govern the use of casein and caseinate products and which largely determine the extent to which milk proteins in the form of isolated caseins, casienates and related products can realize the potential for their utilization in food systems.

World production of casein has in the last two or three years risen because of a significant growth in production in Europe to an extent exceeding decreased production in such countries as Argentina. The European increase has been encouraged by the availability of surplus milk and substantial subsidies on manufacture. Yet total utilization of casein products in each of the main markets has changed little, the development of new uses in foods just compensating the amounts lost in former industrial uses. While a proportion of these new uses in food do indeed exploit significantly the special characteristics of caseins and caseinates, much of the new use is in areas of substitution that are less dependent on functional properties and more upon price. As such, they are vulnerable. Moreover with static total demand, in the major markets and an excess of supply for the reasons noted above, there has been a significant drop in prices that has not, however, stimulated demand. The market for casein proteins is relatively unaffected by price reduction, compared, for example, with skim-milk powder.

Apart from these economic and competitive factors, questions of deliberately restrictive food regulations in many countries, of food-labelling requirements, of consumer misconceptions as to the 'chemical' nature of caseins and caseinates, and of inconsistent functional performance for similarly described competing products all considerably affect the opportunities to broaden the use of isolated milk-protein products. Some of these adverse factors may well be susceptible to concerted efforts to ameliorate them.

Development of newer and modified forms of caseins and caseinates, and new products such as total milk protein do increase the range of possibilities for the end-user, but seem unlikely to be additive in their effect on total utilization of milk proteins. They are part of a structural change within static total demand.

Furthermore, the realization of the uses of milk protein in new areas of application requires a sophisticated and expensive system of research, development and technical marketing that demands a long-term commitment. Such a commitment exists as a matter of necessity for New Zealand, since caseins and caseinate are a major part of its milk-utilization strategy.

So the realization of increased utilization of caseins and caseinates seems likely to be considerably more restricted than their purity, high nutritional value and functional versatility would suggest. We could all wish that such was not so. Indeed some may disagree with what I say, but to disagree would seem to be inconsistent with both experience to date and with the forces at work in the market.

There is certainly a path forward but considerable effort is needed for any measure of success. Supply can easily exceed demand, so that the benefit passes to the user to the extent that it leaves the producer insufficient return to justify the effort expended.

Milk proteins in meat products and soups or sauces

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Summary

Milk proteins are discussed from the point of view of the industry, a major user of these proteins. The best documented dairy ingredients in meat products are the caseinates. Their properties and application are treated in some detail.

Mention is made of the soluble coprecipitates and the new total milk proteinates that may achieve stability comparable to that of caseinates.

Protein-rich whey protein concentrates are considered as to have the capacity to improve the consistency of certain heated milk products, but they still need further adaptation and development.

Remarks are made on the use of skim-milk powder. Calcium is a negative factor in meat products. Lactose is sometimes desired, sometimes undesired.

In soups and sauces, there are applications for a variety of milk-protein (-containing) products. The same holds true for whey-protein concentrates in dressings and caseinates in canned concentrated cream soups and powdered soups or sauces.

Insoluble milk proteins are considered as to have only limited application.

Meat-like texturized milk proteins have to compete with cheap alternatives of plant origin.

CAB descriptors: milk protein, meat, protein quality, easein, dried milk, whey protein, soups, sauces.

Introduction

The contributions of meat and milk production to the world supply of food protein may be estimated to be equal: about 20 million metric tonnes each. Meat and dairy products also share traditionally esteem as two of man's prime protein sources, for their nutritional and organoleptic qualities. As a consequence, the meat and dairy industry have a common interest in a positive image for animal protein.

In other aspects, the meat industry differs tremendously from the dairy and many other food industries. Unlike dairy colleagues, for instance, meat processors have to face non-uniform and variable raw materials, mostly processed in batch operations using not too well defined equipment, such as mincers, bowl choppers, massagers and tumblers, to produce a wide range of different meat products. Only since about 1970 has research on raw materials, processes and product stability started to contribute more exact data than empirical results and finger feel. So new (dairy) ingredient suppliers experience their approach to the meat industry either as a rewarding experience or – if not properly – as a 'frustration beyond their worst nightmare'.

Meat products

Dependent on the country, meat products represent between 9 and 33%, on average 25%, of total meat production (Table 1). Processed meats are all meat-based products that need more than just cutting from the carcase. They are enormously diverse and for their classification many different criteria may be used. A subdivision often made in national meat products statistics is that between ham and bacon, canned meats, burgers and sausages. Sausages may be split up into many categories such as fresh, dried and fermented, smoked, cooked, liver and blood. Throughout the world, thousands of different meat products exist, whose character is often regionally determined. In West Germany alone, consumers can choose from about 600 different meat products. Apart from the above categories we know, for instance, meat snacks, fabricated portioned products for institutional markets and meat-based delicatessen.

Table 1. Production of meat and meat products in different countries and groups of countries in 1983 (in 1000 t).

	Total meat[1]	Meat products[2]
Belgium	895	180
Denmark	1 395	325
West Germany	4 988	1 230
France	5 234	666
Great Britain & N. Ireland	3 099	1 100
Italy	3 500	874
Netherlands	2 348	218
European Community (10 countries)	22 300	4 600
United States	24 127	5 000
Japan	3 090	500
All countries of OECD	64 400	16 100
Eastern Europe[3]	23 000	?

1. Beef, veal, pork, poultry and sheep, expressed as gross carcase weights. Statistics of the Organization for Economic Cooperation and Development (OECD)
2. Various local statistical sources.
3. Including the Soviet Union.

Worldwide, beef and pork raw materials are about equal and stationary in importance; the proportion of poultry ingredients and products is increasing quite rapidly. Fish is sometimes used in meat products in Japan. Quite a variety of processed fish products exist – especially in Japan, Korea and Scandinavia – like fishburgers, fish sausages and fish cakes (e.g. Kamaboko), and which in the following can also be treated as meat products.

In Table 2, the degree of comminution of the basic meat ingredients is used as criterion to classify meat products, because it largely corresponds to why and how non-meat ingredients, such as milk-protein products are incorporated. They are not used in the production of primal cuts, trimmings, boxed beef or other raw materials, but they find their major application in comminuted meat products. Sometimes, however, they are used in injection brines for uncomminuted products, like cooked hams. Different countries show quite different production profiles of the various classes of meat products (Table 3). This, and the different national meat product regulations and the different contribution of various other non-meat proteins and additives (e.g. phosphates, starches) make realistic estimation of the potential for milk proteins in the meat industry rather difficult.

Table 2. Classification of meat products.

Degree of comminution	Examples
none	hams (cooked, smokes, dry); bacon, cooked loins; shoulders
some	ham off the bone; shoulder
coarse	(semi)dry sausages (Salami, Cervelat); fresh sausages (Bratwurst, 'Banger'); hamburgers; meat patties; meat balls
finely	frankfurter; wieners; Polony; Pariser; mortadella; liver sausages/spreads; meat loaves; meat spread.

Table 3. Production of some meat products in particular countries, expressed as proportion of total processed meat volume (%), based on various national statistics, 1981-1983.

	Sausages		Hams		Liver products
	fresh	cooked[1]	cooked	dry	
United States[2]	7	29	11	0.6	0.6
Japan	5	15	20	<0.1	<0.1
West Germany	18	36	9		11
France	12	8	25	13	10
Italy	–	20	31	15	< 1
Great Britain & N. Ireland	35	–	3	< 1	< 1
Netherlands	8	13	24	0.5	14

1. Including canned sausages (e.g. wieners).
2. Excluding cured and fresh/frozen products; including meat patties & minced beef.

When USDA admitted whey products to be used in standardized meat products, Schwarz (1982) estimated the potential for binders in the U.S. meat industry to be about 100 000 tonnes. But he granted this to be an unrealistic goal, only giving some idea of the ultimate potential market. At present some tonnes of non-fat dry milk are used in the U.S. meat industry, the equivalent of tonnes of milk protein. Unlike soya-protein isolates, the use of milk proteins, type caseinate, is not allowed yet in the U.S. for standardized meat products.

Timm et al. (1982) estimated the annual use of milk proteins in West Germany meat production to be 3 000 tonnes (mainly caseinates), which represents 0.25% of the total meat products volume. Several other countries show a substantial higher percentage of overall use. Taking 0.5% as a realistic potential level of high-protein milk-protein products in processed meats, the world market may be estimated to be some 100 000 tons. Presently only a part of this realized. Nevertheless this meat industry is an important user of milk-protein products.

The above figures only consider the use of milk-protein products for functional/technological or extending reasons and not the substitution of lean meat.

The functional/technological use of milk proteins aims at improving the stability of processed meat products and, more in particular, the comminuted types of products. Without these functional ingredients comminuted meat products may not have a great deal of stability and will break down if not properly processed. In coarsely comminuted products the functional protein should assist in water- and meat binding and in improving texture; in the more finely comminuted, 'emulsified' products its emulsifying properties are called upon in addition.

Normally the addition of milk proteins need not to go higher than 3% on the meat product in order to do its functional job properly. Although all showing different stabilisation mechanisms, competitive, functional additives used in the meat industry are soya-protein products, bloodplasm powder, phosphates, starches, mono-diglycerides etc. For extending a meat product formula the high-protein products are often too expensive and as a consequence products with lower milk-protein contents are used. Concentrations used then are often considerably higher than 3%.

Milk protein products

Skim-milk powders

Skim-milk powder (s.m.p.), which may be considered as a milk-protein product, has traditionally been used in the preparation of many kinds of comminuted meat products. In some countries, the U.S. and Scandinavia in particular, it is still extensively used. It often contributes favourable to the flavour of the meat product and sometimes also to its stability. However, knowing that the milk proteins in s.m.p. are present in a micellar, low-viscous form, which is not optimum for emulsifying purposes, and knowing that calcium may negatively influence the binding properties of lean meat proteins, the calcium-reduced form of s.m.p. appears the more logical and more functional choice for meat products. In the U.S. meat industry this calcium-reduced s.m.p. is used quite a lot, also due to the fact that it has been allowed for use in the important category of standardized meat products. Quite recently partially delactosed whey powders with 25 - 40% protein were introduced for use in meat products. Few specific, functional advantages in meat products have been detected so far, but they are certainly able to substitute part of the s.m.p. in meat product formulas economically (Lee et al., 1980; Rust and Olson, 1982; Lefèvre, 1979).

Apart from its taste enhancing properties the lactose present in the above mentioned products has no significant stabilizing properties. In products heated at temperatures over 95 °C it may even give unwanted browning reactions.

Caseinates

A logical step was to isolate the functional milk protein in its most concentrated (low lactose) and most functional (low calcium), condition which is in the form of a soluble caseinate. It is now twenty five years ago that milk protein, type sodium caseinate started its advance as a functional protein ingredient in the meat industry. And it has gone far since then. At present caseinates are the best documented non-meat proteins and used all over the world. Well documented regarding the range of products, the mechanism of action in meat products and the application technology. They are mainly used because of their excellent emulsifying properties and as a result the main application field is that of the rather finely comminuted meat products (meat emulsions).

In contrast to most minced-meat or non-comminuted products an important amount of free fat is created during the preparation of these products, which must be stabilized. Caseinates, being used in the right way, do not only stabilize the fat but also contribute indirectly to better water binding and consistency. They save part of the soluble meat proteins from denaturation in the interface, leaving it available for gelling upon heating (Schut & Brouwer, 1971). This is very important, because in commercial recipes there is often a relative shortage of functional meat proteins because of raw materials or formulas, non-optimum processing procedures, intensive fat comminution etc. etc. Consequently, milk protein, type caseinate, is first of all a functional protein giving the meat product a better stability. It supports and supplements the original meat proteins and does not affect the authenticity of the products when applied in the normal, functional proportions (< 3%). Analytical methods for the qualitative and quantitative determination of caseinates in meat products are available and presently in use.

Caseinates may be applied in dry or presolubilized form at the beginning of the comminution proces, but frequently optimum stability results are obtained when they are processed in the form of previously prepared caseinate/fat (pork skin)/water emulsions. (Schut & Brouwer, 1975; Visser et al., 1983). Quite a lot of work has been spent in the last decade to develop a wide range of pre-emulsion technologies matching almost all possible conditions in meat practise, regarding equipment, temperatures, ratios, consistencies and types of fat. Especially the technologically more difficult and cheap types of fat (beef fat, sheep fat, rendered fat etc.) may perfectly be used by pre-emulsifying them with caseinates. Many detailed and practical application technologies for special meat products and meat processing concepts (preblending e.g.) have been worked out (Hoogenkamp, 1979) and a range of caseinates, tailormade for use in meat products are available at present:

– sodium- and potassium (low-sodium!) caseinates with adapted viscosities, from low till very high. The *high-viscosity types* are very useful in the preparation of economical pre-emulsions.

– special caseinates-type products for use in dry or semi-dry fermented sausages, for use in *low-phosphate meat products.*

– high-density/low dusting caseinates.

New caseinate-based unconventional technologies have been developed for the preparation of for instance liver products and meat spreads (even foamed), all-beef and chicken formulas, the incorporation of mechanically recovered meats.

Giving an improved stability, the economy of the milk protein addition may work out in different ways for each meat processor, depending on the philosophy on quality and production technology, on his formulations and possible problems, on his market demands etc. The possibilities from better stability to economy are:

– improved quality (appearance, flavour, consistency)
– improved production yield
– possibility for more economic formulations (fatty tissue)
– more safety and flexibility in processing
– more freedom in product development.

A rather important property, exclusively shown by soluble caseinates and to a cer-

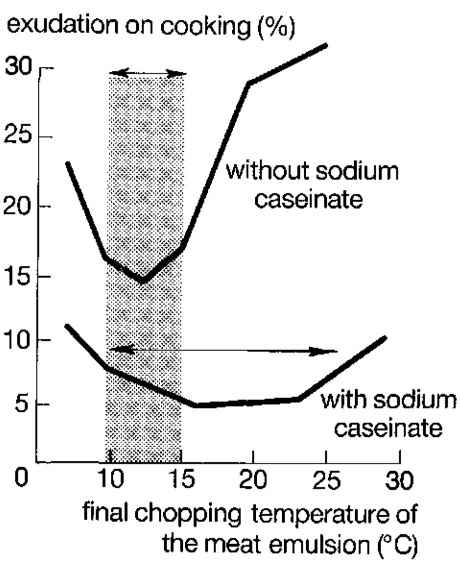

Fig. 1. Stability of finely comminuted meat products independence of the final chopping/emulsifying temperature.

tain extent also by the protein in decalcified s.m.p., is that the stability of comminuted meat products becomes less sensitive to the chopping temperatures, yielding a more safe and flexible manufacturing process. Fig. 1 shows this effect schematically. The strong influence of comminution temperature and time on the product stability is related to the types of fat and other raw materials used, on the formulation etc. This is not only a precariousness for the manufacturer, but also restricts the value of many laboratory or pilot tests done so far on meat product stability and on the influence of functional ingredients.

Total milk proteins

Another group of milk protein products, combining the caseins and whey proteins in their natural ratio, includes coprecipitates (soluble/unsoluble; high/low Ca), milk protein concentrates (M.P.C.) produced by ultrafiltration of skimmed milk and total milk proteinates (T.M.P.) recently introduced and produced according to a new process (Connolly, 1983).

Conventional coprecipitates up to now did not obtain a significant foothold in the meat industry, probably because their solubility and their functionality in meat products could not match that of soluble caseinates, unless solubilizing agents like tripolyphosphates were used which themselves positively influence the binding properties of meat (Goldman, 1974). The precipitation of whey proteins on the casein may have negatively affected the functional properties of the casein part.

Little is known yet on the actual performance of T.M.P.-products, which have the whey proteins present in a soluble condition along with the soluble casein fraction. Functional properties have been claimed, to be better than of conventional coprecipitates. Orientating tests do not indicate special functional advantages in meat applications as compared to traditional caseinates. However, if their performance would be close to that of caseinates, the above products may have labeling advantages compared to caseinates, because the latter are not in all countries allowed to be declared as milk proteins. In addition the nutritional value is somewhat higher than that of caseinates. MPC generally speaking has some functional disadvantages, being accompanied by calcium and lactose, and needs further documentation regarding meat applications.

Whey proteins

None of the milk-proteins products, mentioned above have heat gelling or extensive swelling properties. This restricts their functional/technological application in coarsely or non-comminuted meat products, unless special application technologies are used.

Although not swellable, the whey-protein concentrates (WPC), produced by ultrafiltration (50 - 80% protein) and whey-protein isolates (WPI) have a well documented heat-gelling ability (Hermansson, 1983). The relationship between gelling properties of non-meat proteins and performance in meat products, however, is very complex and not well understood (Hermansson, 1983) and interactions with meat proteins may play a decisive part in it. In addition, gelling of whey proteins only occurs at protein concentrations well above 7% and at temperatures over 70 °C, conditions normally not present in e.g. cooked ham or burger-type of products. So far, WPC's have not been too succesful in filling the functional gap of milk proteins in coarsely comminuted meat products. In finely comminuted products their stabilizing properties are not extensively documented but in general their stabilisation effect is not competitive to for instance caseinates (Karmas & Turk, 1976). Previously prepared WPC/fat/water emulsions may show good emulsification, but are in general rather fluid when produced in economical ratios. These low-viscosity properties, however are of advantage in case a meat processor wants to fortify his comminuted meat product with protein without having a too quick increase in temperature during chopping.

The heat coagulating /gelling properties are responsible for the fact that WPC's are increasingly appreciated as improvers of the consistency of meat products like liver sausages, patés, Frankfurters, etc. and with some additional application know-how this application might be a good potential. Some types of WPC were shown (Lefèvre, 1979) to be capable of replacing egg-white in liver paté on a cost effective basis. Whey-protein products show interesting potential, but still need further modification and adaptation before a strong positive impact on the stability of meat products can be obtained.

Structured milk proteins

Since most of the before-mentioned dairy proteins are soluble, they cannot be expected to replace or substitute significant amounts of lean meat in commercial meat products. For that purpose a fibrous, swellable, but not soluble protein structure is needed. Most of the unsoluble varieties of milk proteins, like acid and rennet caseins, Ca-coprecipitates, 'lactalbumin', although not very suitable for functional use in meat products (Dale et al., 1981), have some water absorbing or swelling properties. Thomas et al. (1976) showed coprecipitates to have good possibilities for simulation of meat. Poznanski et al. (1981) and English (1981) worked on renneted curd products as suitable meat substitutes.

Several further reports and patents have appeared during the last decade describing possibilities to texturize milk proteins. Various techniques and different milk proteins have been used. Although reasonable and good textures have been obtained, neither large scale, commercial production nor succesful marketing of the products in the meat or fish processing industry has taken place so far. The bottleneck has probably been the raw material and processing costs not being able to compete the cheap soya alternatives. In view of the relative abundance of meat available in some markets it may be wondered whether substitution of lean meat in manufactured products, for instance in the EC, is the most sensible thing to aim at.

Conclusion

Today some milk-protein products serve a good purpose in the meat processing industries all over the world. They are appreciated for their functional performance, their good flavour, colour and nutritional profile. Because of this they are able to keep their foothold with vegetable-protein products.

There certainly is a place for more and new specialized protein products (Visser, 1981). Basically, the milk proteins are promising starting materials for the development of such products. However these products should concur with meat-industrial needs and practices. Unfortunately the relationship between functional properties perse and actual performances in industrial meat practice are far from clear and pilot- or laboratory scale tests on meat products need a world of attention and meat processing experience before they may be claimed to be representative and/or predicting for industrial performance. Only experiments made with practical recipes, using standardized, but commercial raw materials as used in industry, using procedures and types of equipment as close to actual practice as possible, standardizing every single step in processing (temperature, time, speed etc. etc.), sampling at different stages (temperatures!) in the process and judging the final products as extensively as possible, will give you adequate information. I cannot help observing that in many cases development and research workers, both in industry and at institutes and universities still do not all realize this sufficiently, explaining many of the often contradictory and confusing results in published work. And this is without mentioning the fact that in many of the tests the functional ingredients are not used in the right way, by not giving them the chance to function properly. Milk proteins have a very positive quality image both in the meat industry and at consumers. In a 1982 extensive Dairy Crest survey of U.K. consumer attitudes, it was shown that around 85% of British housewives believe that the use of real dairy ingredients imparts good taste and texture to processed foods. The listing of milk protein on the label of meat products certainly does not detract from the meat products quality image, on the contrary.

Milk proteins in soups and sauces

This sector of the food industry also knows a very wide range of products. Marketed in fresh, refrigerated, deep frozen, pasteurized or sterilized condition, marketed as a normal soup/sauce, ready to use, or in double concentrated or even dry form, as a soup powder for instance. The product shipments in 1983 of pickles, sauces and salad dressings in the US was more than 4 billion US-dollars.

A variety of milk-protein (-containing) products can be used, mainly for the purpose of emulsification. Skim-milk powders are extensively used, both in neutral and acid sauces and in cream-type of soups. In canned cream soups and sauces soluble caseinates may be used as emulsifying proteins without the browning effect of the lactose. Caseinate emulsions generally show very good sterilisation stability. Using s.m.p. or caseinate in acid sauces or dressings, one should first prepare the neutral emulsion before adding the acid ingredients. WPC's may be used advantageously in such acid products because of their good acid solubility. Combinations of whey proteins and caseinates are suitable too, the caseinate part giving some additional thickening in the acid conditions. The actual choice between the mentioned protein ingredients is also determined by the kind of thickening agents and starches used in the soup/sauce formulations. Little is known of specific interactions between different milk proteins and thickening agents and/or starches and flours.

Main competitors for milk-protein ingredients in these products are synthetic emulsifiers and egg (yolk) proteins.

Dry emulsions or powdered fats are often used in dry creamsoup or sauce mixes or in instant dressing powders. These dry emulsions can be prepared with s.m.p. or caseinate as the emulsifiers. It was recently shown that caseinates may give a somewhat better protection against oxidation of fats/oils in such dry emulsions (Visser, 1983).

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Applications in confectionary and bakery products

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Summary

Dairy products are traditional ingredients in confectionery and bakery products. Texture, flavour and colour result directly from the addition of dairy ingredients. There is an increased and justified interest in milk-derived ingredients.

Each milk constituent can be shown to perform useful functions other than just addition to the nutritive value. Properties of particular interest are texture and flavour with milk fat, colour and flavour with lactose and proteins in the browning reaction. Some applications are discussed.

Casein and whey proteins, the two major classes of protein, function differently in candy, chocolate and bakery products. Both proteins have emulsifying properties. Caseins can absorb water; whey proteins have better foaming properties.

Milk powder in one form or another is a valuable ingredient for milk chocolate. Roller-dried powder is widely used. The properties of roller-dried and spray-dried powder are discussed with respect to expected characteristics in chocolate. Fluidity of chocolate is extremely important as it effects handling characteristics. Dairy products, rich in proteins, are highly appreciated ingredients in candy, chocolate and bakery products.

CAB descriptors: dairy products, dried milk, candy, chocolate, bakery products.

Introduction

Dairy products are traditional ingredients in confectionery and bakery products. It is widely accepted that texture, flavour and colour, expected characteristics in these commodities, are influenced by the addition of dairy ingredient.

Confectionery and bakery products cover a broad range of products with different composition, structure and organoleptic properties. On the other hand, a great diversity of milk products are used:

– products with large variations in moisture content (liquid milk, evaporated milk, condensed milk and milk powder)
– products with different fat levels (whole milk, milk powder, cream, butter and anhydrous milk fat)
– products with different protein levels (milk powder, protein concentrates, whey protein concentrates, caseinates).
This short communication deals with the role of milk proteins; however the interaction with other ingredients such as lactose, minerals and fats has to be considered as well.

General functional properties in confectionery and bakery products

Properties of particular interest in confectionery and bakery products are texture, flavour and colour. The addition of milk proteins in one form or another improves the expected characteristics.

Texture-related functional properties are largely influenced by the addition of milk proteins. Water-binding, emulsifying and foaming properties are of particular importance. Caseins show excellent emulsifying and water-binding properties. The foaming properties of whey proteins are well established.

Colour is an important quality attribute in a range of confectionery and bakery products. Browning reactions affect colour, flavour and stability of foodstuffs. Upon addition of milk proteins, browning is mainly a sugar-protein interaction or a Maillard-type reaction. Caramelization reactions are mainly important in sugars, heated in the absence of proteins.

The interaction of reducing sugar with protein is complex, leading to a series of intermediates and reaction products. The reactivity of dairy products to browning is well known. The occurrence of many free NH_2 groups of lysine explains the reactivity of milk proteins. The reaction may be controlled with the lactose concentration in milk proteins.

Browning reactions are generally considered as negative, especially during transformation of milk into dairy products by heat treatments. Processes are optimized to minimize browning reactions.

In manufacture of confectionery and bakery products, browning is often a desired quality factor. Brown polymers or melanoidins are formed. Intermediates are colourless or yellow. They considerably affect the stability of bakery products.

Lipid oxidation is a major cause of spoilage or quality deterioration of bakery and confectionery products with a low water activity. Milk proteins show antioxidative properties. Colourless intermediates also act as antioxidants. By a controlled browning, the development of an oxidation flavour is inhibited in systems similar to bakery and confectionary products (Huyghebaert et al., 1981).

