Strategy for dairy development in the tropics and subtropics

J.C.T. van den Berg

Pudoc Wageningen 1990

ISN: 527697

J.C.T. van den Berg graduated as a dairy technologist from Wageningen Agricultural University in 1946, and then worked for the Royal Netherlands Dairy Federation (FNZ). From 1954 to 1970 he was dairy advisor for milk and milk products at the Ministry of Agriculture and Fisheries. Thereafter, he worked for the International Agricultural Centre, Wageningen, on assignments concerning dairy development and dairy technology in many countries in Africa, Asia and Latin America; he has lived and worked in Costa Rica, Pakistan and Turkey. From 1982 until his retirement, he was a guest worker at Wageningen Agricultural University, where he lectured on production, marketing and processing of milk in tropical and subtropical countries.

CIP-DATA KONINKLIJKE BIBLIOTHEEK, DEN HAAG

Berg, J.C.T. van den

Strategy for dairy development in the tropics and subtropics / J.C.T. van den Berg. - Wageningen : PUDOC. - Ill.
With ref.
ISBN 90-220-1005-8 bound
SISO 633.9 UDC 637.1(213) NUGI 835
Subject headings: dairy development ; tropics /dairy development ; subtropics.

ISBN 90 220 1005 8
NUGI 835

Printed in the Netherlands.

Contents

Preface

Much of what has been written in this book will seem to be self-evident and largely a matter of common sense. This may be true, but then it raises the question: why is this self-evidence and common sense so often neglected? And why do dairy projects so often not achieve the expected results? One of the main reasons is that in many cases the proponents of dairy schemes generalize the situation in tropical and subtropical countries, particularly in dairy-developing countries. Climatological conditions are merely one issue that deserves attention; others, such as religion, tradition, education, infrastructure, motivation, etc., but also financial and economic aspects are of equal, if not of more importance.

Since there are so many aspects in dairy development, it is not possible to develop a dairy industry in different countries and areas by using a standard design. Especially not if this design is based on the situation prevailing in countries with a developed dairy industry.

This book tries to explain the aspects that should be taken into consideration; although these aspects will not be of equal importance in all countries or areas. It is not intended to describe the situation that prevails under different ecological conditions or in different parts of the world, because this is not possible, due to the many variations. Neither are examples referring to countries or areas given, because this could give a semblance of completeness. Separate chapters are dedicated to the subject 'Milk in human nutrition' and 'Milk products and human health'.

The discussion of a number of subjects in this book is mainly based on the author's own experiences in the field and little of this will be found in a comprehensive way in books or other publications. In these cases, no, or few references to literature will be found.

As in the companion volume, 'Dairy technology in the tropics and subtropics', relevant literature is suggested in the further reading at the end of most sections, whenever applicable.

Acknowledgements

The publication of this book has been made possible by the financial support of the Directorate General for International Development and Co-operation (DGIS) of the Ministry of Foreign Affairs in the Netherlands; the International Agricultural Centre (IAC) in Wageningen; and N.V. Internationaal Zuivelbedrijf Jordanië (Jordan Milk). For this support I express my sincere thanks.

The book could not have been completed without the valuable support and information provided by many colleagues of the International Agricultural Centre (IAC), especially Mrs T. van den Briel-van Ingen and Mr W. Klaver, and Mr A.J. Nell for closely reading respectively the sections dealing with human nutrition and dairy husbandry, and making many useful suggestions for improvement.

A special word of thanks is due to Mr A.G. Haasjes for his contribution to the section about the profitability of dairy plants and for providing the examples of financial analyses.

The author gratefully thanks Prof. Dr F