Flavour properties are to large extend improved by the addition of dairy products. Volatile compounds, present in milk fat or formed during browning, have been studied in detail (Hodge & Osman, 1976).

Confectionery

There is increased interest in milk-derived ingredients for the confectionery industry. This interest is justified because dairy-based products are available that meet all the criteria for ingredient selection. There is a preference for dried products such as caseinates, whey protein concentrates and milk powder, or for products with a reduced water content such as condensed and evaporated products. Fluid milk is rarely used because of its high water content.

More than in other branches of the food industry, the confectionery industry is base on tradition. However a scientific approach is being increasingly used, and development of new products is no longer a matter of trial and error.

The term candy, used in different parts of the world, includes chocolate. In other countries, a distinction is made between sugar confectionery such as toffee, fudge and caramel, chocolate confectionery, made from sugar confectionery covered with chocolate, and flour confectionery, such as chocolate-covered cakes.

Some particular types of sugar confectionery are discussed. The major milk constituents perform useful functions in sugar confectionery. According to Webb (1970), caseins and whey proteins, the two major classes of proteins in milk, function differently in candy. Caseins have emulsifying properties; they adsorb on the surface of fat particles to improve the emulsion stability. Caseins can also bind water and produce a drying effect. Whey proteins have better foaming properties than caseins. Many of the beneficial effects of milk proteins occur during cooking of confectionery. Milk proteins undergo denaturation during heating, gradually unfolding into long fibrous structures, which are interlinked by ionic and disulphide bonds. Caseins can produce a firm chewy body while whey proteins form a softer coagulum.

Caramel, toffee and butterscotch

The distinction between caramel, toffee and butterscotch is based on milk and fat content, the type of fat used, and the moisture content as determined by the degree of boiling. Toffee is usually hard and slightly chewy, butterscotch is hard and brittle, and caramel is soft or hard. Caramel is basically a fat emulsion in a vitrous sugar phase with the milk protein dispersed.

Sweetened condensed milk, whole or skim-milk powder impart important characteristics to these confections. Milk proteins take part in complex interactions with other ingredients such as sugar and lipids. The extent of interaction depend on the manufacturing proces.

During cooking, whey proteins unfold to a random coil configuration. The polypeptide chains of casein and denatured whey proteins interact through the formation of new bounds. These bounds contribute to the plastic and elastic properties of the confections. The overall effect is to bind the confection mass together and impart textural characteristics. The penetration of water is also controlled and the formation of large sugar crystals is inhibited. Caseins produce a firm chewy body. Whey protein form a softer texture and are less capable of contributing firmness to the structure of caramels and toffees than caseins.

Proteins show surfactant properties and enhance the miscibility of the ingredients. They contribute to the candy structure: sugar-protein-water complexes surrounded by a fat layer. The fats used provide shear properties and impart plasticity of the confectionery. Milk proteins interact with sugar during the cooking process to give a milk-and-caramel flavour.

Fudge

Fudge has a solid sugar-crystal phase with a dispersed fat and protein phase. Through the crystalline structure of fudge, the effect of protein on the texture is less significant than in caramel and toffee. As with toffee and caramel, the flavour and colour is predominantly derived form dairy ingredients. Milk proteins are essential to the development of proper characteristics. The minimum concentration of milk solids is 5%, a 10% addition being preferable.

Marshmallows and noughat

Egg albumen and gelatin are used to produce confections with a foam structure.

Original noughat was made from honey, whipped egg white, mixed with chopped nuts and preserved fruits. The present-day noughat bar is basically a high-boiled syrup to which is added a whip, made from egg white, gelatin or proteins. Important characteristics of the whip are a high whipping power and a good foam stability. The foaming properties of hydrolysed caseins and whey proteins may be utilized.

Marshmallows have a similar composition, apart from a higher moisture content and no added fat. Sugar syrups are foamed with a whipping agent and beaten to a foam, which will set into a resilient aerated jelly-like confection. Egg white and gelatin may be partly replaced by defatted whey protein concentrates.

Bakery products

There is continuing interest in fortifying or substituting wheat flour by milk solids in bakery products. There is a wide variety of formulas and procedures for the production of bakery products.

Bread

In some countries, the baking industry is a large user of skim-milk powder. In other countries, the addition of milk solids is almost entirely confined to specially breads. The physical structure of breads reflects the unique properties of the major proteins of wheat flour. Upon hydration, gluten forms a stretchable visco-elastic network, that can entrap gas produced by yeast. The structure stabilizes during baking. Milk solids are used to improve the bread quality by better colour and flavour.

None of the milk proteins shows properties similar to gluten. A few authors claim that the addition of skim-milk powder results in a better loaf volume. However it is generally accepted that milk proteins contain a volume-depressing factor.

In a systematic study on the addition of milk protein to bread, the presence of this factor was confirmed. In this work, the substitution of wheat flour by dehydrated dairy products up to 6% was investigated. A wide variety of protein-rich dairy products was included. The colour of the bread crust depended mainly on the lactose content. Bread, with milk proteins added in one form or another, shows a good crumb structure, bread yield, flavour and keeping quality. The volume-depressing factor was only present in some of the dairy products and could be inactivated by appropriate heat treatment.

Bread was then obtained with a satisfactory loaf volume. The characteristics could be further improved by the addition of the well accepted fats and emulsifiers.

Meringue, cakes and buttercakes

Meringue is an aerated structure obtained by whipping sugare and egg white and stabilizing the foam with heat. Egg white can be replaced by defatted whey protein concentrates (de Wit, 1983). In our work, these results were confirmed for meringue. Other systems studied were angel food cakes and buttercakes. Angel food cakes contain sugar, egg-white and flour. In a butter cake, butterfat is used as a fourth ingredient. Egg white could be replaced in these systems by whey protein concentrates.

Chocolate

Milk ingredients are valuable ingredients in chocolate, especially milk chocolate. According to the current definition of cocoa and chocolate products in the European Community, milk chocolate should contain:

- not less than 14% dry milk solids
- not less than 3.5% butterfat.

Milk powder in one or another form is generally used; however other dairy products may be added too, for instance whey powder of concentrates, cream and anhydrous milk fat.

There is often a strong preference for roller-dried powder; spray-dried powder is used to some extent. The properties of the two types of powders differ essentially in structure, colour and flavour.

Roller-dried powder is manufactured by drying a thin form on a cylinder or a drum. In spray-drying, hot air is used as a heat medium. This is generally called indirect heating in contrast to the direct heating in roller-drying.

Milk powder, obtained by roller-drying is subjected to a more severe heat treatment. For many applications, this is considered a disadvantage. It is however claimed that roller-dried powder offers some advantages for chocolate manufacture.

The solubility of roller-dried powder is lower than for spray powder.

Roller powder consists of particles with a rougher structure and a more irregular shape and size. Spray powder shows a more regular structure and is composed of spheres of different size. This property is relevant during initial mixing of ingredients in chocolate manufacturing.

The more pronounced denaturation of whey proteins is not considered a great disadvantage, as chocolate liquor is further subjected to heat in the conching process during manufacture. Conching, a basic step in chocolate manufacture, is a heating process with aeration and is extremely important for flavour.

The more pronounced browning reaction in roller powder has some positive aspects. Undoubtedly the initiated reaction proceeds further during conching with formation of flavour compounds. During this process, there is a further interaction between milk proteins, lactose and the other components of chocolate liqueur.

Finally the content of 'free fat' is generally higher in roller powder than in spray powder. It is an important characteristic, as it affects the flow properties of chocolate. Fluidity of chocolate is an extremely important factor, as it determines the handling characteristics in the enrober or moulding plant. If the chocolate is too thick, it will not form a thin layer and air bubbles may not rise from it before setting. The more free fat, the higher the fluidity of chocolate. However the finer the particle size of the cocoa, sugar and milk solids, the less will be the fluidity because of increased surface area. There is a limit to the maximum particle size of the non-fat ingredients as coarse particles give unsatisfactory mouth-feel. Milk proteins affect also the flow properties of chocolate.

Milk crumb is the preferred ingredient in the United Kingdom (Minifie, 1980). It is claimed that chocolate, with milk crumb as an ingredient, has a richer creamy flavour. However acceptable flavour varies from country to country. Manufacture of milk crumb is based on evaporation, condensing, mixing with cocoa liqeur and finally drying in vacuum ovens.

Conclusion

Milk proteins are highly appreciated ingredients in confectionery and bakery products. Some products can be considered as traditional ingredients. The recent advances in separation technology have resulted in a broad range of milk protein ingredients, which meet the specific requirements of the confectionery and bakery industry.

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Conclusions of plenary session D

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World production of casein amounts to about 220 000 tonnes per year of which the European Community produces about 50%. After cheese manufacture, the amount of whey protein, if recovered, would amount to some 650 000 tonnes annually.

Milk proteins, apart form their use in dairy products themselves, are incorporated into many food and non-food systems. They are extensively used in beverages, confectionery, bakery products and meat products. Their incorporation is often more for their excellent functional properties than for nutritional reasons. However the undoubted nutritional advantages of milk proteins are widely acknowledged.

Many legal problems exist for various additives in food for human consumption, and stabilizers and emulsifiers are often limited or precluded in many products but little or no objection exists for milk proteins which are often used in these critical roles.

The recent development of a total milk proteinate, in which the whey proteins are soluble (in contrast to their insolubility in conventional milk protein coprecipitates) is seen to have major advantages. Further work to the properties is needed before the new product can be fully exploited.

Soya protein has several limitations in contrast to milk proteins. These limitations include flavour, toxicity, digestibility, solubility and functionality probelms, as well as lower nutritional quality.

Further research is necessary to measure the functional qualities of milk proteins in the various foodstuffs. Their properties in simple systems, such as aqueous solutions, do not always apply when later incorporated into the final product. A new approach starting with the foodstuff and progressing towards the simpler system was proposed.

The use of immobililized yeast to convert the lactose in whey concentrate into ethanol with the latter's removal later by evaporation is in the development stage and offers exciting possibilities for inexpensive purification and recovery of whey proteins in the future.

The use of caseinate in meat products is traditional and has been used for 25 years and skim-milk powder is the commonly used additive in several meat preparations. The use of milk proteins in the meat industry is very well researched, documented and appreciated. However, better promotion would allow much more to be used by that industry. There is a huge market for skim-milk powder in soups and sauces.

In the bakery and confectionery industries, milk constituents have not only a positive technical function but also distinct nutritional advantages. Dairy products are highly appreciated in candy, chocolate and bakery products.

Further promotion of the first-class and varied functional properties of milk proteins needs more development and these properties allied to the almost universal nutritional advantages and consumer acceptability must be extended. The increasing tendency of listing ingredients on the package can only prove advantageous to milk proteins because of their high status in the mind of the consumer.

Markets, marketing requirements and consumer attitudes

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Marketing research and publicity

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Summary

Market research should assist in the development and marketing of food products containing milk protein. This should begin with an assessment of the amount of relevant data available on the potential end-consumers of milk protein and on the manufacturers of products based on milk protein. Cooperation between public bodies and manufacturers having such information should be urgently sought.

Market research should help manufacturers identify and define potential markets for new products based on milk protein; assist in the development of new products, line extensions and enhanced products; and guide the promotion of the product to the end-consumer. Information is also needed about appropriate food manufacturers and market research may be needed to determine their awareness, interest and knowledge of milk protein.

The most effective way of building up the market for products based on milk protein or containing milk protein may be through the synergistic effect of a wide variety of manufacturing companies promoting complementary or competing products but all emphasizing the positive values of milk protein. Coordinated promotional activity would be more effective than a central campaign to promote milk protein to the consumer. Central assistance in the collection, interpretation and dissemination of market research data is not incompatible with the manufacturers then developing and promoting competing products. Cooperation at later stages of product and promotional development would be more difficult.

The extent to which it is realistic to introduce new or enhanced food products, how this might be done and over what time span should be examined, drawing on examples from manufactured and generic food products. Constraints exist on the introduction of new food products and the changing of eating habits. Social forces inducing changes in eating habits must be examined. All products overtly including milk protein should be promoted in a way that will contribute positively to the end-consumer's attitudes to milk protein. This may mean initially concentrating on products for the

main market rather than special groups. Milk protein and milk-protein products should be promoted without undermining other milk-based products and their role in the family diet.

CAB descriptors: milk protein, product markets, market surveys, publicity sales promotion, consumer panels.

Introduction

Everyone at this Congress is involved in the problem of how to use milk protein constructively. In this session, we are concerned with the marketing of milk protein and this particular contribution relates to the use of market research and publicity within the marketing process.

This contribution is intended to communicate

– the need for a coordinated marketing plan to stimulate the use of milk protein

– the major contribution market research could make to such a plan and the consequent need for the industry to share basic market data and information that will benefit everyone engaged in the marketing of milk protein products

– sensitive interpretation of data already available to contribute to a marketing campaign for milk proteins

– particular problems, constraints and opportunities for an aggressive marketing and publicity campaign for milk protein.

Use of market research

It is appropriate that we should begin with market research; with an assessment of what we know and what we need to know to carry out the marketing of milk protein as effectively and efficiently as possible. Market research's role in the marketing process is to aid the understanding of market dynamics and of the consumer. For milk protein, this is complicated by the fact that we are dealing with two markets – the end-consumer and the manufacturer or food processor, who will make the product for the end-consumer. This paper deals primarily with the end-consumer but that should not be taken as an under-estimation of the importance of selling the idea of milk protein to food manufacturers.

There are two parts to the use of the data in marketing planning and they are equally important. One is to collect data and the other is to interpret data creatively and intelligently. This distinction between the collection and use of data means that it is possible to syndicate studies even in intensely competitive marketing situations. Market research can and should be used at different stages in the marketing process. It should be used to help manufacturers indentify and define potential markets for new milk-protein-based products; to assist in the development of new products, line extensions and enhanced products attractive to consumers; and to guide the promotion of the product to the end-consumer.

A considerable amount of the data that we need for this process probably already exists and much of the task of those wishing to improve the efficiency of marketing milk protein may be to persuade people to share some of their data for joint use.

Types of market research data

Demographics

Broadly speaking, there are four types of market research and analysis that can help in marketing milk protein. The first of these is basic demographic statistics. Our purpose is to sell milk protein directly or indirectly to individuals. This will be done most effectively if we target precisely to the physical, social and psychological needs of these individuals. To evaluate the potential target market, nationally, regionally or on a pan-European basis we need to know how many people fall into each target group. Basic statistics to help in this process include all centrally organized demographic data, expenditure data and food-consumption data. These can help us analyse the problems and identify potential target groups for new and enhanced products.

Continuous panel data

My firm specializes in a measurement technique using continuous panels, which can take a variety of forms but basically entails asking representative panels of individuals to keep a continuous record of their behaviour in a particular sphere. This can vary from allowing a meter to be attached to their television set, so that the station it is tuned to is automatically recorded every time it is switched on, to asking someone to keep a diary record of every newspaper or every packet of cigarettes he buys. The value of such measurements is that the behaviour of individuals or subgroups of the population can be tracked over time. As some panels have run for many years, we can see how food purchase and usage patterns have changed over that time and which segments of the population are changing their behaviour.

Comparable studies

Another way of measuring trends or change over time is to make intermittent studies with comparable samples of the population. These may be called tracking studies and can be used to identify change or the response to a particular market-place activity.

Such studies can tell us what is happening but we also need to know why. Although creative interpretation can take us part of the way, specific attitude and behaviour studies are often needed to explain the reasons for behaviour patterns and to give guidance for action.

When it has been decided that there is an opportunity for a new product or an enhanced product, we have to return to the consumer to test the product and the product concept as they are developed and to test alternative forms of packaging, pricing and promotion.

Central coordination of research

Central assistance in the collection, interpretation and dissemination of market research data, particularly at the primary stage of market identification, is compatible with the manufacturers of products using milk protein, even though the manufacturers then develop and promote competing products. Cooperation at later stages of product and promotional development would be more difficult and possibly counter-productive. Projects to elucidate the social pressures and other changes behind market trends could also be developed as joint projects or as centrally funded projects.

Examples of data use

All the four types of market research described above could be used to help in the effective marketing of milk protein. The usefulness of these data will be demonstrated with some examples. Most of the examples are drawn from the United Kingdom as interpretation of data from several countries is complex. Data similar to those used are available throughout the European Community.

Let us take an example of the importance of the intelligent and thoughtful interpretation of basic population statistics. Milk protein has characteristics that make it potentially an attractive dietary supplement to certain special groups in the population: old people, children, athletes for example. Can population statistics, combined with marketing experience, help us determine the wisdom of addressing products to one or all of these special groups, or guide us as to how it should be done?

Initially one would suppose that a product for older people would have considerable potential. Throughout Europe, people are living longer and the average age in our population has increased. At the beginning of the century, only 4% of the population in the United Kingdom were over 65 years of age. In 1981, 15% were over 65. There are now as many people over 75 as there are under 5 (Table 1). However, this does not necessarily mean that elderly people will make a good potential market. If we concentrate on selling milk-protein products to certain subgroups, we may find that we are alienating the mass market. Experience has shown that one can develop a product for one market and then sell it to other subgroups or even develop separate sister products for these subgroups. However the choice of the first product and market is crucial. It would be unwise to associate milk protein with a subgroup in a way that inhibits its expansion into the mass market.

This does not mean that we should avoid all special subgroups. On the contrary, by targeting at a series of different special groups, we could use large amounts of milk protein effectively. We should be aware of the marketing problems that have to be dealt with in this approach.

Before leaving the interpretation of basic population and demographic data, another illustration would perhaps be valuable. Marketers are often castigated for ignoring

Table 1. Population breakdown (%) by age in Great Britain. Data from Office of Population Censuses and Survey.

	Year of census			
	1901	1931	1961	1981
< 5	11	8	8	6
5 - 14	21	17	15	14
15 - 29	28	26	19	22
30 - 44	20	21	20	19
45 - 64	15	21	25	22
65 - 74	3	5	8	9
> 75	1	2	4	6

Table 2. Distribution (%) of household size in United Kingdom in 1981. Data from Office of Population Census and Surveys.

	Proportion (%) of households with						Number of households (millions)	Av. Number per household
	1	2	3	4	5	>6		
1961	12	30	23	19	9	7	16.2	3.1
1971	18	32	19	17	8	6	18.3	2.9
1981	22	32	17	18	7	4	19.5	2.7

Table 3. Distribution (%) of households and of persons by household type in the United Kingdom in 1981. Data from Office of Population Census and Surveys.

Number per household	Distribution of	
	households	persons
1	22	8
2	32	24
3	17	19
4	18	27
5	7	13
>6	4	10

social change. The structure of our society is changing dramatically. Over the last 20 years, the number of households in Britain containing just one person has increased form 12 to 20% (Table 2). Clearly the eating patterns of a single-person household will be different from those of a larger household. However let us remember that the proportion of people living in single-person households is much less than the proportion of single-person households. Products for larger households still have a market potential outweighing specialist products for small households (Table 3) and special groups.

These data have come from one country but sources of comparative statistics between countries already exist. These would allow pan-European assessments of demographics and social trends. One of the associated companies of my group, Infas GmbH in Germany, has developed a data base called Eurobase. This is a report-generating system of analysis which uses regional, political and social data about each of the nine countries of the European Community. There are detailed socio-economic data on all the countries at a regional level and sophisticated computer programming has facilitated the production of data in an easily assimilated form such as computer-produced maps for regional marketing. Such techniques could be invaluable for demonstrating the best potential markets for milk-protein products.

Other basic data

In many European markets, information on changes in consumption of different food types is collected on a regular basis. There are basic data on food production, and on import and export between countries. Additionally, information is collected continuously or intermittently on what foods people eat.

In several European countries, there are continuous panels of households which keep a record of their food purchases over an extended period of time. My firm runs

Table 4. Amount sold and market share in the yellow fats market 1974-1983. Data from Television Consumer Audit, Audits of Great Britain Ltd.

	Butter		Margarine	
	amount (t)	share (%)	amount (t)	share (%)
1974	356 020	65	188 234	35
1975	375 658	67	179 612	32
1976	330 174	61	207 436	39
1977	304 288	55	250 436	45
1978	286 914	52	265 963	48
1979	273 275	50	275 254	50
1980	240 480	43	313 448	57
1981	220 010	39	338 807	61
1982	202 061	36	358 301	64
1983	195 449	36	350 505	64

two such panels, the TCA panel which mainly measures the purchase and use of package groceries throughout Great Britain and Northern Ireland and the Attwood panel which concentrates on fresh foods in Britain.

To illustrate what panel data can tell us, let us look at the unhappy picture of yellow fats (Table 4). Since 1973, the positions of butter and margarine in the United Kingdom diet have been reversed. In 1974, nearly two thirds of yellow fat bought by households was butter and one third was margarine. In 1983, only 36% was butter and 64% was margarine.

The first thing this tells us is that people's eating patterns can change. It would not be wise, however, to be oversimplistic about why this has occurred in this particular case. Almost certainly, there were three interwoven factors: price, attitudes and beliefs about health, and promotion. Over the time we are considering, the price of butter rose four-fold from £0.205 to £0.833 and margarine rose only three-fold from £0.137 to £0.385. However, people do not always choose the cheapest brand, although they may change their purchase patterns if a product goes through a price barrier. Some product fields have extremely high brand loyalty, which is maintained even where there is little product difference and a negative price differential. This is usually found in markets with strong manufacturers and heavy advertising. Within the margarine market itself, premium price products have managed to increase their share. To take three brands which I call A, B & C, A had doubled the volume sold between 1979 and 1983 and more than doubled the value of the sales (Table 5). This brand sells at £0.34 for 250 g and is promoted on a non-specific health platform. Over the same period, B increased the amount sold by more than a third and the value of the sales by 70%. The brand cost £0.33 for 250 g and was sold on a slimming story. This was over a period when the total amount of soft margarine sold went up by 18%

Table 5. Market share of two margarines. Data from Television Consumer Audit, Audits of Great Britain Ltd.

	Expenditure (k£)	
	1979	1983
All margarine	196 292	297 393
Soft margarine	149 000	190 000
Brand A (Health)	15 900	36 500
Brand B (Slimming)	4 500	7 700
	Amount bought (t)	
	1979	1983
All margarine	275 254	350 505
Soft margarine	205 316	242 742
Brand A (Health)	13 964	28 656
Brand B (Slimming)	4 557	6 255

and a good long-standing branded margarine could be bought for £0.21 for 250 g.

Before we conclude that this reflects an interest in healthy eating, we should look at Brand C margarine, launched in 1978, given a boost in 1981 and now commanding 13% of the marktet (Table 6). This brand sells on an indirect positioning of 'flavour like butter'.

Table 6. Market share of margarine Brand C. Data from Television Consumer Audit, Audits of Great Britain Ltd.

	Expenditure (k£)	Proportion of sales (%)	Amount (t)	Proportion of amount sold (%)
1978	447	–	501	–
1979	2 038	1	2 188	1
1980	29 932	12	27 560	9
1981	47 744	18	42 832	13
1982	57 434	20	50 193	14
1983	56 285	19	45 731	13

Table 7. Comparison of type of liquid milk consumed in households in Britain in September in each of three years. Data from AGB Attwood and the National Milk Publicity Council.

	Contribution (%)		
	Sept. 1981	Sept. 1982	Sept. 1983
Pasteurized	85.9	86.1	85.1
Homogenized	3.3	3.2	3.3
Sterilized	5.0	4.9	4.7
Channel Islands	2.1	2.1	1.6
Low-fat (semi-skim and skim)	2.1	2.4	3.7
Ultrahigh-temperature	0.3	0.4	0.5
Others	1.2	1.0	1.2

Table 8. Reasons given for first purchase of low fat milk. Data from AGB Attwood and National Publicity Council.

	%
Couldn't get ordinary milk	3
On a diet	28
Cheaper than ordinary milk	14
Health reasons	17
Just to try it	25
Other	13

Several factors are clearly at play in this market but examining them indicates that different consumers are responding to different pressures and impulses, all working against butter.

Another panel, the Attwood panel has continuously monitored the decline in the in-home consumption of milk per person. Looking at the type of milk suffering the least decline can help us to understand the market. The only sector expanding is the low-fat milk category (Table 7). The National Milk Publicity Council has carried out supplementary research on attitudes to low-fat milk, including the reasons for first trying it. When the housewife bought the product herself it was for a health-related reason in 45% of cases (Table 8).

Again we should remember that there is rarely a single reason for a market trend. Apart from habits and attitudes, you could say that an additional reason for decline in the purchase of milk is that less of it is thrown away. Between 1964 and 1982, the number of homes in Britain with a refrigerator rose from 35 to 93%. We have also seen a continuous decline in the proportion of milk bought from milkmen as opposed to retailers, which could have a depressant effect for several reasons.

Changing food habits

Although the reasons for changing food habits are numerous and complex, there is plenty of evidence from different sources that they are changing. Over the last 20 years, the human intake of energy in Britain has gone down considerably as the standard of living and health education has increased. Affluence has moved us perhaps too far from carbohydrates and traditional foods (Table 9).

Panel data do suggest that some people are moving towards a pattern of what they believe to be healthier eating, and this may well provide the basic platform for the future selling of milk proteins. There are many reasons why such changes have come about and we should not underestimate the importance of advertising as well as editorials and education in raising consciousness of food characteristics and in stimulating change.

Using judgment, we selected a series of products that we thought might be health-related in the minds of at least some of the population. We included bran, muesli,

Table 9. Energy intake per person (MJ/d). Data from Ministry of Agriculture, Fisheries and Food Department of Agriculture for Scotland.

Year	Intake
1966	13.14
1970	13.01
1975	12.18
1980	11.92
1981	11.81
1982	11.65

fruit juice, brown bread, yoghurt and baked beans. We compared the purchases made in the year ending 1 January 1983 with those made in the year ending 6 January 1979. The evidence shows that the extent to which consumption had increased, varied between products but in some cases the increase was dramatic (Fig. 1).

Why did we include baked beans? In the summer of 1982, the concept of the 'F-Plan diet' was strongly promoted in the United Kingdom. This is an eating pattern

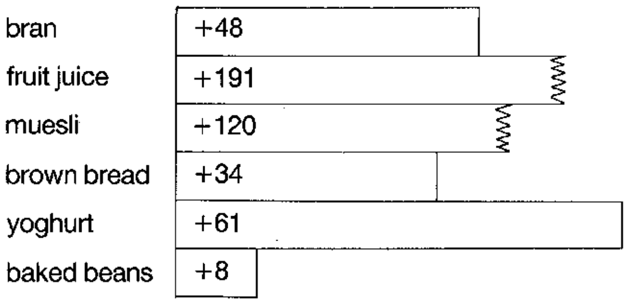

Fig. 1. Market trends in 'health products': percentage increase in amount sold compared with 1979. Data from Television Consumer Audit, Audits of Great Britain Ltd 1983.

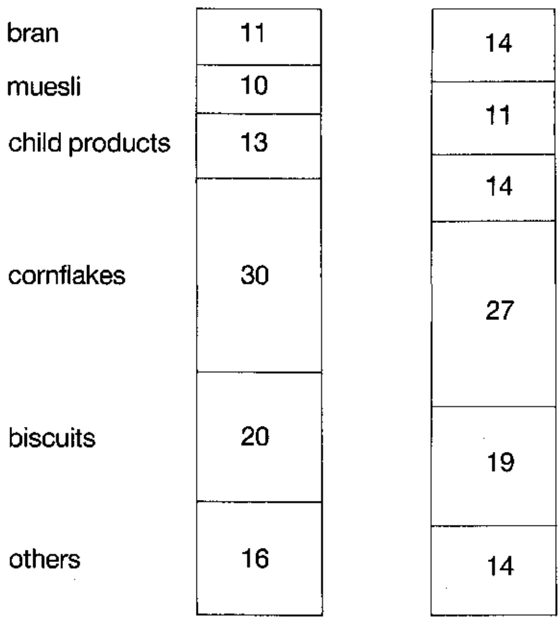

Fig. 2. Breakfast cereal market of Britain split by sector. Comparison for the 24 weeks ending September 1982 and September 1983. Percentage change of the total consumed by category. Data from Television Consumer Audit, Audits of Great Britain Ltd 1983.

that emphasizes the importance of fibre in the diet and we were interested to see what the effect had been. The evidence is quite clear and dramatic. Bran products in the breakfast cereal market increased their share of the market by 3% between September 1982 en September 1983. This is a very considerable increase in a market of this size and means that 30% more bran cereal was sold in that period than in the previous equivalent period. The promotion of the F-Plan seems to have increased the consumption of bran cereals by 10 000 tonnes (Fig. 2).

We looked at some products that have been mentioned in general newspapers and magazines as being healthy. We found that the volume of sugar bought is down; complete ready meals are down; cake, pastry and bread mixes are down; sponge puddings are down (Fig. 3). We believe that there is a trend towards what the consumer, or at least some consumers believe to be healthier eating habits and it would be surprising if this were not so. Editorial columns in newspapers and magazines cover such issues with great frequency and some magazines are totally devoted to such topics. Advertising has also done its share to heighten awareness. Some years ago in the United States, we did a content analysis of food advertising in women's magazines and discovered that the majority made some reference to nutrition as opposed to or in addition to flavour or appetite appeal. This also appears to be true in Europé, although we dit not do as systematic a study as we had done in the United States.

Does this mean that any product promoted as healthy will sell and that health-giving properties are the best ones to stress in order to sell products? Our panel data suggest that this is a great oversimplification and is sometimes just not true. We should never forget that people eat things because they like them and serve them to others because they believe they will like them. There also appears to be a distinction between products which are promoted on the basis that they will help people lose weight or maintain a weight loss and those which are associated with a healthier way of eating. There have been several products developed over recent years which simulate those already existing but have a lower energy content and no difference in price. Such products seem to obtain a small and constant share of their markets.

The products associated with healthier eating are still gaining in their market position and it is too soon to say whether and when they too will level off.

Does this mean that we have to create products and promote them as an integral part of a healthy balanced diet and all will be well? Unfortunately the evidence is that

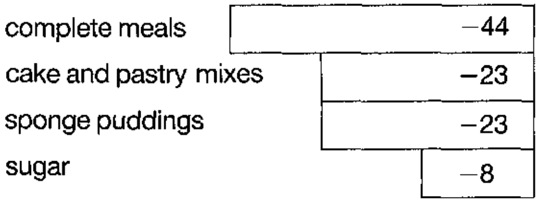

Fig. 3. Market trends for selected products. Percentage decrease in amount sold in 1983 compared with 1979. Data from Television Consumer Audit, Audits of Great Britain Ltd 1983.

Table 10. Annual advertising expenditure on eggs in Great Britain. Data from Media Expenditure Analysis (MEAL).

Year	Expenditure (k£)
1973	845.4
1974	976.6
1975	1082.5
1976	869.9
1977	1367.1
1978	1289.5
1979	1485.2
1980	2245.2
1981	1876.2
1982	2948.4
1983	4619.5

Table 11. Household purchase of eggs in Great Britain. Data from AGB Attwood.

Year	Number of boxes (thousands)
1980	27 598.4
1981	27 339.7
1982	26 882.5
1983	25 531.3

heavy promotional activity alone is not sufficient to support a product no matter how positive the attitudes of the consumer may be. Eggs are an example of this. They have an excellent image with consumers in Britain – only a fringe being concerned about any negative effects to health. According to statistics, total advertising support for eggs in Britain has increased gradually, if unevenly, over the last ten years (Table 10). This has not stopped the household consumption of eggs falling steadily over that time (Table 11).

Problems in product promotion

Not only do we need subtle insights into the reasons different categories of consumers have for choosing different products. We also have to recognize that new food products, or enhanced old food products compete in a very noisy market. Food advertising is the largest single category of advertising in many European countries. This expenditure in certain categories is the synthesized effect of several manufacturers promoting their own brands in a product category. The awareness that can be created this way can be higher than when promotional expenditure is put behind a product category as a whole – what we call a 'generic campaign'.

Sometimes, brand advertising and product-category advertising can work together in a positive and effective way. This is demonstrated by the Cheese Information Ser-

Table 12. Indexed consumption of cheese per household in Britain. Data from AGB Attwoods Consumer Panel.

Year	Index
1973	100
1974	105
1975	105
1976	107
1977	111
1978	112
1979	106

vice in Britain, which was founded in 1973. The advertising activity of the Cheese Information Service was meant to be complementary to the advertising for individual brands and for other cheeses.

In spite of rising prices, the consumption of cheese per person in Britain rose steadily for many years until the Autumn of 1978, when the product appeared to go through a price threshold or barrier and cheese consumption began to decline (Table 12). This decline continued through 1979 and was then reversed by a powerful advertising campaign that began in February 1980. Since that time, cheese has continued on its gradual growth pattern.

The two major points to be made here are firstly that the particular advertising campaign was not working in isolation but was complementary to other advertising carried out by manufacturers. The second part is that a great deal of consumer research was used to identify the problem, explore consumer ideas and attitudes, test out the advertising and evaluate the results.

Coordinated marketing planning

The most effective way to build the market for products based on milk protein and products containing milk protein will be through the synergistic effect of a wide variety of manufacturing companies promoting complementary or competing products but all emphasizing the positive values of milk protein and raising awareness of the product and its value. Coordinated promotional activity of this kind would be more effective than a central campaign to promote milk protein to the end-consumer. It might be necessary actively to promote milk protein to food manufacturers. Lessons on how this kind of activity can be carried out most effectively could certainly be drawn from examining what has been done in other product fields. It would be extremely valuable if any coordinated activity to promote milk protein were to begin by identifying what relevant continuous market measurements exist in all the European countries. The success and failure of different marketing processes and different new and enhanced products must be tracked in an objective way. If mechanisms for doing so don't exist, they should be established in advance of any marketing activity.

This is a major problem we are tackling and it will be a great step towards its success, if those who try different products and different market tests can be encouraged to share their findings, so that we can all learn from each other. If this is to be done, evidence must be collected in a systematic way.

Food manufacturers as a market

If the energy behind the development and marketing of milk-protein products is to come from food processers and the manufacturers of branded products, the relevant manufacturers with the interest and resource to do so must be identified. The attitudes of these manufacturers and their willingness to act cooperatively in order to indentify and define potential markets for milk-protein products should be explored, as also should be willingness to cooperate on an agreed broad promotional theme and on controlled publicity to enhance the concept of milk protein through the promotion of their individual brands.

The image of milk protein and products

Evidence would suggest that the concept of milk protein as it exists in the consumer's mind today is positive. The greatest danger would be that the attractiveness of milk protein could be reduced by associating it with the wrong products, brands or target groups.

Fresh milk and milk products have a positive image. Research also suggests that dairy products used as an ingredient can make a positive contribution to ideas about a product. Research in Britain for Dairy Crest Creameries Industrial Milk Products Division showed that 86% of housewives agreed that dairy ingredients helped give food a nice taste and 82% thought they helped give food a nice texture, while 94% thought they would bring richness to food. Perhaps it is here that we have to tread with caution in the light of all we know about fat, richness and healthy living.

In recent years, many products have become associated with negative effects on our health, at least for some people. Salt, additives, cholesterol, sugar, alcohol: the list is extensive, so why should butter and some other dairy products suffer more than others. We are dealing with a thoughtful, intelligent and better educated consumer. We are dealing with a consumer who pays attention to what she eats and who reads about the ingredients in a new product before she buys it. But some of this consumer's increased knowledge about products is a little superficial. This is hardly surprising as she receives different and sometimes conflicting information from different sources. Some concepts, however, may be particularly easy to assimilate, whether they are accurate or not. That the fat in butter could make you fat and that fat people are unhealthy, because their body organs work less efficiently is a simple concept to understand. It also probably fits well with commonsense and folk experience.

At present we are all half-educated about products and their value. When we talk about them to the consumer, what we say should be not only scientifically correct but also in tune with the ideas, the beliefs and the concepts the consumer already holds.

Only in this way can we expect new information to work positively for us.

Problems in international food marketing

We have an important additional constraint. It would not be to the advantage of the farmers of Europe or the dairy industry of Europe if milk-protein products were developed and promoted in such a way that they became directly or indirectly competitive with existing dairy products. This is an major limitation on potential strategic positionings, which might be developed for milk protein.

Finally it would be folly either to be defeated by the task we face or to underestimate its challenge. Food products are the most difficult to carry across frontiers, not only in distribution terms – although this has its problems – but also in promotional and conceptual terms. Indulgence products are often sold worldwide on the same positioning – soft drinks, music, cigarettes, perfumes, some alcoholic products and even clothes, have a worldwide franchise. No food manufacturer is sanguine about promoting food in a uniform way between countries but we can learn from each other. The preparing and giving of food in the home has deep social and psychological significance in every culture. We eat what we like and we like the familiar. All the changing trends we have seen in the data overlie a deep conservatism which must be treated with respect, culture by culture, if we are to succeed. Howevermore if we take pains to understand the people we would like to use milk protein, we will succeed.

Marketing potential

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Summary

The criteria which a food processor looks for in choosing a raw material as a significant ingredient in his product are defined. Three of these criteria, well accepted taste and flavour, functionality and good nutritional properties are criteria that in essence are judged by the end-consumer. Taste and flavour and functional properties are criteria that much favour the development of milk proteins in food usage. Nutritionally too, milk proteins are extremely valuable, though they have been indicted as the cause of allergies in an appreciable number of people. There is evidence that this indictment is unfair in respect to its extent.

In functionality, the ability of milk proteins to form textured food products is regarded as a major advantage and a plea is made for increased expenditure on research and development of ways of producing textured commercial products. The final criterion of consequence in the use of milk proteins by the food industry is cost. This is not nearly so favourable to the milk industry as the other criteria. In comparison with soya proteins, the obvious alternative proteins, milk proteins are at a severe disadvantage. This disadvantage is compounded by the complexity and, in the authors view, the absurdity of the European Communities pricing support. In the future, dramatic competition is possible from proteins produced by genetic engineering of plants. Such proteins could successfully mimic or may in fact be identical to casein proteins.

CAB descriptors: milk proteins, product quality, texturization, marketing, food.

Introduction

I wish to introduce my subject by describing the criteria a food processor looks for in choosing a raw material as a significant ingredient in his product and then to see how milk protein matches these requirements (Table 1). From this, the opportunities

Table 1. Criteria for commercial acceptance of protein for use in the food industry.

Consumer perceptions.
highly acceptable taste & flavour
functional properties
(nutritional)
acceptable cost

for the use of milk proteins in foods and the competition for these uses may be perceived.

What I wish to demonstrate is that milk proteins, in their various forms, have admirable attributes in respect to the first three criteria and probably fail quite disastrously with respect to the fourth criterion – acceptable cost. The dairy industry should never forget that it is part of the food industry and not something separate with its own life; it must compete with other parts of the food industry that produce alternatives to the three basic components of milk: fat; lactose; and protein. The situation is made more difficult by the fact that the population of the industrial countries (the main consumers of dairy products) is static and there is a tendancy for individuals to eat less, in terms of energy intake.

The dairy industries in most industrial countries have a large percentage share of total food consumed. For example, in Great Britain, 17% of the consumer's expenditure is on dairy products, as conventionally defined, and this would be a higher figure if dairy ingredients of other foods were included. The success of the dairy industry in countries like Britain must be measured by the extent to which the dairy industry succeeds in maintaining that share because, to my mind, it is not realistic to expect to increase it. Paradoxically, however, the right strategy to maintain a market is to attempt to increase it and an effective way is by product innovation and diversification. In the context of the dairy industry, this can only be done by finding new uses for the major constituents of milk and this Congress and others like it must be of great importance to the dairy industry. They are not, however, sufficient in themselves; they must be supported by adequate research and development and I question whether the dairy industry is spending sufficient in this way. In most countries, the sum spent by the dairy industry on research and development concerning milk utilisation is considerably less than for other parts of the food industry, for example, soya.

Taste and flavour

Little need be said in relation to taste and flavour, largely because these are very positive attributes of milk proteins exhibited in the high acceptability of cheese, the major food based on milk protein and the high acceptability of other dairy products, not forgetting milk itself. Purified milk proteins, casein, caseinates and whey proteins can also be produced in forms giving good taste and flavour to products in which they are incorporated.

Functional properties

Milk proteins, principally the casein fraction, exhibit excellent functional properties in binding water and fat, and in emulsifying. These properties are of great value to the meat industry, in such things as sausages, pies and cooked meats.

The foaming properties of milk proteins, however, are only moderate and limited proteolysis is one of the most promising ways of improving these. The degree of proteolysis required to achieve this modification is quite low, 4 – 6%, and good results (an increase in foaming capacity of 20-fold) can be achieved with acid, fungal and neutral proteases from plant, animal or microbial sources. This extent of proteolysis is unlikely to result in the development of bitter flavours from the hydrophobic peptides released from the protein chain. If bitterness is a problem, it may be reduced or cured by further treatment with a peptidase to break down the peptides to individual amino acids.

A functional property of milk proteins still to be exploited commercially is their ability to form textured foodstuffs. Most of the textured foods consumed now owe their structure to a proteinaceous matrix, e.g. meat, fish, bread, cheese. A breakdown of dietary protein intake in Britain reveals that about 80% of the daily protein intake is consumed in the form of textured foods (Table 2).

There are several ways in which milk protein may be texturized but I would draw particular attention to gel formation and spinning. I was delighted to see that the question of spinning of protein is the subject of a special lecture at this congress, because I believe that this is one of the ways in which milk protein in large amounts may be introduced into food products and particularly those simulating meat. The

Table 2. Dietary protein intake in Great Britain.

	Contribution to protein supply (%)		
Milk and cream	19.3		
Cheese	5.1		
Meat and poultry	29.6		
Fish	4.0		
Eggs	5.0 +		
Animal protein		63	
Potatoes	3.0		
Other vegetables	5.2		
Cereals	26.0 +		
Vegetable protein		34.2	
Other foods		2.8	+
Total		100.0	

future for this type of product is dependent upon the costs of the milk protein relative to other materials such as soya protein isolate, which can be spun. Gel formation is, of course, the process by which cheese is manufactured and modifications of the process by which mozzarella cheese is made have been exploited, in particular by Polish workers, as a means of developing meat-like textures.

These attempts to texturize milk proteins are ones that the dairy industry would do well to support by considerable research.

Whey proteins are now available on commercial scale from the ultrafiltration of cheese or casein whey. The extracted proteins have very good nutritional properties, good foaming properties (when fat-free) and good water-binding. Whey proteins are finding increasing use in meat products for their water-binding, in baking for their foaming characteristics and in specialist nutritional meals.

Nutritional properties

The nutritional qualities of milk protein are excellent. They are discussed in detail in session B of this Congress and I shall not try to describe them. I do, however, wish to make two points about nutrition. The first is that most consumers (I exclude special groups like dedicated sportsmen and food cranks) have not been much interested in the positive aspects of nutrition. This may be slowly changing to an increased awareness and would receive greater emphasis if more countries adopted a formal nutritional policy. Consumers are, however, more influenced by negative nutritional factors, milk proteins often being indicted as a major cause of allergy. I suspect that this indictment is often false. I regret that the subject of allergy is not a specific topic in this Congress, because I think it will increase in importance. To maintain its market, the dairy industry must know whether the indictment of its products is true or false. Harris (1982) surveyed 8749 people in Britain to determine the proportion that limited or avoided cow's milk for reasons other than financial and the proportion of those who, by self-diagnosis, considered that they suffered from allergy or lactose intolerance. Only 1.47% considered that they suffered from allergy or lactose intolerance. The self-diagnosis probably overestimates by a factor of 10. Thus, the proportion of the population truly suffering from milk-protein allergy is likely to be about one per thousand and not the inflated figures often reported in the press.

Cost of milk proteins

The major source of milk protein not fully utilized for human food is skim milk. Of the 48 million tonnes of skim milk produced in the European Community in 1982, 52% was converted to skim-milk powder, of which about 75% (i.e. 39% of skim milk) was used in animal feeds. An additional 11% of skim milk was given to animals without further processing, making a total of 50%. By comparison, only 6% of available skim milk was converted to casein. Market prices of skim milk in the European Community in 1983 are shown in Table 3. (£/t).

These prices can be compared with prices for soya protein (Table 4).

The dairy industry, in the European Community at least, cannot expect to develop large-scale uses for proteins in human food when the product, skim-milk powder, which represents the major source of milk proteins, is so grossly overpriced in relation to competitive soya protein, whilst, skim-milk powder is sold at give-away prices to feed animals. The high price for milk proteins as exemplified by intervention skim-milk powder results from an absurdly artificial pricing structure. It is the major constraint to the use by the food industry of milk proteins, which are otherwise valuable for their consumer acceptability, their functional characteristics and their nutritional properties. The high price of protein from such commodities as beef and chicken demonstrate a considerable potential for milk proteins in meat analogues.

In price soya proteins represent a major competitor to milk proteins for use in the food industry, including use in meat analogues though they are distinctly inferior to milk proteins in customer acceptability, nutrition and some aspects of functionality. For example, the soya industry has attempted to produce a 'vegetable milk' which has very poor acceptability compared with real milk. To reduce flavour defect, the protein content of soya milk is kept very low, giving poor nutritional quality. Improvements may, however, come. The applications of biotechnology may offer the soya industry (or some other source of vegetable protein) the opportunity to modify

Table 3. Prices for skim-milk powder and for its protein in the European Community in 1983.

	Skim-milk powder	Protein
Intervention price	926	2646
Price as calf feed	549	1569
Price for liquid feed to pigs (calculated as powder)	302	863
Pig/poultry scheme	146	417

Table 4. Approximate prices (£/t) of milk proteins, soya protein and other proteins in Great Britain in 1983.

	Mass fr. of protein	Price of product	Price of protein
Defatted soya flour	0.50	300	600
Soya protein concentrate	0.70	900	1285
Soya protein isolate	0.90	1800	2000
– skim-milk protein intervention price	0.28	926	2646
– pig/poultry scheme	0.28	146	417
Casein	0.90	1500	1667
Whey protein concentrate	0.60	1800	3000
Dried egg white	0.90	5000	5550
Lean beef	0.19	1800	9473
Chicken flesh	0.23	1050	4565
Gelatin 200 bloom	0.85	2300	2705

vegetable proteins so that, in function and taste, they more closely resemble milk proteins. It is becoming technically feasible to implant genetic material into plants, 'instructing' them to produce particular proteins. Such techniques have been developed, for instance, by the Plant Breeding Institute, Cambridge in England and by groups in Ghent University in Belgium and Washington State University, St. Louis, in the United States. They involve the insertion of genetic information into the Ti plasmid of the bacterium *Agrobacterium tumefaciens*, which attacks a plant and incorporates the plasmid in the plant's genetic constitution. So far, this technique is available for A. tumefaciens only in relation to dicotyledonous plant. Workers at the Plant Research Institute, Cambridge, believe that within a decade it will be possible to insert genetic material into plants for the expression of the major casein fractions. If these casein fractions are produced in reasonable amounts, their production by these vegetables, including harvesting and extraction, would be substantially cheaper than production of the same proteins by the cow. If this conjecture proves true, the conventional dairy industry, as now known, will face severe competition.

Reference

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Milk-protein activities in the Netherlands: the introduction of a specific magazine on milk protein

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Summary

Information is given on projects in the field of milk proteins. All these activities were based on the necessity of keeping all positive aspects of milk proteins in the attention of the nutritional and technological key groups. This also counterbalances unjustified and incorrect messages reaching them. Milk proteins include both milk proteins in traditional dairy products such as milk, cheese, milk powder and yoghurt, and milk proteins like casein/caseinates, whey-protein products and total milk protein.

For the continuous flow of information to the technological key groups, a specific milk-protein magazine was introduced at the beginning of 1984 with a controlled distribution. The paper also deals with the questions of content and lay-out, style of the magazine, and holding readership.

As topics, the excellent nutritional and functional properties of milk proteins, the marketing of milk proteins for both functional and nutritional reasons, new applications, assuring a dialogue with the key groups, human interest, new research results all have their place in the magazine. All these aspects must be balanced if this magazine is to function as a marketing tool for milk proteins and close contact must be maintained with the Dutch dairy industry.

CAB descriptors: milk protein, publicity sales promotion, journalism, dairy industry.

Introduction

The Dutch Dairy Bureau (DDB) has been initiator of various educational and promotial campaigns on the nutritional value, functional properties and technological application of milk proteins. One of the most recent developments has been the introduction of a magazine on milk protein in the Netherlands.

This magazine forms part of DDB's strategy of informative campaigns aiming at increasing the awareness of the functional-technological and nutritional value of milk protein.

These DDB activities are closely coordinated with the Dutch dairy industry. The aim is to support and promote the total range of dairy-linked trends and developments that interest the dairy industry. The efforts on milk proteins are mainly financed by European Community Coresponsibility Funds and bear the milk-protein vignette.

Nutrition education department

Before describing the specific educational and promotional activities undertaken by DDB for milk proteins, let me explain the nature of the Nutrition Education Department of DDB. This department, operating since 1973, has a primarily informative function. Its services are aimed at a broad range of nutritional key groups. These groups initially included doctors and medical specialists, food experts and dieticians, food industry, governmental agencies and consumer organizations.
In the course of time, more key groups have been added to the department's files and today include heads of institutional catering services, dietary cooks, instructors and curriculum officers of nutrition training institutes, and graduate and trainee food technologists.

To understand why the step was taken to publish the Milk Protein Magazine, let me review the phases through which our publishing activities have passed since we started in 1973.

Activities started in 1973 with a series of brochures with a highly specific scientific content. Though the subject matter of each brochure varied, it was limited to nutritional aspects of milk and dairy products. The information in each brochure was presented in the form of a scientific article, with a subject index for reference. This series is still running.

It came to our attention that members of the key groups did not equally share their appreciation for the highly scientific character of this series. In 1979, therefore, a new periodical was designed for easier access to nutrition-oriented information and developments affecting the dairy industry. This periodical wast titled: 'Zuivel & Voeding' or in English 'Dairy and Nutrition', and is still running. In terms of layout, subject matter and tone, this publication is still highly appreciated among its readership.

Marketing research enabled us to monitor the acceptance of our publications. These research activities also help to obtain quantitative and qualitative data about attitudes to and awareness of dairy products. In this way, we can evaluate our publications in a more professional manner, as well as factors in the complex and dynamic marketing environment of the dairy industry.

The evaluations are used as feedback and control mechanisms to create a better dialogue between our organization's informative services and our target groups. A similar marketing approach is planned for the Milk Protein Magazine.

In keeping abreast of significant marketing developments, opportunities can be noted as well as threats in the dairy marketing environment. Successful dairy policy and strategy cannot be built only by defining the needs of the dairy industry. We, like all marketers, must devote time and energy to ascertain the needs and desires of our current and prospective customers. Ways must be found to meet these needs. This is the path to be followed in order to ensure the continuity of our own industry.

As to noteworthy developments, we are all aware that a shift has taken place to a more vegetable-based diet. In the Netherlands for example, the Dutch Nutrition Education and Information Bureau has introduced the 'Meal Guide'. In my opinion, though, the Basic Five offers a better view of nutrition.

Moreover, we are confronted with the public relations activities surrounding soya protein in particular. Whether the arguments employed to promote soya protein are cogent or not, they have an impact on major sectors of our own marketing environment.

In view of this, we strive to achieve something other than a defensive reaction to the competitor's activities. By informing our key groups of the real advantages of milk protein, both in terms of nutrition and technological applications, we are serving their needs and interests, and ultimately those of the dairy industry. Attention can then be directed to the specific range of milk-protein activities undertaken by the DDB since 1979 and leading to the introduction of the unique publication, the Milk Protein Magazine.

The first campaign was on a pan-European level, with material in 6 languages. The information was addressed to professionals in various sectors, including food experts, i.e. nutritionists and dieticians, food manufacturers, food technologists, government representatives, consumer organizations, research institutes, and media groups including publishers of scientific journals.

In 1981, a completely new milk-protein campaign was started in order to reach trainees in food technology. In line with the curriculum of various training institutes in the Netherlands, a multi-media programme consisting of video and supporting text was introduced.

The courses comprise about 80% technologically based information and about 20% nutrition-oriented material. With this campaign, the link was made to ensure that new professionals entering food technology would be aware of the functional properties and the advantages of milk proteins in the manufacture of food products.

In 1981 too video material was first used in our continuing efforts to keep professionals up-to-date with applications of milk protein. On this level, DDB launched a national campaign, with seminars in regional centres, making use of the video material created for the training courses.

In 1982, in collaboration with the Royal Netherlands Dairy Federation, FNZ, the Sport and Nutrition Congress was organized. This event received a great deal of positive coverage by the media and public enthusiasm. Nutritionists, dieticians, sports officials, medical advisers, physiotherapists, prominent sports figures, heads of government agencies and institutes, research specialists and representatives of consumer organizations participated in this successful symposium.

Major topics of discussion were interrelated aspects of sport, nutrition and health, and the role of milk products and milk protein in particular. The congress included a panel discussion led by a leading television personality. Some members of the panel were prominent Dutch sport figures, who have excelled on the international level.

This congress stimulated high public interest, partly through the increasing popular interest in various sports among the Dutch. From football to jogging, rowing, tennis and cycling, the sport-minded public were eager to hear about the diets and food intake of their favourite sports 'heroes'.

In 1983, we continued to address various target groups in the professional, governmental and industrial sectors as well as those individuals participating in food technology training programmes. The year marked the beginning of a new educational campaign directed toward students of dietitics and home economics at various Dutch educational institutions.

This programme, introduced in coöperation with the curriculum officers of the various training institutes, also included video material and supporting texts. But unlike the multi-media programme designed for students of food technology, this material concentrated on the nutritional aspects of milk protein and only 15% of the matter was technological application.

This educational programme should be viewed from different aspects. The individuals receiving the information play an influential role in daily life. Many of the graduates of these training institutes in turn become teachers at professional training centres and other academic institutions. So they can transmit their knowledge of milk proteins in the daily food to their own students.

Those who become dieticians in medical centres, clinics, hospitals and other health organizations, can help to create a better nutritional basis for specific population groups, including expectant mothers, convalescents, young children and the elderly.

For any of you who are interested in seeing any of the written material and the video tapes I have described, you are welcome to browse at the Dutch Dairy Bureau's stand in the exhibition hall.

At this point, a critical remark can be made about the effectiveness of some of our activities. It would be unreal to suggest that all phases of our milk-protein activities have been successful. The 1981 national campaign in regional centres, for example, had a major drawback. In our attempt to reach professionals in food technology, we found that some participants were not eager to join in discussions and pose certain questions in the presence of their competitors. The dialogue we had hoped for could not be achieved in this manner. This overall experience led us to introduce the Milk Protein Magazine. The prime purpose of this publication is to offer a continuous flow of information about technological and nutritional aspects of milk protein in their broadest context.

Our goals are to increase awareness and 'goodwill' in various sectors, including various levels of industry. Furthermore, we are interested in creating a more active open communication, which will certainly benefit those involved in the production, utilization and consumption of milk protein.

The following remarks may help to clarify questions about the Milk Protein Magazine target groups. For example, the food technologists: by supplying substantial information about new applications, research findings and functional properties of milk protein, we hope to increase demand within the food industry.

By drawing attention to the nutritional advantages of milk protein, we hope to increase awareness among product-development specialists, marketing and policy-making management, and opinion leaders associated with the food industry.

Our target group also includes members of food-linked ministries such as those of Agriculture and Fisheries, Health, Welfare and Culture, as well as governmental institutions, such as Nutrition and Quality Control, Health en Welfare, Veterinary Services, and Products Safety. These are the central governmental offices in national nutrition policy. It is certainly in the interests of the dairy industry that the governmental body be kept informed of nutritional and technological research results.

Another vital target group works in education. Professors, teachers and instructors in training programmes for food technology, dietetics and home economics will be kept informed of the newest research findings about milk protein, and will be better equipped to transmit up-to-date information to their students.

Representatives of consumer organizations as well as a variety of interest groups, technologists in other industries, such as pharmaceuticals, members of the Dutch Parliament and the press are also on the mailing list.

We started with a closed circulation of nearly 5000. Since the first issue, we have received subscription requests from other individuals in various sectors.

We hope that the Milk Protein Magazine will help to ensure the continuity of information relevant to the key groups involved now and in the future with milk protein. Our role as an independent publisher enables us to present a quantity and quality of information on milk protein which would not be possible if we were restricted to the criteria of other publishing groups.

Because the readership is so varied, we have sought a 'formula' which would be appreciated by all. Therefore a decision was made to divide the content into what we called 'core' information and what we described as 'fringe' information.

The core consists of information mainly significant to technologists because of its functional and technological character, and for individuals involved with product development and research activities.

The fringe has a more general character, and includes scientific information of a more social or commercial significance. It is directed to the practical problems of the food manufacturer, for example. Fringe articles deal with consumer affairs, government policy and legislation, packaging and labelling, advertising, marketing, sports and dietetic foods, institutional catering and convenience foods.

Attention is also focused on nutritional developments that could help in forming policies towards world health and underdeveloped countries. There are also special articles on the nutritional significance of milk protein for specific population groups.

We look for opportunities to include articles based on interviews with individuals involved in food manufacturing, scientific research, product development, and other milk-protein-related activities in order to raise awareness and interaction among our target groups.

Because our target groups are so broad, we strive to ensure that all information is presented in a manner that can be appreciated by all. For instance, technological information and results of product development are 'translated', so to speak, from technical jargon into a language acceptable for non-scientific key groups. Practical implications of new research findings must be easily definable for industrial management. Summaries and news items must stand out clearly. Moreover, information must be relevant and worthwhile.

Besides the who en the how, the question remains, 'Why a magazine?' Certainly the complexity of the information and the difficulty in visualizing it have been relevant in our decision making. Budget also plays an important role. But ultimately it was what we can define as strategy that determined the form of communication. In our attempt to serve the interests and needs of our target groups, we have sought to offer them information in a familiar form, namely a trade journal. No other publication directed to the industrial market embodies information on milk protein in such a way.

In the discussions on a strategy for the Milk Protein Magazine and on a milk-protein strategy in general, we have been struck by some inconsistencies. Let me refer to some findings from marketing research among consumers. In this sector, dairy products enjoy what we may call a favourable traditional image, namely that dairy products are tasty and healthy. Most people surveyed are aware of the need to eat a variety of foods.

However specific awareness about nutrients hardly exists. If knowledge of protein intake in even a broad sense hardly exists, how are we to approach the consumer on an even narrower subject, namely milk protein?

Returning for a moment to the methods of a good marketer, let us examine the needs and interests of the consumer. Apart from their useful presence in traditional dairy products, milk proteins are applied in the manufacture of various products because of their high nutritional value. These products include baby food, sports food, low-energy preparations, clinical food and protein-enriched products.

Studies of buying patterns and consumer behaviour offer significant 'food for thought' about milk-protein policy. Sectors interested in extra protein intake are 'open' to milk-protein information. Sports food with its high milk-protein content is meaningful to that group of individuals highly involved with sports performance and fitness. Similarly, there is a sector of the consumer market more aware of the role of milk protein for dietetics. Dietetic preparations for the aged, for expectant and lactating mothers, babies, children and convalescents are sold because of their milk-protein content.

But in all fairness, can we expect the average consumer to prefer one soup manufacturer's products to another's because the one employs milk protein in his canned soups instead of soya protein? The consumer may benefit from the milk-protein ingredient by its emulsifying property, making a 'better' soup, but ultimately the consumer's awareness directs itself to the total product.

We must never lose sight of the fact that our product makes up only a small part of the total marketing mix in industries other than our own. So in terms of the functional properties and technological applications of milk protein, aspects such as solubility, gelling power, viscosity-increasing function and foaming capacity, we strongly believe that we must continue to focus on the industrial sector, where the characteristics of milk protein offer direct solutions to practical problems.

In terms of the nutritional value of milk proteins, except for the key groups and the small segments of the consumer sector we have already described, perhaps we will have to be patient and creative. It may take one or two decades before knowledge of milk protein in one's daily diet enjoys something comparable to the favourable traditional image which dairy products have. Perhaps we should even be thinking how we can create educational material for schools as well as consumers, so that our children and their children can learn about the nutritional advantages of milk and one of its most important components, milk protein.

Promotion of recombined milk products for industrial use

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Summary

In France, milk and milk components for industrial use and in particular milk proteins constitute major new market with a large potential. The development of this market, however, faces difficulties in legislation, traditional working methods of food manufacturers and the image of milk components. The paper discusses a campaign set in motion in late 1984 to promote the use of milk components (including milk proteins) in the food sector. The main objects of this campaign are:

– to provide manufacturers with comprehensive positive information about these components. This campaign will have to be vigorous, since potential users express only a vague need of information on this subject. To strike home, this information had better be 'called for'.

– to show distinctly the 'dairy solutions' that meet the industrial user's functional requirements.

– to influence current legislation on finished products.

The start of this campaign was to be initiated at a stand at the international food products fair to be held in Paris, 18 - 21 June 1984. In this stand, a minicomputer was to be available to visitors. It would clearly show the numerous applications of milk components by various categories of users (such as ice-cream manufacturers, producers of meat and bakery products, and caterers).

CAB descriptors: milk protein, food products, publicity sales promotion, food legislation.

Introduction

The scope of our campaign is not exclusively milk proteins but milk components, separated or recombined, for specific industrial uses. The promotional campaign was started on the home market by the French Dairy Corporation.

It was felt that former descriptions of these products seemed to detract from their acceptability, for example 'by-products of milk for industrial use', 'recombined milk products', 'milk derivatives'. It was therefore necessary to find a satisfactory designation clearly indicating the process of fractionating the raw material and recombining, though avoiding any name that might detract from their image. The description selected reads: 'Composés lactés' (for industrial use).

A promotional campaign for these products began in 1984. The preparatory market survey showed the following:

– the market can be considered important because the industrial uses of certain products represent up to 13% of the observed consumption
– the market is still new.

Indeed we are beginning to learn

– better separation techniques for different milk components
– more about their functional properties and how to exploit them.

Every marketing campaign starts with a survey of the environment and of the demand. This one, which was committed to a specialized organization, has enabled us to define our objectives clearly and to improve the campaign's approach.

Analysis of the supply of milk compounds for industrial use

Relative discrepancy in production

A substantial discrepancy was observed among manufacturers and their range of products, which was due to the following factors:

– the size of the enterprises and the moment of penetration into the sector of (recombined) milk products for industrial use
– the development and advancement of the techniques used and the amount spent on research
– the marketing strategy used for the feedstuffs industry.

More particularly, a big discrepancy is observed between manufacturers in their knowledge of users and their approach. Two approaches exist:

– a voluntary and offensive method, characterized by marketing adapted to the specific needs of the users
– a manufacturer's method characterized by a passive wait-and-see attitude and a lack of understanding of the needs of end-users.

The differences within the trade mean that interests are going to vary from one enterprise to another and this determines any action to communicate.

Categories of products

The market for milk products for industrial use can be divided in two categories:

– traditional products, called 'products of the first generation', for which supply and demand are well structured
– new products with a high added value of a highly technical nature, for which supply

and demand are not yet very structured.

Products of the first generation

These 'traditional' products, such as milk powder which are more or less common with standard ranges, for which supply and demand are important and very well structured. They are also specific products, in that they have adapted to the criteria of the users and involve a marketing strategy sufficiently adjusted from sector to sector and from company to company.

Finally they are products that are generally used to replace or complement existing products (for instance butter powder).

New products of the so-called 'second generation'

Second-generation products are complex. They include products with a high added value, involving much more than simple substitution or complementing.

They are products connected with advanced technologies. They are mostly products having a confidential nature, which are elaborated from 'company to company' and which come up to the specific technological requirements of the user. Finally these products may acquire 'patents of nobility', thanks to adapted terminology and appreciation of their nutritional and functional properties. These properties allow application in other food systems, such as meat, bakery, confectionary products, soups and desserts, or enhancement of the nutritive value of a certain prepared food.

Commercial strategies of enterprises

A new market is involved, for which it will be convenient to frame a new marketing scheme, resulting in the realization that the risks are apportioned between industrial producers and users. In this case, the method is a solitary one: it involves confidential reports, from company to company, between research workers.

It is a market that is still hardly open, involving only a few enterprises. However several factors can delay the development of markets. The restriction of this market sector can be caused by

- legislation
- the cost of research and development
- the attitude of the consumers, who are not aware of these new raw materials and are traditionally attached to 'conventional' products.

Elements in assessment of demand

Failure to understand end-users

There is a failure to understand the needs, motivations and expectations of the users from the side of the dairy industry. This is largerly explained by the segmented character of the French feedstuffs sector, with many small and medium-sized companies, with little investment in research and marketing. Lack of understanding is aggravated by the use of different terms: supply occurs in certain terms and demand in different terms.

Big discrepancy among users

The 20/80 act is respected. Except for some big feedstuffs companies, the market is in the hands of many small units, characterized by
- tradition
- ignorance of motivation for use of milk-based raw materials
- poor knowledge of dairy science and recent advances in it.

Legislation

Compulsion of law

Legislation represents compulsion and is often considered to be retrograde and coercive; it obstructs the introduction of new products because of its restrictiveness in product definitions and descriptions.

For technological innovations, the existing regulations are usually too restrictive.

Opportunities for evolution

It is the category of new products for which legislation has to be made (for example, legislation for deep-freeze products). It is the tolerance systems, attuned to certain products, which help to make legislation evolve.

Promotion policy

The efforts to develop a French market have a double aspect. General information on milk and its constituents gives products their 'patents of nobility'.

Up-stream, it involves
- appreciation of the image of milk as a noble, flexible and complex product by giving information on the richness and diversity of its constituents
- updating the image of milk by giving information on the technological evolution of the dairy industry and its innovative capacity
- making the final consumer receptive to the way foods are elaborated and to the naturalness of milk proteins.

Down-stream, it involves
- appreciation of the milk derivatives and more particularly milk proteins for industrial use. The users have to be adequately informed about the nutritional and organoleptic properties. They also have to be informed of their functional properties and of their role in the improvement of the finished products. It involves drawing the

attention of the users to the new product, being the carriers of an innovative and appreciative image of milk and its derivatives.

– emphasis on the milk solution. The second aspect involves the creation of a 'milk reflex' among users, which means pointing out to them that milk derivatives always offer a solution that satisfies the special needs of each user. For this purpose, particular attention has to be directed to

– the flexibility of the new technologies
– the flexibility of the raw material milk.

The described starting-point however should be offensive and should be accompanied by the will to have a better knowledge of the users in order to satisfy expectations more efficiently. The knowledge required implies the establishment of contact

– from corporation to corporation
– from manufacturer to users
– from manufacturers to consumers.

Procedures for communication

Principles

The above analysis of the market situation results in the following communication needs:

– the need to create a desire for information. At present, industrial users do not know the applications offered by dairy products. As they are not aware of their needs in this field, they also do not feel the need for information. It is therefore first of all recommendable to create and feed the need for information: to be receptive, information should be requested.

– The need for long-term information. As the system of legislation affects the evolution of the sector for a fixed period, it will be important to include those who take political decisions in the information channels we create.

Three-year programme

The first year involves the creation of the need for information. In the course of an initial phase, the programme is trying to create, encourage discussion and exchange of information on the use of these products among industrial users. Rather than supplying persons who have few incentives and therefore are hardly receptive to information, it seems necessary to intrigue them and incite them to request information.

In the second year, attention will be directed to continuation and development of the information. It will continue the initial communication effort in the industrial sphere. Factual information should be amplified on:

– the functional aspect of the products
– their nutritional aspects.

The third year will be directed to removal of legal impediments. After the first year,

the government should be receptive of the problem and consequently will be the one to whom information on the trade will be directed,
– when the major legal impediments have been identified
– when a real discussion has started within the trade
– when expectations of the feedstuffs industry about these products have become evident.

Programme for 1984

The aims of the action initiated in 1984 were to
– gather elements of information that can be developed later
– start public discussion on the subject among feedstuffs manufacturers
– release factual information on the problem.

These actions were to be aimed at the feedstuffs industry, the present or potential users of these products, the economic and specialized press and the government.

The actions described were to be in two phases:
– a phase of investigation. Collecting information on economic effects (issues, industries, areas involved . . .), technical effects (uses of the products, functional and nutritional aspects of the problem . ..) and legal effects (legal impediments, harmonization of European legislation . . .). The information received will provide the means for later communication. It will also allow identification of the interveners involved in the problem (industries, trade organizations, executives).
– a phase of factual information. The 'SIAL'exhibition in Paris was to provide an excellent opportunity to spread information on milk constituents.

This could be given:
– in factual form, in order to guarantee the impact on categories hardly receptive of the problem;
– in prospective form, in order to demonstrate that this initial effort fits into a continuous process.

Information flow was to be under the control of an information office possessing a file destined for the press (specialized, economic, agricultural . . .).

A roundtable conference or discussion was to be organized by the Institut d'Etudes Supérieures d'Industrie et d'Economie Laitières (IESIEL) in October 1984.

Food law and harmonization in the European Community

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Summary

An ideal of the European Community is free movement of food products within the Community. This free movement is impeded by differences in legislation between States. These obstacles can be overcome by two approaches, which are separately analyzed.

'Positive integration' means harmonization of the different State laws. Two examples taken from the milk sector illustrate the procedure.

'Negative integration' means abolition of unjustified barriers, which are forbidden by the European Treaty. Justification may exceptionally result from regulatory powers left to the Member States in the absence of Community provisions, especially in order to protect health, the consumer and fair competition. Recent cases show how free trade and these 'mandatory requirements' are balanced up.

These two approaches do not constitute alternatives, and are not open to free choice. The Commission is obliged to intervene if imports are hindered, whereas justified barriers can only be overcome if regulations are harmonized at Community level. Nevertheless, the limits are not clearcut. Either approach has its advantages and disadvantages.

CAB descriptors: European Communities, food legislation, consumer protection, trade barriers.

Introduction

When the European Community was established and later twice enlarged, it was confronted with a voluminous and constantly developing food law in the member states. Its main objective is protection of public health. Furthermore, it aims at protecting the consumer against confusion and against being misled, while securing fair competition between producers. Finally, food law should help to promote the quality of food and provide for necessary control measures.

The community recognizes all these objectives. The first aim of the community is to establish a Common Market presenting the characteristics of a single internal market, which means free movement of goods between member countries. (In the field of agriculture, wider objectives are pursued, but as food law in the strict sense is affected only to a small extent, I ignore agriculture).

There is thus no contradiction between the objectives of food law and the establishment of the Common Market. But – as in other fields as well – the law of member countries must be adapted to the new situation of the Common Market. Its status as 'National' must not impede the functioning of the Common Market. In that state regulations differ and are applied not only to national products, but also to imports from other member countries with different regulations, the result is to disallow these imports and to create trade barriers within the Community.

There are two ways of overcoming these obstacles. Uniform provisions at Community level; or prohibition to application of state regulations for imports from other member countries. Let us see how these two methods have been used in the Community in the course of its development.

First period

In the *first period*, emphasis was undoubtedly put on *harmonization* of state regulations. Indeed, the Commission started from the view that such provisions, if indistinctly applicable to national and imported goods, were in principle justified and forbidden only if excessive or if misused. Consequently, a special program for harmonization of food law was adopted in 1969 and revised as early as 1973, alongside a general program for industrial products. It provided for about 40 directives, only a third of which have been completed so far. Today, the programmes are largely regarded as out of date. The predominant impression is that the work of harmonization has slackened off and is only continued pragmatically.

What are the causes of this development? They are manifold: the complexity of food law; the long duration of procedures, comprising first the elaboration of a draft directive, then its discussion in the Council committees; the necessity to reach unanimity among all member states. As of 1 February 1984, 308 Commission proposals were awaiting a decision by the Council; of these, 87 for over five years! Figures relate to all Community activities, and not only to food law. As frequent consequences, only parts of a given field would be harmonized, reservations and exclusions had to be provided, and only optional harmonization would be achieved. In other words, the original national regulations were allowed to remain in force for national products, alongside the Community provisions. The method of vertical directives – that is, product by product – soon turned out to be rather unfruitful: just imagine the fear if a uniform Euro-bread were to be imposed on the consumer. More promising are horizontal directives, especially for additives. It is true that they can often only give a frame that has to be filled in and completed for the different products.

Two examples taken from the milk sector may serve to illustrate some traits of harmonization.

– The commission proposal for certain lactoproteins was handled for four years in different committees of the Council before it was finally adopted in July 1983 (1). It determines not only the composition, but also the names and the labelling of the products concerned, which is necessary because of the interrelations existing between them. An essential point appears here: it is true that it is not the task of the Community to create an independent and complete Community food law, but once it adopts certain provisions, it must take into account all the objectives of food law. If it appears that this is not possible, reservations must be made in favour of national laws, as we find them also in this directive (Art. 6 Par. 2). Reservations, derogations and references certainly do not ease application of the rules governing a certain field. Another relevant point is the necessity for the member country to transpose the directive into national law, and for the Commission to verify that this is done correctly. If, for instance, the national legislation construes the wording of the directive that the product information must be made 'in a language easily understood by the purchaser' in a narrow way and requires the exclusive use of the national language, then a dissent between member countries has not been settled, but only shelved by the directive.

– As for baby food, the services of the Commission have elaborated a proposal (2) based on the opinion of the Scientific Committee for Food and an international code of WHO. The text in question is a specific directive supplementing an existing outline directive of 1977 relating to foodstuffs for particular nutritional uses. We will see the fat of this proposal in due course. It should be quickly approved, as it is obviously based on internationally recognized scientific opinions. Add to this that – as in most other directives – a safeguard clause (Art. 10) with a simplified procedure allows adaptation to scientific progress.

As an example of the relationship between Community and national law, let me cite the Dutch regulations on production of cheese; this case was decided by the European Court of Justice February 1984 (3). Because the Common Market organisation for milk and milk products is silent about designation and quality of cheese, the member countries remain entitled to legislate in this field for their national producers, except with application to imports. There is thus no objection from the Community to national rules ensuring that only first class cheese is produced in the Netherlands. The Dutch producers are then exposed, even on the Dutch market, to competition from producers of other member countries who are not subject to the stringent Dutch rules. This is not regarded by the European Court as discrimination against Dutch producers, but rather a desirable and fair competition. It is up to the consumer to decide whether he prefers price or quality!

Second period

Let me move on to the second period, in which we still seem to live and where the stress is put on prohibition of trade barriers. This change is due not only to the difficulties in the harmonization work but also to the jurisprudence of the European Court. Its case law has somewhat modified the doctrine of the Commission and thus rendered superfluous a certain part of harmonization. I here cite two judgments that marked this development and therefore are constantly referred to: the Dassonville case (4) gives such a large definition of 'measure of equivalent effect to quantitative restrictions' that practically any national provision of food law would be such a measure, unless justified by the protection of health. The case 'Cassis de Dijon' (5), on the one hand, narrows down this definition because 'mandatory requirements', above all the protection of the consumer and fairness of commercial transactions, can cancel the effect equivalent to a quantitative restriction. On the other hand, the judgement is more stringent than the Commission's original doctrine: indeed it demands that indistinctly applicable measures can only be applied to imports in exceptional and duly justified cases. The European Court's premise seems to be that all member countries pursue the objectives of food law in a comparable manner, even if thoroughness and means may differ. In consequence, when a product has been lawfully produced and marketed in one member country, it can be presumed that it satisfies the requirements of food law, so that its import into another member country may not be opposed. Accordingly, priority is given to the free movement of goods, unless the importing country proves, in the absence of Community rules, that the national rules must be applied to imports as well, in order to meet 'mandatory requirements'. On no account, however, must this application be excessive, e.g. no absolute prohibition of import or sale if marking or labelling were sufficient, nor must it be misused for protectionism.

So far, the principles. Let us now consider some cases relating to the different objectives of food law.

Different objectives of food law

The conception of health protection does not generally differ much between member countries. It can be assumed that no state will allow that food products endanger the health of its citizens or neighbours. So protection of health was found no valid ground for import barriers in many cases. French brioches, apple vinegar, liquor with low alcohol content are not dangerous to public health, even if not corresponding to the rules of countries other than that of production. It may also arouse suspicion if a rule is not valid for exports.

The assessment is more delicate if scientific research is still under way and no unequivocal opinion exists about hazards to health, for instance from certain additives. In the absence of Community rules, the Court leaves room for discretion to the member country in regulating such problems of health protection. Thus, a country can prohibit the addition of preservative (6) to melted cheese, considering the actual situation of science and Community law. Equally, vitamins (7) can be added subject to authorization which, however, must be granted in technological need. In the second vitamin case, the Court has stressed that it is for national authorities to prove that a serious risk exists to public health.

In the field of protection of the consumer and fair competition, the question of necessity and proportionality is decisive. The Court has been rather strict in this, and in many cases has condemned prohibition of sale as excessive, clear labelling being sufficient. This corresponds to the tendency in harmonization to drop 'recipe laws' determining the obligatory composition of a product and to content oneself with the obligation to inform the consumer about the actual composition. In the same line of ideas, the 'expectation of the consumer' or the 'traditional' qualities of a given food product by no means justify the prohibition of goods produced 'according to a different tradition' in another member country as long as the label clearly states that it comes from another member country, as in the Kikvorsch case (8) relating to the import of a German beer specialty into the Netherlands. Another example: in Freiburg, Germany – thus not far from the French border – a French cheese, Crottin de Chavignol, was recently confiscated by the local health authorities. But the judge acquitted the accused dealer, finding that the taste of the average German consumer is not decisive and there is no reasonable ground for prohibiting the sale of this French specialty.

Although no exhaustive list of 'mandatory of imperative requirements' exists in the meaning of the Cassis jurisprudence, promoting the outlet of certain goods is no such ground. The reason is that restrictions of free movement of goods in the Community are not a lawful instrument of economic policy. An example is the fruit vinegar case (9) where the condemned Italian rules aimed at promotion the sale of wine and thus were even in harmony with Community policy. Similar considerations will apply to coffee whitener made of vegetable ingredients or to soya milk. As for the Community legislation, the European Treaty expressly prohibits discriminations between producers or consumers within the Community (Art. 40, No 3, Par. 2), and so the Court has twice cancelled regulations. I refer to the milk powder case (10) and the market for sweeteners containing sugar and isoglycose (11). According to these principles, it seems that the Commission refrains from direct interventions in this respect. As for the marketing of milk and milk products, it has recently adopted a proposal for a regulation on the designations used, which will provide better protection against imitation products (12).

Considerations about the future

The last part of this lecture is concerned with some considerations about the future of food law in the Community.

The Cassis jurisprudence is by no means the end of the harmonization work. The Commission has declared that it will continue with harmonization, while concentrating on the elimination of trade barriers that would otherwise have to be tolerated. The Court has always taken into account the state of harmonization, and in some cases expressly pointed out that remaining obstacles could only be removed by Community rules. The present standstill must be overcome by fixing new priorities and by improving procedures. Priority should depend on the importance of the problem for the proper functioning of the Common market. Continuous work should above all be dedicated to horizontal harmonization for additives and to a greater practicability of the labelling rules where the numerous gaps and exclusions of the directives should be eliminated. The Commission has begun to revise the labelling directive and will start consultations shortly. The implementation of a directive should be more clearly stated and thus facilitate its verification. The national implementing measures relating to each directive could be published periodically in the Official Journal; these measures should clearly state that they serve to implement a Community directive. Finally, the Council should determine a framework only and leave the details to the Commission, after getting approval from a majority of State representatives.

The prohibition of obstacles to free movement of goods, provided for in the Treaty itself, must be enforced, if necessary by bringing an action before the Court if the application of national rules to imports is not justified and has protectionist effects. As a premise, the Cassis judgment was criticized; but criticism has gradually died down after the Court had made it clear in later cases that reasonable requirements are well balanced. In some respects, the enforcement of the prohibition and the result could still be improved. It is true that the great number of preliminary questions referred to the Court in Luxemburg by national tribunals cannot and should not be influenced: the Community citizen has a right to free trade within the Community, which he can invoke in any tribunal. But the Commission, for its part, should at once examine whether a direct regular procedure should not be introduced, as only the direct procedure can give full guarantees for a satisfactory and complete solution. Furthermore, before lodging any action against a country before the Court, the Commission could enlarge the preliminary procedure, consult all member countries as well as interested parties, and strive for a Community solution. The Court, asking, as a rule, to be informed about the state of law in the other member countries, already seems to hint in this direction. The possibility, for the parties as well as for the Court itself, to ask the opinion of experts and committees, including consumer associations, could also be used to a wider extent.

Finally, the situation would be improved if obstacles resulting from new measures could be prevented at the outset by previous checking. If measures lack justification their adoption would be prohibited; otherwise, the question would be settled at Community level. Such previous checking is already in force for industrial products, and also in the labelling directive (Art. 16, No 2). For example, the Commission has obliged Belgium, by a decision adopted in August 1983, (13) to suspend for two years the introduction of a provision for sausages asking for the label 'artificial, not edible'. Even after two years, in the absence of Community rules at that time, Belgium can apply the measure only with certain restrictions.

I have come to the end of my considerations. There are still many questions in the complex and even politically sensitive field of food law that I could not mention. I hope nevertheless to have given you the promised outline.

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Development of an international dairy symbol

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Summary

Woolmark, the trade mark for pure wool, was launched 20 years ago and promoted internationally. Wool and milk protein have a lot in common. Both are natural raw materials made into a variety of end-products; both compete with mass-produced synthetic products; both have quality connotations; and both are promoted, to varying degrees, in the developed countries of the world. It would seem, then, that there are lessons to be learned by dairy producers and processors from the success of the Woolmark.

The wool farmers conceived and developed their programme around the world in the face of fierce competition, similar to that facing milk protein. The dairy industry will need to draw upon similar resources if it wishes to launch its own symbol/trademark.

If the dairy industry wishes to employ a similar strategy for milk protein, it will need an international organisation to promote and control the mark, a large budget for direct and joint promotional work, cohesion and a strong sense of purpose!

CAB descriptors: milk protein, trade marks, qualify labelling, standard labelling, product presentation, wool.

Introduction

The main contribution this paper will make to the debate on whether the dairy industry should have its own consumer symbol or trade-mark is to provide a case history of how another industry faced and answered the same question. That industry was the world's wool producers, who, back in the early sixties, conceived and launched the international Woolmark, their own certification trade-mark for products made of pure new wool.

This paper will attempt to outline the circumstances that faced the wool farmers

20 years ago and how they conceived their programme and developed it successfully around the world in the fase of fierce competition. It will also try to draw analogies between wool and milk protein, and illustrate the resources the dairy industry will need to draw upon if it wishes to launch its own symbol/trade mark.

Before doing so, however, let me briefly state my credentials for presenting such a paper. The Woolmark was launched in 1964 and it was just one year before that that I joined the world headquarters in London of the International Wool Secretariat (IWS), the marketing arm of the world's wool growers, to join the management team planning the Woolmark programme.

As Director of Public Relations, I supervised a global programme for publicizing the mark. In 1968, I moved into IWS line management and took responsibility initially for the British market and, later, a group of key markets in Northern Europe (including, Britain) and the whole of South America. In that time, I presided over the development of the Woolmark in my territories and led a team skilled in a wide range of marketing techniques. I resigned in 1980 to set up my own business and am now chief executive of one of Britain's leading promotional agencies and chairman of a marketing consultancy.

I have made every effort to ensure the accuracy of statements and facts contained in this paper, but the opinions expressed are my own and not necessarily those of IWS.

Wool and milk protein: are they analogous?

The answer must be yes. There are many points of similarity between the two raw materials. Firstly, they are both natural products, emanating from agriculture. Both are primary materials that are not sold to their eventual consumer in their raw state but are converted into final products, often only after they have passed through several complicated processes – so often obscuring their identity at point of sale.

They both face competition from manufacturers of synthetic or partly synthetic products who possess strong commercial expertise and promotional resources. But both have strong quality connotations, based on emotional and rational arguments, and both draw support from the current ecological movement.

Lastly, both milk proteins and raw wool have international and national organizations either capable of mounting promotional and marketing programmes of some sophistication, such as would be needed to launch an international dairy symbol.

The conclusion therefore is that there are indeed lessons to be learned by the dairy producers and processors from how the wool growers have tackled their identity problems over the last twenty years.

Need for a woolmark

The invention and production of synthetic fibres was hastened by World War II, when the need to clothe armies put pressure on the agriculture-based natural fibre producers. The subsequent years of expansion, particularly during the affluent fifties, led to further break-throughs in synthetic-fibre technology, most significantly in the invention of polyester, whose performance brought it into direct competition with wool for quality clothing.

By the early sixties, two fundamental problems faced the wool growers problems that threatened to take their product out of the real market-place and reduce it to highly priced esoteric fibre like silk.

Firstly, the proliferation of synthetics (and not all of them the post-war high-performing fibres) was hastening the spread of end-products made of blends of wool with synthetics. In those days, labelling legislation was comparatively poor, even in developed markets, and many garments and carpets were labelled and promoted as being made of wool, even when wool was only a minor element in the fibre mix. The result was that wool got the blame when the product performed badly. And a new race of consumers was born, who were 'fibre agnostics' because of the confusing fibre blends being offered.

A second and more disturbing trend, however, was observed by the more discerning leaders of the wool-growing industries in the main producing countries of Australia, New Zealand and South Africa. This was the potential threat posed by industrially produced artificial fibres to wool's price structure.

As new fibres were introduced by the main chemical companies, they entered the market at much higher prices than those being earned by wool under the open auction system. Gradually, however, as research, development and other costs were amortized over easily expanded production runs, it became clear that prices of synthetic fibre would fall. The problem was that the competing fibres were fighting for the same customers and, in the market's eyes, the prices of natural fibres and synthetics were linked. The real danger to wool therefore, was that, as synthetics' prices fell, so too would those for wool. And, while the giant chemical companies could compensate for lower margins by mass producing, the wool farmers were stuck with their centuries-old problems of weather, slow gestation, under-capitalization and general inflexibility. By 1963, wool was facing the prospect of being priced out of its own market.

The approximate prices compared in Table 1 depict how that threat did indeed

Table 1. Price (£/kg) of wool and synthetic fibres for clothing and other uses in Britain. Data from International Wool Secretariat.

Year	Wool		Synthetic fibres	
	clothing	other	clothing	other
1960	0.81	0.62	1.45	0.70
1965	0.86	0.62	1.11	0.55
1970	0.75	0.43	0.88	0.45
1975	1.67	1.05	1.00	0.75
1980	3.02	1.80	1.05	1.07
1982	3.05	2.00	1.16	1.15

certification trade mark

pure new wool

Fig. 1. Woolmark.

develop through the decade of the 1960s in one typical market (Britain) and how the prices of synthetic fibres fell and took wool prices down with them.

By 1963, the wool growers needed some kind of initiative in the marketing field to provide:
– protection against poor labelling legislation in the main markets
– a guarantee of quality to the consumer, to justify a higher price over competing synthetics
– an immediately recognized indentity at point of sale
– a focal point to symbolize quality promotion across a wide range of end-uses.
They also needed, and much later were to introduce, reforms in the handling and selling of wool.

The answer was the Woolmark (Fig. 1). It became and has remained the cornerstone of wool promotion across the world.

The woolmark concept

The Woolmark was and still is the property of the International Wool Secretariat, the body set up in 1937 by the wool growers of Australia, New Zealand and South Africa (later joined by Uruguay) to create and maintain demand for wool in the end-products markets of the world, most of which are in the Northern Hemisphere. The Secretariat team that planned the mark quickly realized that a good-looking symbol which merely 'signed off' even the most memorable advertising was not enough to create and maintain a price premium over synthetics. The programme therefore had to be linked to quality standards.

Once the symbol itself had been created (itself a highly complex operation, involving legal searches in many countries), it was registered as a certification trade mark or its local equivalent in 90 countries, so defining it as the guardian of a set of specifications to be met if the mark was to be carried on the end-product.

The specifications themselves were necessarily basic. Primary was fibre content: pure new wool (not reprocessed and so weakened) fibres, but with small controlled minorities of other fibres allowed for decoration and inadvertent impurities. Performance specifications were linked to end-products and concerned such factors as tensile strength, colour fastness and, later, washability.

No charge was made to manufacturers applying the mark to their products, but they had to be licensed to do so and to promise to observe the specifications and provide production statistics to the Secretariat.

Elaborate quality-control procedures had to be set up internationally to ensure that the specifications were not being abused and this involved the creation of a panoply of testing procedures and national staffs of quality controllers. Legal surveillance had to be mounted in those 90 countries, to make sure that the mark was not being pirated by unlicensed manufacturers.

Similarly, the Secretariat felt that it could not sit back and simply expect the spinners, weavers and end-product manufacturers, who were its customers, to struggle to reach the standards without help. So a strong programme of technical development was put in train as a more positive side to the policing duties of the quality-control officers.

Corporate disciplines for the use of the mark itself were laid down. It must always appear with the words Pure New Wool (or local language equivalent) beneath the symbol; it must always be printed white on black or black on white; if it figured with another brand, a line must be drawn between the two to avoid confusing the consumer . . . and so on.

The total programme was carefully planned and complex. It was also expensive. The Secretariat had already been carrying out wool promotion of some sophistication for many years. But the Woolmark programme demanded a total budget increase by a factor of four or five to have any real effect. Accordingly, a campaign for a huge increase in Secretariat funds was mounted in the three grower countries then concerned and, eventually, an annual budget of £13 million was raised for the launch of the new mark in 1964.

Woolmark penetration

Five countries only were selected for the initial launch: the United States, Great Britain, Japan, France and Germany, with markets such as Italy, Benelux, Scandinavia, Australia and Canada, to follow in the second year, and the smaller countries in 1966.

In fact, despite careful pre-selling and pump-priming, an anxious textile world did not clutch the Woolmark to its breast with gratitude. On the contrary, there was considerable hostility. Synthetic fibres were increasing their penetration of markets by the month and both the 'wool-type' textile industry and the clothing and domestic furnishing industries were looking towards synthetics and blends as the way ahead in the sixties. The powerful German weavers even attempted to have the Secretariat expelled from the International Wool Textile Organization.

It was weight of promotion and persistence that eventually changed these attitudes and which enabled the new mark to gain a foothold and grow to become the most successful branding operation in the world's textile industry.

Firstly, the mark – as a symbol of quality – was only launched at the top of each trade. Only a handful of top-quality weavers, coat, dress, suit, sweater and carpet manufacturers were approached to be members of the exclusive launch club of licencees. Many refused at first. But, as the months and years rolled by, it was difficult to resist the weight and professionalism of Woolmark promotion.

The Secretariat mounted its own generic advertising campaign for the Woolmark, explaining from pages, posters, radio and television directly to the consumer what it meant and stood for. Less conventional promotions were mounted: the Pope blessed the mark in the Vatican for the Italian launch; English sailor hero Sir Francis Chichester sailed single-handed round the world against prevailing winds and currents with the symbol on his cap and bows; wool-clad athletes ran the length of America's Death Valley; Miss World carried the symbol to countless fashion shows in 1966 . . .

The whole promotional resources of the Secretariat was put behind the programme throughout the world, so that spinners, weavers, merchants, garment and carpet manufacturers and retailers could not gain any promotional or other support from the Secretariat unless they were manufacturing or selling Woolmark goods. The pressure mounted; so too did the number of Woolmark licencees, and the public's recognition and awareness of that Italian-designed symbol. Though synthetics continued to increase production, so making wool an increasingly minority fibre in overall terms, the symbol was used more and more on labels and swing tickets, on retail show-cards and posters and in advertising around the globe.

At the end of 1964, the launch year, there were less than 100 licencees in five countries. Now, 20 years on, there are 15 500 in nearly 60 countries, including virtually all of the world's garment manufacturers with a reputation for quality. Many of those are happy to join with the Secretariat in cooperative advertising activities.

No-one within the Secretariat or the wool-growing countries would claim that the Woolmark alone has saved the wool-producing industry. Promotion can rarely be precisely measured. In any case, there have been other reforms in wool production and an undoubted emotional swing-back in developed markets towards natural products – a move the Woolmark may or may not have helped to create.

What is clear is that the mark is recognized throughout the textile world and beyond as being a success story. And what appropriate statistics there are would seem to confirm this.

Every year, the Secretariat carries out market research to measure the consumer's recognition and understanding of the Woolmark in the eight main developed markets of the world (Britain, West Germany, the Netherlands, Belgium, France, Italy, the United States and Japan). The figures show that the mark is near saturation point by most criteria (Table 2).

Despite the continuing increase in synthetic-fibre production, and the occasional pressure on wool growers to run to more fashionably rewarding crops, world wool production too has continued to increase (Table 3).

Lastly and arguably, the most important measurement of all, the downward relationship between the price of raw wool and competing synthetic fibres seems to have been broken (Table 1, data for 1975-1982).

Table 2. Proportion (%) of the population in eight main countries of the wool market who recognized or understood the Woolmark. Data from International Wool Secretariat.

Year	Recognized	Understood
1966	48	37
1970	80	66
1975	81	68
1981	84	72
1983	84	75

Table 3. World production of clean wool (in million tonnes). Data from International Wool Secretariat.

Year	Production
1955	1.27
1960	1.48
1965	1.56
1970	1.62
1975	1.52
1980	1.61
1982	1.67

In other words, wool's price structure has survived after all. Wool is still under great pressure, but it would be the most begoted of critics who did not concede that the Woolmark had played a central role in stabilizing wool's price and in establishing it as a premium quality fibre in world markets.

The question for the dairy industry is now, Is a similar programme relevant to milk protein and, if so, what resources are needed to mount it?

An international dairy symbol?

I know considerably less about food production than about textiles, and there are obvious dangers in drawing too close a parallel between the wool and milk protein. In any case, there may already be the framework of an international dairy symbol programme in the United States Real Seal initiative, so making the Woolmark analogy rather redundant. Nevertheless, there are certain relevant principles that arise from the experience with wool.

– Quality. With milk likely to grow more expensive and vegetable protein cheaper, the need for a dairy symbol to equate with quality and so justify a price premium is real. To earn respect and acquire consumer pulling power, such a symbol ought to have specifications attached to it. They will be a source of controversy to food and drink manufacturers, so the sooner a start is made the better.

– Education. To make it worthwhile, the new symbol must be a consumer mark, enabling the housewife to justify why she should pay a little more for products carrying it. This means that some education on milk protein, at least rudimentary, should form part of the programme: what it is, why it's good for us. This is not like wool, where nobody really knew or cared about the difference between wool and second-hand, re-used wool.

– Internationalism. The symbol must work across frontiers. This means that its shape and style must be easily remembered (that of the Woolmark is simple) and must not rely on words.

– Market level. Primary product marks tend to sink through a market as they spread. If quality is important – and it is – then the dairy symbol should not appear on the market at first on high-volume low-quality products. Once down-market, it is virtually impossible for a new symbol to go up.

– Money. Presuming that the countries of the European Economic Community would be the first real target for the launch, it is difficult to see how anything less than an annual budget of Us$ 50-60 million could meet the cost of promotion and control.

– Organization. A commercial international organization would be required to manage the scheme and its budget. Technical assistance, quality control and promotional deal-making skills to handle cooperative advertising would be required in each country, in addition to international management. Good agency back-up will be necessary. At risk of being accused of immodesty, I would offer my services in this and in other areas where my experience could be useful!

The 'Real' Seal dairy symbol

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Summary

United Dairy Industry Association and American Dairy Association, have been involved in the development of a symbol of identity for real dairy foods, the 'Real' Seal, for four years (1980-1983). Currently, over 1000 dairy processors and retail food store chains that market private label dairy foods have been certified to display the 'Real' Seal. In volume this represents about two thirds of the United States commercial diary industry.

In terms of its consumer audience, the 'Real' Seal program is designed to increase the dairy shopper's ability to distinguish genuine dairy foods from their imitation counterparts. Moreover, the promotional thrust of the 'Real' Seal program is to increase the consumers' awareness, recognition and ultimate consumption of real dairy foods.

Largely through its widespread acceptance by dairy processers, the 'Real' Seal has developed into a viable marketing tool for the United States dairy industry. While the 'Real' Seal supports the collective efforts of the entire dairy industry, it also augments individual brand dairy promotion. It serves as a link between non-brand and brand promotion efforts. Such cohesion of non-brand and brand promotion efforts should have a positive effect on total consumption of dairy foods in the long term.

CAB descriptors: dairy products, trade mark, simulated foods, publicity sales, promotion, 'Real' Seal.

It is indeed a pleasure to have this opportunity to visit Luxembourg with the fine people assembled here at the Milk Protein Congress, and to relate to you a program adopted four years ago by American Dairy Association. The program, 'Real' Seal, is designed to enable consumers to identify real dairy foods.

But, first, let me briefly tell you about our overall organization in the United States. The American Dairy Association is one of three major divisions of our parent organization, which is United Dairy Industry Association (UDIA). United Dairy Industry Association is an organization which was formed in 1971 as an alliance of American Dairy Association and its two sister organizations, National Dairy Council and Dairy Research, Inc. to eliminate duplication of program efforts, and to coordinate educational, research and promotional programs. The objective was to concentrate funds to achieve the greatest market impact.

Today, UDIA's total program includes the advertising and marketing services of American Dairy Association, the product and process research and development projects of Dairy Research, Inc. (DRINC), and the nutritional research and nutrition education programs of National Dairy Council (NDC).

UDIA is principally funded by dairy farmers by way of our 20 state and regional member organizations and our 33 affiliated dairy council units. Collectively, UDIA represents about 95% of the United States Dairy farmers and 85% of the United States milk supply.

The basic need for a program such as the 'Real' Seal dairy symbol stems from the increasing proliferation of imitation dairy products now being marketed in the United States. Though the relative extent of encroachment on the market for real dairy products by imitation counterparts in countries of the European Community has not reached those levels experienced in the United States as of today, the overall situation is one that we not only share now – but will continue to share in the years ahead.

As a somewhat analogous situation, the erosion of demand for milk protein in the European Community, created by competition from vegetable-protein alternatives, poses a long-term threat to the continued stability of the European dairy industry.

One fundamental concept upon which I know we can agree is this: milk and dairy products represent a vital part of the diet – and milk's protein is a high-quality rich source of protein that, to a certain extent, is not being fully utilized today. Nor are dairy products themselves fully appreciated, or understood, by today's consumers.

The reasons are these: the consumer's mind is filled with all sorts of problems these days. Economic as well as social problems. Life just seems to keep getting more complex, with little sign of relief.

And sometimes it's the little problems, the ones that gnaw at us, perhaps below the level of conscious recognition, that collectively begin to well up in the consumers' attitudes and patterns of behaviour.

Perhaps that is why today's consumers seem to be short on patience as well as time and money. And, to make matters worse, food and grocery shopping decisions in the United States, for example, are complicated by hard-to-understand labelling and listings of ingredients that make it virtually impossible for consumers to know exactly what they are buying.

And so, in this day and age, we have good reason to listen to the consumer, to learn more about what his and her contemporary needs are, what problems exist, and what we can do to make life a bit simpler.

Marketing and economic research is one means that we use on a continuous basis, to probe the minds of the American shopper, and to focus on specific issues of relevance to contemporary consumer needs and wants. In October 1980, for example, UDIA completed a nationwide study on consumer attitudes and understanding of the labelling of authentic and simulated dairy products.

The objective here, of course, is to observe, to listen, and hopefully to anticipate consumer needs. Among the findings of this study, 'consumers are experiencing problems in their dairy-type product selections . . . and feel that they must be more clearly informed . . . as to product identity' . . . in terms of authentic versus simulated dairy products.

Secondly, 'consumers do want the food-selection process simplified'. The research cites that consumers 'now exhibit confusions about product types or classes. They find ingredient lists and name designations hard to understand'.

One of the major conclusions of the research, which was conducted by the Nowland Organization, Inc. of Cambridge, Massachusetts, is: 'Accordingly, the greatest shopping assistance which could be rendered to consumers . . . is to simplify the entire comparative product naming and descriptive situation'.

So, by clearly identifying real dairy products in a simple straight-forward way, we can indeed provide at least a little help to shoppers.

Let us examine the american Dairy Association's 'Real' Seal dairy symbol – as a little bit of help to shoppers in their complex daily lives.

It is a 'milk-drop' symbol of assurance to shoppers and a means of helping them quickly identify genuine dairy foods at retail.

In many respects, the 'Real' Seal is similar to the Woolmark, as it was so ably explained to you today by Wilcox.

The 'Real' Seal can help aid product recognition, of course. And it can also support consumer confidence, encourage favourable product association, and reinforce positive brand image.

The background and development of the 'Real' Seal is this. Some eight years ago, the California State Milk Advisory Board (CMAB) developed the seal as a public service to help the western United States retail shopper to ease identification of real dairy products . . . and to distinguish them from their artificial counterparts. The CMAB program had been successful in California – but as time passed, and the program progressed, it became apparent that this valuable program deserved national support.

So, in March 1980, an agreement was reached between CMAB and UDIA, whereupon the federally registered trademark, the 'Real' Seal, was transferred to UDIA for administration and promotion of the seal on a nationwide basis in the United States.

The stated objectives of the 'Real' Seal program, as it is now administered and promoted by ADA, are these:

– to get consumers involved with the Seal, to broaden and enhance the shopper's knowledge, recognition and appreciation of real dairy foods, particularly at the retail level

– to obtain acceptance and application of the Seal in the dairy industry, including acceptance among dairy food processers, distributors and retailers . . . with the Seal becoming an integral part of their packaging and total promotion.

At the end of 1980, there were 167 dairy processers who had agreed to display the 'Real' Seal symbol on their packages of milk and other diary products. At the end of 1983, that number had increased to over 1000 program participants, which represents an increase by a factor 5.3 over four years. In amounts of milk products, participation in the 'Real' Seal program today represents about two thirds of the United States commercial dairy industry.

The 'Real' Seal symbol now ranks as the most widely exposed food industry symbol of its kind in the world. Its exposure on fluid-milk packaging, for example, is estimated to be about 35 million packages of milk purchased daily by American consumers.

In line with the promotional thrust of the 'Real' Seal program – to increase the consumer's awareness, recognition and ultimate consumption of real dairy foods – the Seal has been applied to the complete family of milk and milk products as a means of achieving this goal.

In terms of developing consumer awareness of the 'Real' Seal and its value to shoppers in identifying real dairy foods, we have developed a full complement of advertising and promotional materials. The leaflet distributed at this congress, entitled 'Will the real dairy product please stand up?' is just one example of the consumer information materials that have been developed to support the 'Real' Seal program.

The primary method of communicating the meaning and benefits of the 'Real' Seal has been through the use of television advertising. Television viewing in the United States continues to flourish, and the TV is an excellent method of getting our message across to the American consumer.

In late 1981, the American Dairy Association evaluted the general effectiveness of the 'Real' Seal advertising materials. Specifically, the main focus of the evaluation centred on the relative effectiveness of the 'Real' Seal creative strategy utilized in television advertising. Testing of an introductory television commercial, aired in many United States markets during 1981, fell short of expected goals in terms of the stated consumer-advertising objective to build consumer awareness and recognition of the 'Real' Seal. Though the advertisement achieved adequate levels on certain communications measures, it was felt that the basic audience recall of the overall message should be improved in subsequent commercial executions. Through available information sources, it was also determined that the general category of symbol advertising appeared to require 'extra effort' in order to deliver acceptable levels of unaided recall when compared to other product or brand-specific types of consumer advertising.

In analyzing various alternatives to a new commercial approach, it was determined that utilizing borrowed but relevant interest could improve consumer awareness of the 'Real' Seal message. Subsequently, research was conducted to determine the appropriateness of using a well recognized name personality to present the 'Real' Seal message. Part of this research involved measuring consumer reactions to specific personalities in terms of their perceived relevance to the 'Real' Seal message.

As another part of the screening and selection process, alternative personalities were considered from the basic standpoint of their availability and cost.

The outcome of the research was that Vincent Price (a film star and gourmet cook) was selected to serve as the 'on-camera' spokesman for the 'Real' Seal. In comparison to other personalities tested, Price was rated the best choice in terms of the important measures of

- recognition
- image
- popularity
- credibility.

Most of the research participants not only immediately recognized Vincent Price, but also readily associated him with gourmet cookery. His 'image' was described in terms of his versatility, since he is also well known as a television, film and theatre performer, author and art collector. Another strong positive reaction among the research participants was frequent reference to Price's distinctive voice. His popularity was viewed as spanning a wide range of age groups as well as balanced apeal to both men and women. On the important consideration of credibility, Vincent Price was viewed as the most credible of the personalities tested.

All ADA 'Real' Seal commercials have been tested by a nationally known testing service called McCollum-Spielman. Study participants were asked to view pilot TV programming in the theatre situation made up of both commercials and programs. Then after viewing all of this, they were asked to answer a questionnaire.

From the testing of three ADA 'Real' Seal commercials using Vincent Price as a spokesman, three specific points of interest were addressed. In therms of identification of Vincent Price, an average of 66% of the study participants correctly identified him on an unaided basis. 63% then responded by saying that they liked him either 'very much' or 'somewhat'. This score is above the norm for a 30-second personality food commercial established by the research firm (63% against 39%). More specifically, those who responded that they liked him 'very much' were a major part of this overall positive reaction.

Lastly, from an average of the three commercials, almost three quarters of the viewers found Vincent Price convincing, about two thirds felt that he added interest to the commercial, was knowledgeable about dairy products, and half would describe him as a gourmet cook. Therefore, it is our belief that he is an excellent spokesman for the American Dairy Association's 'Real' Seal.

Over the past few years, we have produced three television commercials in which Vincent Price serves as the 'personality-presenter' of the 'Real' Seal message. In each advertisement, the objective is to communicate the meaning of the 'Real' Seal and to encourage the viewer to look for the seal on packages of genuine dairy foods.

The first commercial takes a very straight-forward approach, combined with a bit of lightly humorous dialogue from Mr Price that is reminiscent of his film roles in horror and mystery movies.

In the second advertisement, Price chats with a little girl, Melissa. It is designed to amplify the idea that the 'Real' Seal symbol 'stands for products made from milk'.

By explaining this simply idea to a child, rather than directly to the viewer, it was felt that our message was less likely to be construed as 'talking down to the audience'.

In the third advertisement, the cross-reference of fine art to our dairy symbol was designed to underscore Mr Price's reputation as a connoisseur of fine art *and* fine food in a way that enhanced the memorability of our message.

In addition to television advertising, magazine advertisements are used to extend the 'Real' Seal message during key holiday periods when consumer food purchases reach peak levels. Each of the advertisements contains a seasonally appropriate holiday recipe featuring one or several dairy products. Our spokesman, Vincent Price, reminds the reader to look for the 'Real' Seal.

Another method of reminding consumers to look for the 'Real' Seal is accomplished by use of outdoor billboards. This type of advertising is designed to complement our television and publication advertising by providing a simple message in a visually arresting and appetizing fashion.

In addition to the main-line advertising program in support of the 'Real' Seal, all American Dairy Association product and promotional advertising includes the dairy symbol. This includes milk, cheese and butter advertisements.

An excellent example that illustrates how the 'Real' Seal is integrated into all of our promotional activities is the use of the Seal as a featured element in a consumer sweepstake sponsored by American Dairy Association.

This sweepstake, which offers over $300 000 in prizes, promotes the 'Real' Seal dairy symbol and the genuine dairy foods that display the seal. To enter the sweepstake, consumers must mail in a 'Real' Seal from a dairy product container or a copy of the symbol.

In addition to advertisements in publications, point-of-sale displays announcing the sweepstake are installed in grocery stores throughout the United States. The displays highlight the appealing prizes offered, provide shoppers with entry blanks and details about the sweepstake, and encourage consumers to purchase dairy products that display the dairy symbol.

Another method of communicating the sweepstake to consumers is by printing the offer on the side-panels of milk packages. Last year, an estimated 500 million milk packages carried the special sweepstakes offer.

This promotion, which was launched for the first time during the June-July period 1983, generated a recordbreaking 4.6 million consumer entries, which in turn had a substantial effect on dairy-product sales.

In terms of the achievement of broad-based awareness of the symbol by consumers, the net effect of the advertising and promotional activity has been a steadily increasing awareness. In our research design, we measure two forms of awareness of the symbol. The first measure is defined as the 'association score'. This connotes general familiarity with the 'Real' Seal symbol. The second measure refers to the 'identification score', which connotes the ability to describe accurately the meaning of the symbol.

At the end of 1983, awareness of the symbol had increased to 45.1% for the association measure and to 20.6% for the identification measure.

Our long-term objective is to move these awareness levels for association and identification to the 50-60 percentiles and to the 70-80 percentiles, respectively. Based on a straight line projection, such levels will be achieved within the next three to four years.

Finally, if I may, I would like to offer a few words of advice regarding the potential for development of a milk-protein symbol by your dairy industry. As for the 'Real' Seal symbol in America, development of a milk-protein symbol would indeed demand a strong commitment by your industry to consumer education, advertising and promotion.

Though any type of dairy identification program cannot promise entirely to solve the problems of competition facing the dairy industry, such a program can do much to address contemporary consumer needs – at the very least in a 'supporting role' that fits in with marketing directions and product position of individual brand food processers who might support such a program.

Moreover, for such an identity program for milk protein to emerge as an effective device for the entire industry – and a symbol that provides the consumer with a meaningful point of distinction – it is essential that the symbol be associated with the full spectrum of basic dairy foods in a way that is appealing, credible and memorable to the consumer public.

If such a program be established and the symbol gain exposure on a wide variety of food products, you may count on winning new and renewed interest, appreciation and involvement with milk protein by aiding the consumer's 'choice-decision' and her ability easily to identify and select the product she wants – to the ultimate betterment of all program participants.

Dairy policy in the European Economic Community

P. Dalsager

European Community Commission

Summary

The milk industry is characterized by an imbalance between supply and demand. In the reform and reshape the Common Agricultural Policy, the milk sector has to be the central part of any plan.

Proposals of the Commission of the Europan Communities and decisions taken by the Agricultural Council of the European Communities concerning this sector are described.

Because of the structural surplus, no commercial outlets for dairy products can be created within or outside the community for several years to come.

But there are reasons to look to the future with a certain confidence and optimism. Economic growth will replace economic recession. Expansion of the population in the developing world will offer a potential market of significant size.

Measures are described that will serve to promote expansion of the market for milk protein.

CAB descriptors: dairy legislation, European Communities, milk protein.

In my introduction to this Congress, I mentioned that the Commission had submitted to the Council of the European Communities its proposals for the reform of the joint strategy in the field of agriculture, and offered suggestions for the consistent and coherent adjustment of that strategy in the near future.

The Commission has been focusing its attention on the dairy market as the most urgent problem area where the situation had become quite dramatic. Demand, both on the domestic European Community markets, and on the world market is stagnating, and obviously no more tools are available to promote the consumption of milk and milk products at acceptable cost. The same applies to milk fat and milk protein.

After long and difficult discussions, the Agricultural Council of the European Community took its decision on 31 March 1984 with the result that the new agricultural prices and the other measures came into force for the 1984/1985 marketing year on 2 April. The overall agreement can be summarized in six points:

– confirmation of the principle of threshold levels and their extension to other products
– containment of milk production by the application of quotas
– a return to market unity, by way of dismantlement of the Monetary Compensatory Amounts
– a realistic price policy
– rationalization of aids and premiums for different products
– respect for Community preference.

Not all of the reforms proposed by the Commission have been adopted by the Council. For this reason, as well as the continuing delay in the Council's decisions and the deterioration of the market situation, extra funds will be necessary to finance the Common Agricultural Policy in 1984. The Community must prove its financial solidarity with the farming population, to consolidate its agricultural policy on a healthier economic and financial basis over the coming years.

The milk sector, which is characterized by a serious imbalance between supply and demand, had to be the central part of any plan to reform and reshape the agricultural policy.

In its proposals to the Council of July 1983, the Commission formulated a specific alternative: either reduce milk prices by about 12% or introduce a quota system guaranteeing reasonable prices to producers for a limited amount produced. In recommending the fixing of quotas corresponding to the volume of milk deliveries in 1981 + 1%, the Commission was thinking both of the necessity of protecting farm incomes and of the possibilities for disposal – on the Community markets and for export.

The council has agreed to introduce, for a five-year period, quotas based on 1981 deliveries + 1%. This system is to be applied realistically and with a certain flexibility:

– to facilitate the transition, an additional amount has been added for the 1984/1985 marketing year for all Member States; the extra cost of this amount will be covered by an increase of 1% in the coresponsibility levy paid by milk producers
– aware of the difficulties of adaptation, the Council has extended by two years the direct Community aid of 120 million European Units of Account for small milk producers
– rules are laid down to ensure smooth implementation of the system in keeping with general and regional conditions, providing for the possibility of administering the quotas at the dairy level or that of individual producers. The improvement of the structures of milk production must be encouraged.

These reforms represent a courageous effort made by the Community to reconcile the social objectives of the Common Agricultural Policy and the market realities.

I shall only briefly touch upon a few further elements of the Council's decisions in the milk sector:

– unchanged target price in European Units, which, in national currencies, on average, will only result in an increase of 3%
– a change in the target price ratio for butterfat to skim milk from 55:45 to 50:50. This leads to a reduction of the intervention price for butter of 10.7% and an increase of the intervention price for skim-milk powder of 10.9%
– a reduction in the direct butter subsidy, corresponding to a decrease in the intervention price for butter
– an effort to find new efficient outlets for sales at reduced prices of butter in certain parts of specialized food industries and semi-skim-milk powder as animal feed.

I will now take a look at the actual market situation for dairy products.

The structural surplus, which is building up too fast in the dairy sector, can find no commercial outlets within or outside the Community for several years to come.

The non-commercial sector is also increasing too fast, resulting in unacceptable budgetary burdens. The milk sector represents less than 20% of the Community's agricultural production but accounts for 30% of the total FEOGA Guarantee expenditure. And, looking at the intervention products, we find that almost 40% of the butter production and 80% of the skim-milk powder production needed a substantial degree of sales support in 1983. In spite of this, our intervention stocks increased – in milk equivalent – by the totality of the increased milk production plus the equivalent of our reduced exports.

Thus, we have been producing for the stocks only. In 1983, the world market for dairy products was reduced, and total international stocks now exceed one year's international trade in milk products. We have seen the prices falling within the Community and on the world market.

This kind of analysis indicates that there is no immediate and simple solution to these problems. To solve them we must:
– adapt production to the market needs
– adapt prices to what people can afford to pay
– adapt support policies to the available financial means.

Nevertheless, since the courageous decision of the Council of Ministers, I believe that we have reasons to look to the future with a certain degree of confidence and optimism. An increasing degree of intervention deliveries can only curb the producer revenues and, over time, take away the incentive to maintain efficiency in production and marketing.

These reasons are, I believe, the most important ones to demonstrate the necessity of limiting milk deliveries and, thereby, the intervention purchases. It was never the idea that the intervention system should represent a permanent sales outlet in the milk sector. The idea was that it should act as a 'safety-net' and as a regulator on market instability to support the price policy. The decisions on quotas have been taken, and I believe that the measures proposed will be efficient enough to reduce the size of the intervention purchases.

I consider it of paramount importance that the milk industry remains competitive and further develops its efficiency. This should be a natural consequence of further steps to assure unity and to develop the market. The international market for milk products is now shrinking with the effects of economic recession, of increasing production in importing countries, of restructuring of food aid policies and of unstable international currencies, just to mention some major reasons.

On the other hand, the situation illustrates our interest in working for stable world market conditions, stable price policies and orderly trade. As you will know, we have already achieved quite a lot in terms of agreements with other countries: the GATT (General Agreement on Trades and Tariffs) arrangements on dairy products, the bilateral agreements on cheese imports and exports and the New Zealand arrangements on butter imports.

They all form part of the general aims of our international trade policies; to assure harmonious development for exports as well as for imports. Therefore, we cannot subscribe to a general import-limiting policy. Lasting and favourable international agreements can only be built on reciprocity, striking a balance between advantage and disadvantage.

I am convinced that the new orientation of the milk policy, which has now been launched, both in the Community and in other countries, will have a favourable impact on the international situation. However we must be realistic and accept that the necessary reduction of the excessive international stocks will take some time. In this period, we must be attentive to irregular stock-disposal policies.

May I give another reason why I think we should remain optimistic.

Looking a few years ahead, we expect to see economic growth, even at a moderate speed, replacing economic recession. International cooperation is likely to prevent these positive tendencies from being killed, as they have been many times before, by increased protection. Furthermore, demographic expansion in the developing world still offers a potential market of significant importance. When these elements are added together, we shall probably see a revival of the international market for dairy products.

Let me finally add that this ability is also of paramount importance on the internal market of the Community. Our policy must be oriented towards prices the consumers can afford to pay. Fortunately, we have not performed too badly. Let me demonstrate with some figures from the butter market. The average price for butter in the Community in 1980 equalled some 2.3 times the price for margarine, reflecting a relative fall in butter prices as a result of what we called a prudent price policy for milk. Through the last ten years, the real, deflated, butter price in the Community has fallen on average by 2.4% per year against only 1.5% for margarine. Thus, we have increased the competitive ability of butter on the internal market. The decision to change the target price ratio of butterfat and skimmed milk will result in further decrease of butter prices.

I found it extremely gratifying that the dairy industry in the Community is developing a programme of activities to look for new outlets. This milk protein congress, which has been hosted by the various interested associations in the field, has dealt with the wide variety of topics concerning milk protein. Having seen the long list of participants from the whole world and their capacities, I have no doubts now in declaring this congress a great success.

From the beginning the Commission and I myself fully recognized and appreciated the major significance of this event and agreed to fund it. Having said this, let me draw your attention to the Commission's activities supporting milk protein.

Besides our aids for animal feed, which have already been dealt with in one of your workshops, there are several other measures about which I would like to inform you.

In 1977, the Community introduced a coresponsibility levy for milk producers. In the recitals given for the legislation, the Council stated that the objective was to establish a more direct link between production and outlets for milk products in order gradually to restore equilibrium between production and market requirements and to reduce the heavy costs incurred by the Community as a result of the current situation, in particular the large surpluses.

The funds raised in this way are used for measures to expand markets for milk products. As far as milk protein is concerned, there are three categories of measures that serve to promote disposal:

- expansion of the markets for milk protein
- research measures
- seminars and conferences.

On market expansion, I should like to mention promotion and publicity for cheese within and outside the Community. In order to avoid distortions of competition, such measures must be neutral, i.e. generic and therefore not brand-oriented. Furthermore, schemes exist providing know-how for improving marketing conditions, consumer information and advertising for cheese, milk powder, casein and milk replacers in non-Community countries. The main emphasis is on cheese, over 500 varieties of which are marketed by Community producers.

In the research field there is a wide range of activity including the development of new or improved products. To date, 370 research projects have been financed under four programs to the tune of about 22 million European Units of Account. Three programs have already been completed and the final reports are available at a central office in each Member State for inspection by anyone interested.

So far, 35 specific research projects covering milk protein have been carried out, 23 of which have been completed.

Small-scale conferences on protein have been held in the Netherlands and West Germany, and these are being crowned with this worldwide event.

To provide publicity, seminars and symposia are being organized for teachers and doctors to stress to these important mediators of information the role of milk protein in human nutrition. The highly qualified experts running these events ensure their success.

Even if more has been done in recent years to promote the use of milk protein, we still have a long way to go. The high proportion of milk protein being used in animal feed should be a constant incentive to greater effort.

I hope that this congress helped towards achieving this aim and that you all had a pleasant and usefull stay in our Community. My best wishes for a good and safe return.

Report of plenary session E

Ian G. Reid (rapporteur)

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Earlier papers have established the existence of two different markets for milk protein. First, the market in the developing countries where the need from the nutrition viewpoint is great but the effective purchasing power is relatively low. Second, the market in the developed countries where the effective demand is considerable but can be met in part by competing protein sources, and where functional value rather than nutritive value is of increasing market significance.

The topic of this plenary session had also to be seen against the background painted by Kirkpatrick who suggested that the market for milk protein is static, open to substitution by protein from alternative and possibly cheaper plant and fish sources, and that any development of the market would require considerable and prolonged investment in research and development, both in the natural and social sciences, if this static situation were to be changed.

In her paper on market research, Burdus emphasized the need for information and pointed out various sources of both 'public' and 'private' information. She suggested that consideration should be given to the pooling of some private information through syndicated research executed for companies and other organizations. She also stressed the need for a careful assessment of the validity and robustness of the data. Care and creativity were needed in their interpretation. She strongly emphasized the need to distinguish between the market represented by the food manufacturer and that concerned with the end-consumer.

She showed how consumer tastes and diets have been changing significantly over the past few years, such changes giving rise to new market opportunities as well as problems of adjustment in food manufacture and retailing.

Coton set down the criteria for the food manufacturer's choice of milk protein for incorporation in his final product. He stressed that milk protein was weakest on relative cost, and he placed the main responsibility for this upon the dairy policy pursued under the Common Agricultural Policy. The recent decision to introduce a quota system for milk production might also cause an increase in the cost of processing the milk and milk protein.

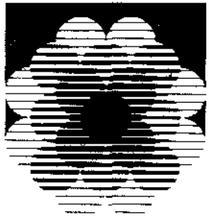
He discussed two possible future developments of potential significance to the demand for milk protein. First, the increased production of textured foods in which milk protein could be an attractive ingredient because of its taste and functional properties. Second, the application of genetic engineering in plants to overcome the present disadvantages in plant protein. The competition should not be underestimated.

Having discussed various aspects of who constitute the market for milk protein, Hiddink and Faucher then demonstrated how the information concerning the particular and special characteristics of milk protein – its flexibility, the possibility of making tailor-made products for specific manufacturing and dietetic needs – is being imparted to key groups, including a whole range of intermediaries such as catering officers and dieticians in institutions, teaching staff of schools and colleges, and sports coaches, in the Netherlands and in France. It was pointed out that manufacturers of milk proteins and not just the users and consumers of it were often deficient in their knowledge of these attributes and the possible advantages to be found in milk protein.

The development of any market requires that the production of the product must be technically and economically feasible. The product must also be valid legally. Thus Matthies led the discussion into food legislation in the European Community, showing that there have been two stages. First, harmonization of national food legislation was pursued. But the program has almost come to a halt. The second stage has been to prohibit the erection of barriers to the freer movement of food products. This has been done in line with the European Community's general philosophy of liberalizing the internal movement of goods, thereby to exploit the benefits of trade based on the principle and existence of comparative advantage. However good the theory, the ingenuity of man has been used to protect current positions, and delay or nullify the operation of comparative advantage. Milk proteins are no exception.

On several occasions during the Congress, mention had been made of the increasing tendency for milk protein to trade down-market, to be moved into feed rather than food. Currently some 80% of skim-milk powder from the European Community is highly subsidized in order that it may compete with plant protein for incorporation into animal feedstuffs. Wilcox showed how the market for wool which, 20 years ago was in a situation similar to milk protein's current market, had been completely changed through the conception and introduction of the Woolmark.

Dohrmann likewise demonstrated how a 'product image' – dairy products – can be used to increase customer acceptability and to enhance the quality differentiation in the consumer's mind. Both these practical examples gave encouragement to the industry. But such programs need considerable investment and coordination of effort. The audience was left to ponder the question of who is to commission and coordinate the adherent market research and subsequent promotion. It will be an expensive but necessary task if the competition is to be met and the market for milk protein increased.



Workshop 1. Functional aspects of milk proteins

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Discussion

To extend applications of milk proteins in food systems, substantial research has been focused on protein modification. The aim is to optimize funtional characteristics and to have proteins tailor-made for specific foods. Technological functions of milk proteins must be clearly defined and have to be representative for the behaviour of milk protein in a complete food system.

K.J. Burgess Skim-milk powder as such has a limited capacity as a functional protein in food because of its low protein content and inacessibility of about 80% of the protein. Improved functionality can be achieved by ion-exchange processing to remove calcium and disrupting the casein micelle. The protein so freed can interact with water and other proteins at the air – water and oil – water interfaces. Functional properties such as foam expansion and stability, and water hydration capacity are thus improved. Ultrafiltration after removal of Ca^{2+} leads to a functional protein ingredient suitable for non-dairy food systems. The casein and whey protein remain present in the same ratio as in milk.

W.J. Donnelly Substantial research and development is designed to improve the functional properties of (vegetable) proteins to facilitate their use in food products, in which milk proteins are currently uniquely suitable. The response of the dairy industry to any imminent competition should be to apply similar scientific skills to optimize the suitability of milk protein. Optimization of functionality implies, in most cases, alteration of molecular size of proteins or electrochemical characteristics. Modification of proteins by enzymes will be the most viable route to development of industrial processes as they will not – in contrast to chemical methods – encounter problems of acceptance for food use. Industrial application of modification by enzymes needs bulk production of appropriate enzymes. Hydrolytic enzymes are considered to be the most promising.

H. Klostermeyer Specific treatment of milk proteins to optimize their functional characteristics must not lead to reductions in nutritional value. Special care is required when milk proteins are tailor-made for dietetic purposes. Furthermore, treatments must not lead to the formation of toxic factors. At present, analytical parameters can rate the carefulness of producers in maintaining nutritional value and wholesomeness. Prevention of LAL formation is possible.

J.M.G. Lankveld Depending on the processing procedure, different types of milk products can be obtained. Several milk protein fractions are manufactured on industrial scale, including casein/caseinates and whey proteins. Other processes lead to formation of coprecipitates. The aim is to obtain fractions, with excellent solubility properties and thus optimum use of functional properties.

In manufacture of caseins or caseinates from skim-milk, the maximum yield does not exceed 80% as the whey fraction remains in solution during precipitation of the casein fraction. Heating to a higher temperature precipitates whey proteins and increases protein yield. However the total milk protein obtained, known as coprecipitate, has lower solubility, thus hampering wide application.

A special treatment at pH 9-11, followed by acidification to pH 2-4 and further pH adjustment to the iso-electric point results in the isolation of a total milk protein with good solubility and useful functional properties. This procedure was developed in New Zealand by Connolly and co-workers and patented in 1982.

At the Netherlands Institute for Dairy Research (NIZO), a similar process for the recovery of total milk proteins from skim-milk was developed. However the skim-milk is only raised in pH to 7-7.5, and is then heated to 80 °C for about 20 min (or flash-heated to 145 °C for several seconds to denature the whey proteins. The mixture is then cooled to about 45 °C and the pH adjusted to 4.4-4.7 to precipitate proteins. Proteins can be spun down. The NIZO process differs from the New Zealand process in the intensity of heating and pH treatment. Both procedures result in high protein recovery of about 95%. NIZO has patented the process as manufacture of soluble lactoprotein from skim milk.

J.M.P. Papenhuijzen Statements about whey proteins are as follows:
– in upgrading whey products, whey protein will become increasingly important.
– the protein composition of breast milk reflects the high nutritional value of whey proteins
– whey protein concentrate (WPC) obtained with ultrafiltration is characterized by low or moderate denaturation and high functionality (e.g. solubility, gelation, emulsification, foaming)
– tailor-made functional properties may be obtained by variations in the processing conditions (e.g. concentration factor, temperature, pH)
– WPC is superior in acid foods and beverages
– WPC may be a competitive source of non-fat milk solids in confectionary, ice cream, bakery.

H. Reimerdes In the use of milk proteins in food systems, two of the major aspects to be considered and needing intensive further development are as follows:
– modification of caseins for tailor-made functionality related to optimized effects in food matrices
– suitable standard methods for the characterization of various functional properties.

In a case report on physico-chemical, enzymic and compositional modification of milk proteins as emulsifiers, specific functional requirements were significantly improved by various pretreatments. These definitely depend on the structure of the proteins which is optimum for caseins and whey proteins.

With the development of an entirely new simple method for the determination of emulsion stability, the direct comparison of the properties of the proteins as emulsifiers was achieved. The method is based on the measurement of Cherenkov radiation and can be automated.

F.M.W. Visser Establishing functional properties of proteins usually gives more on the physico-chemical background of our proteins than on their practical feasibility and potential success in food products. Relating functional properties of protein products or results of model experiments to actual performance in meat products is usually very difficult, partly because the stabilization mechanisms of meat products are complex and incompletely understood.

The stability profile of comminuted meat products is highly dependent on – to mention just two factors – temperature during communition and the way functional non-meat ingredients are added. Unfortunately, only a few research workers, testing and comparing non-meat proteins, have realized this sufficiently; consequently many workers obtain wrong or incomplete results.

Functional properties of soluble total milk protein products (TMP) can in most cases be anticipated to be better than those of conventional coprecipitates. Their possible advantages over soluble caseinates, however, may not so much be found in their practical functional performance.

H. Werner When investigating properties of milk proteins the results can often be difficult to express and to explain when factors responsible for the results are not unknown. For example, the extent of denaturation of whey proteins vary with pH and heat treatment. The conditions under which specific functional properties are assessed have to be standardized and accurately described. Standardization allows comparison with other results: Apart from conditions, the testing instruments also have to be standardized and the geometry has to be in accordance with the conditions during manufacture, for instance of foams and emulsions.

The International Dairy Federation (IDF) will establish two working groups on functional properties of milk proteins and will review the properties wanted and methods of assessment. It will lead to international standard methods. In principle, standards for functional properties of milk proteins must be suitable for other proteins such as vegetable proteins. Apart from functional properties under practical conditions there is a need for a better understanding of the relation of functional properties with the chemical and physical molucular structure of milk proteins.

M.M. Hewedi, D.M. Mulvihill and P.F. Fox Milk proteins can be recovered by ethanol precipitation. The stability of milk in ethanol has been used as an unselective test of the suitability of milk for the manufacture of sterilized evaporated milks. Ethanol precipitation of milk proteins is described for whey proteins in the literature, but the procedure to recover total milk proteins has so far not been reported. A method has been developed to recover about 77.3 and 81.5% of the total nitrogen, respectively, from HTST-pasteurized or more severely heated (10 min, 90 °C) skim-milk. Some losses of protein are incurred during subsequent washing to reduce lactose. The dispersibility in water of the freeze-dried materials from HTST and the other described heat treatment were 99 and 96%, respectively. The recovered material retained micellar properties and was coagulable by proteolytic enzymes.

Concluding remarks

W.IJ. Aalbersberg Modification of milk proteins offers new opportunities. Improved functionality of skim-milk by calcium removal, improved functionality by tailor-making of whey-protein concentrates and improved functionality by selected combination of milk-protein fractions have been proposed. A second area proposed is the enzymatic modification of milk proteins to give new functional properties. Bitterness of intermediate-sized peptides might be avoided by the use of the proper combination of amino-peptidases and carboxypeptidases. Genetic engineering may lead to the specific application of certain enzymes in the industrial modification of milk proteins. New applications of enzymes in the food-processing industry may encounter some resistance. Neither food legislation nor consumer attitude will be very open to these applications. However when manufacturers give a thorough proof of their safety, these problems will be overcome. Some new concepts of total milk protein also offer new opportunities. In order to estimate their potential, the functionality of the total milk protein either produced by a low pH or by hightemperature treatment should still be evaluated and compared with existing means. A wider application of milk proteins on the basis of their functionality needs improved and standardized methods to measure functionality. These standardized methods should be based upon the need of the user of milk proteins and should be applicable in the food system itself instead of in a standardized food system.

Workshop 2. World food and nutritional prospects: the role of proteins

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Discussion

Milk proteins can be considered an essential food consistent in the present world food situation. The effectiveness of their use depends on the nutritional status of the consumer, traditional food patterns, age and health. They can be used to improve the nutritional quality of diets of vulnerable groups in developing countries.

C.A. Barth General agreement about the nutritional quality of milk proteins is reflected in the large amounts of oral foods in West Germany based exclusively on milk proteins. Of 30 oral foods, 18 were based on milk proteins, 4 contained other proteins of animal or plant origin. In Great Britain, 9 were based on milk proteins and 5 contained other types of protein.

The nutritional quality of milk proteins depends not only on optimum amino acid composition and high digestibility but also on amino acid sequence in the polypeptide chain. Futhermore milk proteins can function as carriers for minerals, trace elements and vitamins.

M.I. Gurr Allergy to cow's milk protein in young children ranges from less than 1%

to just under 10% of the population. Although the true figure is nearer the 1% level, it implies allergic reactions to cow's milk for significant numbers of infants that cannot feed at the breast. Alternative formulas based mainly on soya-bean isolates or enzyme-hydrolyzed caseins are not yet entirely satisfactory. Soya-bean formulas can cause immunological hypersensitivity. The immumologically sensitizing effects of alternative formulas are correlated with the intensity of the heat treatment. Any immunological benefit obtained by heat treatment must be weighed against any damage caused to the nutritional quality of the product. Intense heat treatment can severely denature whey proteins, though the residual undenatured protein in the alpha-protein fraction appears to increase. By removing fractions of low molecular weight (lactose and vitamins) before heat treatment of whey-protein-based formulas and by adding appropriate amounts after heating, a non-sensitizing baby milk without casein can be manufactured.

The form in which essential vitamins such as folates and vitamin B-12, are presented may influence their value to the baby. Together with iron, these vitamins can be bound to specific proteins and so are unavailable to micro-organisms. The binding activity can prevent too rapid multiplication in the gut of bacteria that require folate, vitamin B-12 or iron for growth, or simply protect the nutrients from uptake by the micro-organisms. There is a need for a better understanding of the function of these binding proteins, in order to optimalize the nutritional quality of alternative formulas.

L. Hambraeus Milk has three roles in human nutrition:

- as a source of essential amino acids and nitrogen for protein synthesis
- as a source of proteins for defence against microbial infections
- as growth factors and modulators (proteins of low molecular weight).

There is a need for further knowledge of these specific functions of proteins. For human nutrition with emphasis on specific age categories, the following questions have to be answered about cow's milk.

- Is species specificity more important than nutritional value?
- What is the influence of relative variation in content of specific milk proteins?
- To what extent is the content of milk proteins affected by environmental factors?

G.K. Jensen As only 20-25% of the world milk production is produced in developing countries, which have 75% of the world's population, the availability of milk is inadequate in these areas. Furthermore, the limited increase in local milk production lags behind net population growth. Milk ingredients – especially milk proteins – must be transferred from districts with a surplus to Third World countries. FAO calculates the milk equivalent required to exceed 17 million tonnes a year for a minimal nutritional adequacy of protein in the diet. Milk proteins then complement the cereals predominating in the developing countries.

To supply more milk protein in areas with insufficient milk production, the manufacture of recombined milk and dairy products is expanding at a rate of about 17% annually. Recombination of milk and dairy products is normally based on skim-milk powder and butter oil, but the need for lower production costs and affordable product prices has triggered the use of substitute components such as vegetable oils. Unrealistically low prices for recombined dairy products will not stimulate further development of local milk production. There is a need for a proper balance between ensuring reasonable supplies of dairy products at acceptable prices and encouraging farmers to produce milk. Modern technological development allows manufacture of milk based on raw materials assembled according to the desired composition in the final product. For example, formulas have been developed with extra protein and low in lactose.

International agreements and standards are needed for raw materials of adjusted composition, for instance a powder with

- standardized protein content, normally increased
- lactose content decreased
- standardized mineral and vitamins content.

The goal for industrial dairying should be preparation of a local dairy product by simply adding water and supplements produced locally (fats and crops) to ensure nutritional quality and maintain the traditional eating habits in the area.

J.A. Kusin Prolonged breast feeding is still common in many areas in developing countries. An average woman produces about 500 ml, 200-400 ml and 100-200 ml of breast milk at 6 months, 9-12 months and later after bearing. However breast milk must be supplemented with other ingredients after 4-6 months to supply the necessary energy, protein and nutrients. The traditional complementary foods are usually of low quality, merely consisting of cereals and tuberous staple foods.

Legumes are introduced late, towards the end of the first year of life, and the amounts given to young children are small. The reasons include cost (legumes are expensive; they must be cooked for a long time, requiring much fuel), inconvenience (it takes a lot of effort for the mother to prepare legumes for an infant or toddler) and physiological constraints (they are bulky, difficult to digest and cause flatulence). Local sources of animal protein, such as eggs and fish, are introduced even later and very irregularly, for economic reasons and because of food restrictions during early childhood. No such taboos exist for milk.

Statement 1. In population where breast feeding is prolonged, as in most rural areas in developing countries, non-human milk is not necessarily a component of supplementary or weaning foods. Milk can, however, be a more acceptable ingredient of home-made or processed weaning food mixtures, provided that it is competitive in price to local protein sources and provided that a system exists to give the target population the necessary nutritional guidance.

Many studies have been made of the effect of milk-based and vegetable-protein based diets on rehabilitation of severly malnourished children, using anthropometry and biochemical parameters as indicators of success or failure. Little research has been done, to assess the possible difference in response between the two types of diets, considering better health indicators such as morbidity and immune status as variables. Milk protein might support the almost continuous production of antibodies and other defence mechanisms (being mainly proteins of high quality) in a more efficient way than vegetable protein mixtures.

Statement 2. There is a need to compare the impact of cereal-legume and cereal-milk mixtures, to be used as weaning food on breast-feeding patterns and on general health as measured by – for instance – morbidity and immune status.

J.A. Phelan Opinion is divided on the extent and nature of future world food shortages. Developments in food technology have minimized the constraints imposed by seasonality and geography of production. The improvement in world-wide food distribution and reduction of losses is a major challenge to food science and technology.

Of milk protein, about 60% is consumed as conventional dairy products, about 35% is used in feedstuffs in liquid or dried form. The present utilization pattern for milk proteins, therefore, does not adequately reflect nutritional and functional properties. There is a need for diversion of this valuable food constituent from feed to food. The target could lie in developing countries where only 1,5% of total energy consumption is obtained from dairy products compared to 20% of total energy in the West.

Research is needed into new or modified products suitable for direct consumption in developing areas. New techniques such as ultrafiltration could contribute to the manufacture of tailor-made recombined dairy products. Increasing demand for high-quality proteins of animal origin will depend on a rise in purchasing power in developing countries. It has to be linked to coherent and longer term programmes of food aid, where the potential for an expansion of commercial exports of specialized products have first to be established. Cheese is at present the only dairy product whose consumption is increasing in all developing countries. In contrast, new products and uses must be found for milk proteins to arrest any decline in dairy product consumption.

The problem of surpluses in the European Community can be solved only by aggressive market development combined with a strategic food aid programme.

E. Renner Protein requirement for children is substantially higher than that for adults; not less than 10-15% of energy intake should be supplied as protein. To ensure nutritional quality, 60-70% of the protein intake should be of animal origin.

Protein deficiency, frequently encountered in developing countries, can put a child's development at risk. Continuing deficiency of protein and thus of essential amino acids impairs development and can lead to a reduced number of brain cells. The advised daily intake of essential amino acids for children and juveniles can be met by consumption of 500 ml of milk. During active growth, the need for essential amino acids increases.

If only substitutes for cow's milk are available the content of essential amino acids have to be adjusted. There is a need for supplementation with lysine, methionine, valine, leucine and isoleucine. Reconstituted milk products based on a mixture of cow's milk and soya milk can reach optimum biological value. Imitation products without milk constituents cannot be recommended for children in developing countries.

Ultrafiltration of whey can give a milk constituent with high fortification capacity of regular vegetable-rich diets in developing countries. Whey proteins equal in protein efficiency ratio and net protein utilization to whole egg protein and can be considered as an ideal nutritional protein for reference standard. Whey protein products often have a 'surplus' of essential amino acids over the WHO reference standards. In traditional diets, whey proteins can impart a strong increase in nutritive value. Average production of whey proteins of about 500 000 t per year can lead to substantial fortification of human diets in developing countries.

H. Schelhaas Increasing famine can be expected in the Third World. Including China, the number of people suffering from undernourishment is estimated to be in the range 800-1100 million people.

The great majority are women and children. In the poorest countries, the physical and mental health of 25-50% of all children in the range 1-5 years of age threatens to become permanently impaired as a result of food deficiency and malnutrition.

Food shortage could be overcome by raising the agricultural production in the Third World itself. This will not be achieved in the short term. In fact, the shortage of food will increase in the next 20 years despite all efforts at local food production.

The unique qualities of dairy products can play an important role in food aid programmes. The dominant position of cereal grain in food aid can thereby be maintained.

– Milk as the basic component of all dairy products contains all nutrients in reasonable amounts, except for iron. Milk protein yields all essential amino acids in practically optimum proportions. Because of the surplus amount of lysine, milk protein is well suited for combination with staples, most of which, especially grain and rice, contain little lysine.

– The good qualities or milk are maintained in milk powder and concentrated milk. Milk powder has a high content of protein of excellent nutritional value. It is the cheapest protein of animal origin and therefore eminently suitable as additive to a daily diet with an otherwise adequate supply for balanced nutrition. On account of its less favourable protein composition, cereals cannot serve the same ends as milk or milk powder. For certain groups of the population, such as infants, who are nutritionally nulnerable, this is a special disadvantage. Enriching local food based on grain components with milk or milk powder can therefore be recommended.

– In future, the European Common Market can expect a large structural surplus of milk powder, which, at small additional costs, may be reserved for free distribution among vulnerable groups suffering from famine. The argument that these countries will then turn to a Western type of consumption behaviour is far-fetched. In most developing countries (e.g. much of South America, much of North and Central Africa, India and Turkey), large segments of the population have long known milk and dairy products. Moreover, the alternative is acceptance of persistent malnutrition and hunger.

– Extensive research has shown that 200 ml of milk (or milk equivalent) daily eminently suits schoolchildren and their growth, even in those areas with 'lactose intolerance'. Many studies indicate that the clinical phenomenon of lactose intolerance resulting from a rather high intake of lactose does not coincide with what we call milk intolerance.

– Dairy aid implies that additional food supplies be made available, which the poor in the Third World would otherwise lack. To a large extent, dairy food aid is extra aid. With grain aid, extra cereals are only partly made available. The developing countries merely receive it at cheaper prices. A recently published advice of the Dutch National Advisory Board on Development Problems (the World Food Supply and the EC Agricultural Policy) shows that real food aid is only that kind of aid which offers free food to the vulnerable groups, as is frequently true of dairy food aid. Channels ideally suited for the distribution of dairy food aid are medical centres, schools and hospitals where the most deprived are helped.

The implementation of the food aid programmes, including dairy food aid, can certainly be criticized. In developing countries, every program is confronted with enormous difficulties. A substantial part of technical and financial aid is not optimally used. The infrastructure, the lack of expertise locally and the frequently powerless state-organizations present immense difficulties. Consequently goals can only be partly achieved, if at all. Part of the dairy food aid programs will also not be adequately implemented. The obvious action is then not to cut down on this aid but to try to improve it. In particular distribution systems can be improved.

Food aid should be temporary, as a necessary evil, and should be subordinated to a large-scale plan aimed at guaranteeing the world food supply in the long run. For the time being, however, it will have to remain an essential part of development aid in view of the food shortages expected to continue in large areas. So rather than criticize, let us stress the positive aspects of food aid mentioned earlier. I would like to quote twice from a speech by Jos van Gennip, director of Cebemo (Roman Catholic Organization for the Co-financing of Development Programs), at the hearing of the European Parliament. About the importance of school diets, of which milk and dairy products form essential ingredients, he said: 'How many chances of development will be lost if a child, often after a long walk of three quarters of an hour or more, begins the day at school on an empty stomach; how much physical or mental absence will this cause'. He remarked further on food aid in general: 'Food aid, especially by private organization, can offer a marvellous contribution to development and self-reliance. It can be a unique instrument to penetrate where other forms of assistance and other institutions are doomed to fail: namely with the most deprived, because for those who have given up the struggle the only stimulus that remains is the one of staying alive, trying to get hold of food'.

During recent years, some 100 000 t per year of skim-milk powder has been assigned to food aid from the European Community. This implies one cup of milk per day for 10 million of people. Doubling this dairy food aid will by no means cause the world to be flooded by dairy products. Only 20 million people could then be so helped.

Fighting starvation in the world is not a matter of choosing between the promotion of the agricultural production of the Third World, carrying out structural reforms, providing cereal or dairy aid: all four are necessary. For dairy aid, the choice is whether to extend and improve this kind of assistance or to accept starvation on an even wider scale than it is at the moment.

A substantial improvement and extension of the dairy food aid programs are needed in view of the still increasing famine in the world.

Food aid can be improved by the foundation of a World Food Bank. The aim of this bank would be twofold:

- in the short term, to fight hunger directly
- in the longer term, to stimulate local food production in the Third World.

A World Food Bank would offer the necessary food aid to those developing countries expected to face serious food deficiencies for some years. The period of aid could extend to five or ten years. Food aid will be mostly in the form of cereals, but dairy products play an important role.

A prerequisite for developing countries to apply for food aid through a World Food Bank would be the commitment of the national authorities to the development of their own agricultural output. A necessary policy should imply the guarantee of prices leaving sufficient incentives to stimulate local production. If the food aid is sold on the domestic market, the proceeds should be used to incourage national agriculture.

The fact that a World Bank would offer loans to developing countries only under strict conditions about their economic policy can be considered as an example of the same principle. In any case, aid would be available only when the authorities in the recepient country agree to follow the requested development strategy. In this way, food aid would not only be short-term relief for the starving in the world but a long-term tool for agricultural development, as in fact the Operation Flood in India can prove.

Fighting the world problem is as old as the world itself. The main goal of the Food and Agricultural Organization in 1945 was stated to be safeguards against starvation, along with the improvement of the agricultural production. Since then, the frequent meetings never lack promising words and new ideas. On the occasion of the first World Food Conference in Washington in June 1963 president Kennedy spoke these famous words: 'We have the resources; we possess the power to banish hunger in our lifetime; we only need the will to achieve this goal'. At the World Food Conference in Rome in November 1974, the representatives of all countries of the world unanimously supported the resolution put forward by Henry Kissinger: 'By 1985 no child should go to bed on an empty stomach'. As it looks now, it will take us far beyond the year 2000 before that goal could be achieved. The efforts of many are not preventing the world food problem from becoming more serious every year.

Concluding remarks

J. Hautvast

– Milk proteins can be considered as a good nutrient and a good food ingredient and can therefore play a major role in improving the quality of diets of vulnerable groups in the developing world.

– Milk proteins should only be taken as a part of other foods, as a mixture or in one or another recombined way. In this context, debates about the quality of plant or animal proteins is not relevant. However we must formulate standards relevant for the local or regional situation, for those foods using milk proteins.

– Continuous attention should be given to study the nutrition quality and other properties of different protein sources.

– Milk proteins should preferably be used as food, not feed.

– Milk proteins as part of food aid should not be given directly to targetconsumers. Intermediate groups, like NGO's should be identified and should be given responsibility.

– The creation of a European Community/European Food Bank may improve procedures in food aid programmes and may improve the adequacy of local use of food aid.

Workshop 3. Milk proteins and animal feed

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Discussion

C. Calet Physiological properties of milk proteins for growth of animals depend on their physical structure in the stomach or abomasum. The net digestibility of the proteins depends on:
– coagulability of the protein determining the rate of gastric emptying and duration of proteolysis, as indicated by the substantial difference in curdling behaviour between skim-milk or casein in water solution and mineral solution of casein or of dried whey
– sensitivity to proteolytic enzymes such as chymosin, since the peptides obtained initiate gastric secretion and emptying
– flow rate of protein digestion products, as can be demonstrated by increasing flow with a duodenal catheter and thus activating gastric emptying
– milk protein decreasing the sensitivity of the intestinal wall and, in contrast to vegetable proteins, reducing the content of endogenous nitrogen in faeces, perhaps by antibacterial effects of milk-protein peptides in the gut
– milk-protein hydrolysis giving phosphopeptides active in mineral transport and absorption (P, Ca, Mg, Mn, Fe, Cu, Zn, etc.) and preventing the binding of Ca to lipids

in the gut, thus leading to increased absorption of both Ca and lipids
– peptides from milk protein hydrolysis activating gastric hormones involved in gastric secretion.
Weaned animals given milk proteins in their diet (skim-milk or denatured whey) kept in good health and usually grew better than those having received vegetable proteins. Scouring occurred less frequently.

B.O. Eggum Milk is a basic food, especially in early life. Milk proteins have a balanced amino acid pattern, making them almost indispensable at an early stage of life.

Compared to soya-bean meal with a net protein utilization of 65%, skim-milk powder and casein have a net protein utilization of 88 and 81%, respectively.

Increasing amounts of skim-milk powder in diets, up to 15% of dry matter, to pigs weaned early, increased daily gain. The first 5% had a greater effect than subsequent steps up to 20% of dry matter. Thus pigs yield more return for skim-milk powder at lower concentrations in their diet.

Milk protein, and especially sour milk, stimulates the appetite of young pigs and thus has a favourable effect on daily gain. Substitution of soya-bean meal for milk to 75% of the total dietary protein reduced weight gains and food conversion of pigs by 85% between 7 and 14 days of age, and 31% between 21 and 28 days of age. Replacement of milk protein by two isolated soya-bean proteins resulted in weight gains of 34 and 60% of the gains of pigs given milk protein.

Pigs weaned at 2 days of age were given diets in which a functional fish-protein concentrate supplied 0, 350, 525 or 700 g crude protein per kg of total crude protein. The remainder of the crude protein was supplied as dried skim-milk and whey. In trial to 28 days of age, performance was inversely related to the amount of functional fish-protein concentrate in the diet.

Calves (about 7weeks) were given liquid diets made up from either skim-milk powder or soya-bean meal for 14 weeks. Growth rates were higher with skim-milk powder. At least part of this difference would be due to coagulation of casein, in contrast to soya-bean protein, in the abomasum of the calf.

Nutritive value of stored milk proteins could be markedly reduced, according to temperature and water content during storage.

J. Gay Organization of the Community market in milk and milk products started in 1968 with the imminent surplus production of milk proteins. In some member states of the Community, the protein was significantly undervalued in comparison with the fat. In extreme cases, the price ratio of fat to protein was 9. From 1964-1968, this ratio was aligned within the community, beginning at 1.82 when market organization started. Today the ratio is 1.22. Within the Community, about 3.7 million tonnes of milk protein were produced in 1983, resulting in a self-sufficiency of 120% (108% in 1979). Only about 60% of production can be disposed of in the Community food sector at market prices. About 20% is used in animal feed with ordinary support; the rest has to be disposed of under special measures.

Member states differ significantly in their self-sufficiency. Italy with 70% needs to import considerable amounts, whereas Denmark, Ireland and the Netherlands need to export over half their production, despite a particularly high consumption per person.

The Community support for milk protein, regarded as disposed aid, is divided into three categories:

- intervention buying-in of skim-milk powder
- aids for skim-milk and skim-milk powder
- special measures.

Intervention. The Community buys in unlimited amounts of skim-milk powder of required quality for a present buying price. At present the price is 1.499 4 ECU/kg (0.4987 ECU/kg in 1968). The amounts bought in fluctuate considerably from year to year. In 1971, hardly any skim-milk powder had to be bought in, whereas in 1975 about 42% of Community production went into intervention. In 1981, 1982 and 1983, the amount bought in amounted to 11.8, 21.1 and 34.4% of the total production in the Community.

Aids. An integral part of the Community's organization of the market is the aid for liquid skim-milk and skim-milk powder, used for animal feed. Every year the European Council fixed the lower and upper limits of aid for skim-milk powder. The Commission then fixes the actual amount of the aid in accordance with established principles. The level is adjusted in line with market factors and can be revised during the year. According to a current Council decision, aid for liquid skim-milk is in proportion to aid for skim-milk powder. The amount fixed by the Commission is currently 0.061 ECU/kg of liquid skim-milk.

The amounts of skim-milk equivalent in animal feed have fluctuated around 16.5 million tonnes per year, which corresponds to about 20% of all milk delivered to the dairies. Use in liquid form is continually declining, thus shifting towards substitutes. In 1983, only 10% was offered to livestock as liquid skim-milk against 35% in 1965.

Since 1969, a further build-up of surpluses of milk products motivated new measures to ease disposal and to prevent accumulation of new surpluses. The measures laid down additional aids to make these products competitive with others for use in feed for animals other than calves. About 47 million tonnes per year of skim-milk equivalent (65% in powder form, 35% in liquid form) have been used in animal feed representing about 3.8% of the milk delivered to the dairies.

Aid for casein is another measure to encourage the disposal of milk protein. Competition with aid for skim-milk powder is avoided. About 3% of the skim-milk delivered to the dairies is processed into casein(ates). There is a distinct upward trend. In recent years, milk production increased sharply, though consumption remained. Thus increasing amounts of skim-milk had to be disposed of with aids. On weighted-average basis, 26.3% of all milk delivered to the dairies has been disposed of, thanks only to Community aids. Since 1968, the producer price for milk has risen by 120% also leading to an increase in aids. As an average over the last 15years, the aids for disposing of skim-milk in the animal feed sector (incl. casein) have accounted for half the net value of skim-milk.

Other aid measures. To establish a more direct link between production and outlets for milk products in order to restore gradually equilibrium and reduce costs, the Community introduced a co-responsibility levy for milk producers in 1977. The levy currently amounts to 2% of the target price for milk, 0.005 486 ECU/kg. The funds raised in this way are used for three categories of market expansion:

- market expansion within the Community
- market expansion outside the Community
- search for sales outlets and improved products.

Actions to promote disposal of milk proteins can be divided into

- expansion of the markets for milk protein
- support for research
- seminars and conferences.

After approval by the Commission, actions proposed by the industries involved are at their own responsibility. Financial support from the Community generally amounts to 75% of proven expenditure. On market expansion, promotion and publicity for cheese as a milk-protein product can be mentioned. Actions, however, must be neutral and not brand-orientated.

Another activity for market expansion was the elaboration of schemes to exchange know-how about how to improve market conditions, consumer information and advertising for cheese, countries, milk powder, casein and milk substitutes in non-Community countries, with emphasis on cheese. For research, the following actions were undertaken:

- development of new or improved products
- research on ways of increasing sales of liquid skim-milk
- research on new or expanding markets for milk products outside the Community
- scientific study of nutritional aspects of milk (components)
- market surveys of special merit aimed at improving the marketing of milk products within the Community.

To date 22 million ECU has been spent on 370 projects under four programmes. These programmes are completed. So far, 35 research projects specially on milk protein have been in operation, of which 25 have been completed. Research areas were

- animal feed
- development of improved testing methods
- new uses in food
- uses for whey protein
- market analysis on ways of expanding sales of milk protein
- nutritional aspects of milk proteins
- development of new products
- physical and chemical properties of milk proteins
- seminars and conferences, crowned with the International Milk Protein Congress.

Seminars and symposia are organized for teachers and doctors to underline the role of milk proteins in human nutrition. The high nutritional quality of milk proteins underlies the continual effort to direct milk components to human food, thus lowering the high proportion of milk proteins being used in animal feed.

H. Hagemeister The composition of milk is related to the requirement of the newborn sucking animal with a high protein deposition and low activity of proteolytic enzymes in the digestive tract.

Characteristic of casein is to coagulate at pH 4.6. and with rennin at a pH optimum of 6.5 in calves and lambs. This coagulability allows a continuous outflow from the stomach and, through this continuous amino acid supply, a high efficiency of utilization. Calcium release during and after coagulation influences the activity of pepsin. Increasing the proportion of casein to whey in the diets of calves increases rennin activity.

Impairment of rennin or pepsin clotting in ruminants seems to be important in predisposition to intestinal infection involving Escherichia coli. Undigested protein and peptides will pass into the distal part of the small intestine and hind gut and will be a suitable substrate for microbial growth. The pH barrier in the small intestine is influenced by the amount and type of fermentable carbohydrates. It is desirable for the animal to have a well balanced pH range at the distal part of the small intestine. The animal is likely to be affected with putrefactive diarrhea, if saccharoproteolytic organisms predominate.

When skim-milk is replaced by whey, fish or soya protein in liquid feed given to calves, output of renning decreases without modifying pepsin secretion. Through lack of coagulation, abomasal emptying is much faster than for whole milk. The milk substitute must be acidified down to about pH 4.2-4.5, as is done in milk substitutes on the basis of whey protein and formic acid. Formic acid provides additional protection from coliform bacteria. High frequency of feeding with small amounts of milk substitute reduces the requirement for casein.

According to the rate of growth during rearing or veal production, critical amounts of coagulating casein are needed. There is no completely satisfactory replacement for skim-milk protein during the first weeks of life.

P. Mulvehill Whole milk is the natural diet of the young calf. The nutritive value of cow's milk as human food created the need for milk substitutes as cheaper alternatives. The availability of skim-milk powder led to its widespread use, stimulated by improvements in processing technology and market demand. After 25 years of almost exclusive use of skim-milk powder in calf-milk substitutes, new technology allowed introduction of a range of high-protein whey and non-milk protein products. Future use of skim-milk powder will depend on its competitiveness against alternatives.

Before 1955, the newborn calf was reared on whole milk fed a rate of about 100g per kg liveweight per day. Milk substitutes first became popular in the early 1960s, being based on skim-milk powder processed for the growing demand for butter and cream. Parallel to this was the availability of fats of suitable quality and the improvement in processing technology. Business expanded with increasing numbers of cows and of veal calves. At present about 1.3 million tonnes of skim-milk powder are used per year (60% of total skim-milk powder production). The current financial status of the Community and the possibility that financial aid may be terminated has encouraged the search for alternatives in calf feeding, including whey and non-milk proteins. Nutritional and least-cost aspects must be evaluated with proper knowledge of the physiological process of digestion. In the young calf, digestive activity is initiated after the first feed of colostrum, resulting in normal functioning at 2 days of age.

For proper digestion of milk protein, the casein has to coagulate, thereby entrapping fat. The resulting clot is gradually broken down by enzyme action into polypeptides and fats. Clot formation is essential for effective breakdown and absorption.

The coagulability of skim-milk powder depends on the processing method, on which depends the chemical structure of casein and whey. Weak clot formation results in undigested protein reaching the lower alimentary tract and altering the sensitive gut flora. Minor changes in the chemical structure of skim-milk powder markedly influence calf performance. Formulating a milk substitute without milk protein is therefore a difficult task. However there is a need for alternatives if formulations with skim-milk become too expensive. At present, various alternative protein mixes can be used, with an essential amino acid profile closely matching the amino acid requirement of the calf. Supplementation with synthetic amino acids can overcome a specific amino acid deficiency. Modern technology allows the use of whey protein concentrates in a formula based on whey and other essential ingredients such as fats, vitamins and trace elements. The requirement of a good digestibility remains. A more rapid passage of dietary protein from the abomasum to the small intestine has been observed. With non-milk proteins, such as soya flour, the digestive function is disturbed. Total replacement of milk protein can lead to digestive upset and sometimes diarrhea. Partial replacement of milk proteins by soya-protein concentrates and fish protein, however, allow normal function.

In formulation of substitutes, two factors determine the composition:

- quality and cost of raw material available
- inclusions and constraints on nutrients and raw materials set for least-cost formulation.

The minimum inclusion rate of skim-milk powder is determined by Community regulations governing the subsidy paid. It induces a constraint on formulation of skim-based milk substitutes, which is not of nutritional standing. This can have the effect of increasing the competitiveness of alternative protein sources. The latter can be formulated to lower nutrient densities and in particular to lower protein levels.

Future use of skim-milk powder in formulation will depend on the subsidy paid for this ingredient. Price increases of skim-milk powder have led to substantial production and use of zero calf-milk substitute for calf rearing.

H.E. Pesch Contrary to some aspects of human nutrition, animal nutrition places no demands on the functional properties of milk proteins. Isolation of milk proteins is not necessary, thus allowing use in traditional dairy products with different protein

Table 1. Dairy products used in animal feeding.

Dried/powdered products		Liquid products
milk powders	whey powders	
– skim-milk powder (36% protein) – fat-filled milk with 22-23% prot. and 35-40% non-milk fat – in the near future partially decreamed milk powder with about 32% protein + 10% milk fat	– whey powder with about 12% protein – delactosed whey powder with 18-25% proteins – fat-filled whey powders or lactose-free powder with 7-18% protein and non-milk fat 30-40% – whey protein concentrates (WPC) with 36-75% protein	– skim-milk with about 3.3% protein can now be joined by condensed skim-milk – whole milk (3.3% protein + 3.8% fat)

contents.

Only solubility in water is crucial in two cases:

– when the animal is too young to take in solid food or, later, cannot meet its nutritional requirements from dry food alone. This applies to calves for herd replacement or for beef production and to orphan animals (e.g. lambs or piglets).

– veal calves not old enough to have ruminant digestion and kept purposely on monogastric digestion. By supplying proteins in the liquid (milk), the oesophageal reflex is maintained.

Dairy products for animal feeding are low in protein, with contents in dry matter of 70-380 g/kg. A rare exception is whey-protein concentrate. Other milk components are, in fact, supplied in larger amounts. The digestibility of these other components limits the use of dairy products in animal feeding (Table 1).

Market segments based on amounts sold. Demand for dairy products in animal feeding does not originate from one uniform market. Two main market segments can be distinghuished by the final utilization of the dairy products (Table 2):

– feeding of calves

– feeding of pigs.

To feed veal calves and rearing calves, 1.7 and 0.7 million tonnes of milk replacers are used per year. This implies an average intake of 55% skim-milk powder and 21% whey products in the formula. Each formula naturally differs significantly in composition. Market segment (Table 2) uses 1804 million tonnes of dairy products (skim-milk + whey powder), i.e. 65% of total utilization in animal feed. As amount of dry matter (13 million tonnes per year), it constitutes 12.55% of total non-fat dry matter in milk delivered to dairies. The calculation based on non-fat dry matter in milk is based upon the fact that no milk fat is used in milk substitutes. The market segment of liquid milk for calves feeding is of much less significance. It constitutes just over 1% of total dry matter used (Table 2). Subtotal of dairy products used for calves feeding constitutes nearly 2 million tonnes of dairy products, i.e. 14.4% of total dry matter and 20.6% of non-fat dry matter. Over 70% of the total amount of dairy products for animal feeding in general goes to calves.

The feed for pigs is another important market segment for dairy products. Other animals like poultry or cattle are of less importance. Poultry have difficulty in digesting lactose, leading to a lower energy value for skim-milk powder than for soya meal. Furthermore every conceivable surplus of skim-milk powder can be used for pig feed alone.

For cattle feed, feed millers use cheaper alternatives than soya meal as a source of protein, for instance rapeseed cake, groundnut cake and maize gluten feed, utilizable thanks to the compound stomach of the cow. About 0.5 million tonnes of skim-milk powder per year used in pig feeding represent only 1.8% of the total amount of pig feed produced (26.5 million tonnes per year). From the nutritional point of view, up

Table 2. Amounts of dairy products in animal feeding in 1983.

Market segment and dairy product	Content of dairy product in formula (g/kg)	Amount (t)	Proportion of dry matter in milk delivered to dairies (%)	Proportion of non-fat dry matter in milk delivered to dairies (%)
a. Milk substitutes (calves)				
skim-milk powder	550	1 304 000	9.61%	13.75%
whey products	210	500 000	3.68%	5.27%
Skim and whey	760	1 804 000	13.29%	19.02%
b. Liquid skim-milk (calves)		(1 633 000)		
Equivalent in skim-milk powder		149 000	1.10%	1.57%
Subtotal for feeding calves		1 953 000	14.39%	20.59%
c. Compound feeds (pigs)				
skim-milk powder	18	479 000	3.53%	5.05%
whey products	3	70 000	0.52%	0.74%
	21	549 000	4.05%	5.79%
d. Liquid skim-milk (pigs)		(2 192 000)		
Equivalent in milk powder		266 000	1.96%	2.81%
Subtotal for feeding pigs (c + d)		815 000	6.01%	8.59%
General total (a + b) + (c + d)		2 768 000	20.40%	29.18%

to 25% of skim-milk powder could be used in pig feed, but handling and other practical problems set the limit at about 10%. Even so, up to 2 650 000 tonnes of skim-milk powder per year can be used in pig feeding, if the price be right. This data must be a relief for all concerned.

Total utilization of dairy products for pigs is less than a third of total utilization in milk substitutes but still represents 4% of total dry matter delivered to dairies and nearly 6% of total non-fat dry matter. This is quite substantial for a newly reintroduced scheme.

Division d of Table 2, liquid skim-milk for pigs, is nearly twice as much as liquid milk for calves. The subtotal for feeding of pigs, with 815 000 tonnes, represents nearly 30% of the total utilization of dairy products in animal feeding. It represents 6% of total dry matter and 8.6% of total non-fat dry matter delivered to the dairies. Overall utilization for calves and pigs represent slightly more than 20% of total dry matter and nearly 30% of total non-fat dry matter delivered to the dairies.

The yardstick for price setting of skim-milk powder destined for incorporation in compound feeds is the market price for soya meal with about 42% crude protein. The manufacturer of compound feed for pigs will as a rule of thumb be prepared to pay for skim-milk powder with 36% protein 0.01-0.02 ECU/kg and biological value (28%) of skim-milk powder as compared to soya meal, whereas on the negative side some partial inconveniences linked to the use of skim-milk powder and the lower absolute protein level are taken into account.

Market segments based on revenues obtained. In Table 3, the net sales prices and net sales revenue for dairy products in the animal feed market in 1983 are compiled. In milk substitutes (a) for calves, skim-milk powder has a net price of 0,853 4 ECU/kg, calculated as compound average of the successive intervention in 1983 minus the compound average of the successive aid in 1983. The total revenue for skim-milk powder reaches at least 70% of the revenue for dairy products used in animal feeding, although the share in overall amounts is only 47%. The net price for whey products is a personal calculation, i.e. 0.38 ECU/kg. They have only 12% share of overall revenue.

The net price of 0.0524 ECU/kg for liquid skim-milk powder is the compound average of successive maximum selling prices in force in 1983 for this market subsegment. This average price for skim-milk has been converted to an average price for skim-milk powder equivalent on the basis of the average content of dry matter in skim-milk powder (96 g/kg) and that of liquid skim-milk (87.7 g/kg). Overall share of amount and of revenue are 5.4%. The subtotal of all dairy products used for feeding calves clearly shows that this market segment is even more dominant in terms of revenue, with an 87.8% overall share than in terms of amounts of milk.

For pigs, the net price obtained for dairy products is significantly lower than in the market segment for calves. Accordingly, nearly 20% of overall utilization yield only 8% of overall revenue. In liquid skim-milk for pigs, virtually the same low net price is obtained with the same result of the share in overall utilization, which is more than twice as much as the share in overall revenue. The subtotal feeding of pigs naturally

Table 3. Net sales prices and net sales revenue for dairy products in the animal feed market in 1983.

Market segment and dairy product	Net price (ECU/kg)	Quantity sold (t)	Proportion of total quantity (%)	Total revenue (ECU)	Proportion of total revenue (%)
a. Milk substitutes (calves)					
skim-milk powder	0.8534	1 304 000	47.1	1 112 833 600	70.4
whey products	0.3800	500 000	18.1	190 000 000	12.0
		1 804 000	65.2	1 302 833 600	82.4
b. Liquid skim-milk (calves)	(0.0524)	(1 633 000)			
Equivalent in skim-milk powder	05737	149 000	5.4	85 481 300	5.4
Subtotal for feeding calves	0.705 2 (0.824 7)*	1 953 000	70.6	1 388 314 900	87.8
c. Compound feed (pigs)					
Skim-milk powder	0.233 0	479 000	17.3	111 607 000	7.1
Whey products	0.250 0	70 000	2.5	17 500 000	1.1
		549 000	19.8	129 107 000	8.2
d. Liquid skim-milk (pigs)	(0.021 4)	(2 192 000)			
Equivalent in skim-milk powder	0.234 6	266 000	9.6	62 403 600	4.0
Subtotal for feeding pigs	0.235 0 (0.233 6)*	815 000	29.4	191 510 600	12.2
General total		2 768 000	100	1 579 825 500	100

* Average price of skim-milk powder equivalent without whey products.

shows the same picture, a substantial share of nearly 30% of overall utilization yields a minor share of slightly over 12% of overall revenue. Table 3c confirms the paramount importance of the market segment feeding of calves in terms of amounts used but even more so in terms of revenue.

The average net price for the whole package of dairy products used in the segment calf feeding is three times as much as that for pig feeding.

Table 4. Additional data for 1983 and 1984.

	Milk production (t)	Proportion of non-fat dry matter (%)	Non-fat dry matter (t)
1983	103 800 000	8.77	9 103 260
1985 in conformity with quota	98 700 000	8.77	8 655 990
Reduction	5 100 000		447 270
		Skim milk powder (t)	Non-fat dry matter (t)
Intervention stock as per 19-83-12-15		1 006 000	
Intervention stock as per 19-82-12-15		567 000	
Increase		439 000	
Sold for pig feeding		479 000	
'Surplus' 1983		918 000 × 0.96 =	881 280
Minus reduction through impact of quota system			447 270
'Surplus' 1985			434 010

Additional data. The upper half of Table 4 concerns the impact of the quota system. In 1985, milk production as compared to 1983 will be reduced by 5 100 000 or nearly 5% and production of non-fat dry matter will be reduced accordingly by 447 270 t. The lower half of Table 4 calculates the surplus of non-fat dry matter. By surplus, I mean the sum of the increase of the intervention stock and the amount of skim-milk powder sold for pig feeding.

The data given on dairy products in animal feeding lead to the following statements.

– In 1985, export of non-fat dry matter of milk will have to be 434 t higher than in 1983 or milk production will have to be reduced by another 5% below the presently agreed quota, or the sale of skim-milk powder for feeding of pigs will have to be continued at about the same level as in 1983.

– Any amount of skim-milk powder by which the intervention stocks are to be reduced come on top of the amounts to be exported or to be fed to pigs.

– In view of the importance of the market segment calves in terms of amounts of dairy products used and even more so in terms of revenue obtained, the Community's dairy policy should encourage veal production.

V. Sadini According to EC Regulation No 625/78 skim-milk for public storage must not contain other components, such as butter milk or whey. Another EC

Regulation No 986/68 deals with SMP for use as animal feed. This product may consist of powdered milk or buttermilk in whatever proportion. The maximum fat and moisture contents of SMP has been fixed by the Council at 11 and 5%, respectively.

It can be financially attractive to manipulate SMP by adding whey, which is available at a lower price. Thus there is a need for the detection of (rennet) whey in SMP delivered for public storage. The full contribution describes two analytical procedures developed for the detection of whey in SMP. In this context, 200 samples have been examined by a ring test carried out by a few official laboratories in the Community. Results obtained are given by underlining certain limits for the validity of both procedures. Constructive support of milk protein can only be finalized if their quality is sufficiently defined and consequently tested (Sadini, 1984).

Reference

Sadini, V., 1984. Analytical aspects of milk proteins: activity of an EEC Commission Working Group, Dairy Research International 49(11)29:31-32.

Towards a milk-protein strategy

Conclusions and resolutions

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The following conclusions, resolutions and further initiatives were recorded from the forum discussion scheduled during the Closing session of the congress 'Milk Proteins 1984'. For the forum discussion the theme 'Towards a milk-protein strategy' was chosen.

Forum members

Discussion leader: T. Meggle, Director of Meggle Milchindustrie (DE), former president of ASSILEC.

Forum panel members: W.IJ. Aalbersberg, general director, Netherlands Dairy Research Institute (NL); T. Friis, managing director, Nestlé Nordic (DK); J. Gay, Commission of the European Committees, General Direction Agriculture, Dairy Division (EC); I. Gordon, director, Express Food Ingredients (GB); C. O'Leary, president ASSILEC (IE); H. Schelhaas, president, Commodity Board for Dairy Products (NL); W.E. Speckmann, vice president, Nutrition Research, National Dairy Council (US).

Conclusions and resolutions

The congress is aware that only an offensive strategy on a long term approach would be effective. The goal of this strategy is the marketing of dairy products through the image of high quality milk proteins to customers, firstly being end-consumers and secondly food manufacturers.

The basis of the milk-protein message incorporated in the strategy is the knowledge and confidence in milk proteins. The dairy industry must consider it as her own responsability to implement this confidence on potential customers. Confidence in the numerous qualities of milk proteins, contributing to the added value of traditional and innovative dairy products, is based upon the following useful characteristics of these proteins.

Table 1. The use of milk and dairy products.

Consumer use	
I	II
functional developed countries	functional and nutritional developing countries
complex nutritional and functional	nutritional
IV	III
Industrial use	

Milk proteins are

– natural, health supporting, tasty, nutritive, and functional and within the nutrive and functional properties they are even flexible and useful for taylor-made products with specific purposes.

– with regard to the health situation milk proteins are adaptable to the product designs attuned to the changing consumers' habits, their demands and even needs. In this respect markets both in developed and developing countries must be taken into consideration. The use of milk and dairy products can be demonstrated by a four sector diagram Table 1 (designed by Dr W.IJ. Aalbersberg).

– are price efficient (not cheap). All these properties and their combination including the flexibility is our knowledge we have to improve and is basis for our confidence. Dairy will serve nutrition in future as it did since mankind exists. The dairy industry has been able to meet consumers' demands by constantly developing new products based on advanced technology and knowledge of changes in the market. In this respect the dairy sector has often played a leading role in the food industry. It is in the interest of the dairy sector, i.e. both industry and farmers, to upgrade milk and supply this raw material with a high additional value. The economist will relate milk proteins to the importance of a healthy dairy industry in the EC.

– Without milk proteins or dairy products it is very difficult for the people in the developed countries to compose their meals in a nutritionally acceptable way.

– Milk proteins can be a very useful nutritional supplement of daily diets in developing countries. Especially for those recovering from (infectuous) deseases a sufficient daily supply of proteins with a high nutritional value is essential. Milk proteins can contribute to the optimal nutrition status of human populations in the world.

Further initiatives

With regard to further initiatives there is a need for the continuation of further research on nutritional and technological functions of milk proteins. Furthermore a research for specific marketing data on milk proteins is proposed with emphasis on changing patterns of consumption and consumers awareness of the presence and function of milk proteins in dairy and other food products. With respect to efficient exchange of information, regarding the mentioned nutritional, functional and marketing aspects of milk proteins it is concluded, also, as a follow-up of the congress, to organize seminars preferably in the form of work-shops. Priority one should have a meeting of a restricted number of experts discussing the item 'Communication of the Milk-Protein Message'. In this communication firstly the dairy sector i.e. industry, diary man, organization in the field, have to become more familiar with the message. Secondly, the 'communication seminar' should deal with further initiatives in addressing the public/market. It could imply the need of a milk-protein 'symbol' in analogy with the discussed function of the 'woolmark' and also the 'Real Seal' program in the United States. Thirdly taylor-made messages should be prepared for journals etc. distributed in specialized sectors of the human food market.

The realization of plans and initiatives greatly depends on the guarantee of financial support. So far the European Community has financed about 370 research projects with coresponsibility funds of which about 10% were focused on milk proteins. To optimalize the outcome of all these projects, performed in different member countries there is a need for efficient coordination in order to divide the necessary work in the different member states and formulate priorities of activities. The coordination of EC-supported projects could be the topic of the mentioned seminars. In the past all efforts were completely relying on the financial support from the EC and the applicants made use of the possibilities described in the EC-regulations. If the proposed reform of the joint strategy in the field of EC agriculture should lead to the termination of the described support, the only alternative would be to rely on the industry itself. Still the congress audience looks forward to a continuation of the support by the EC.

The dead-line set for future activities with high priority should be 1985. This deadline will then be in good harmony with the planning of the International Dairy congress by the IDF in the Hague, the Netherlands, September/October 1986.

The realization and outcome of Milk Proteins '84 in Luxemburg is the result of an internationally coordinated effort. In the latter it yields 'experience' to be used in future international projects concerning milk proteins and dairy products. This includes the organization procedures and time-planning and support by all member states of the Community. Further work will rely on the individual within the dairy sector to invest ideas and energy following the work described in this Congress 'Proceedings'. To conclude an advice from the discussion leader, Mr. Meggle, will be repeated here: Each member of the Congress audience go home, to your countries and trace your way to the appropriate Federations and authorities to make optimal use of the results of this Congress. Consider the described milk-protein strategy to be a long term approach.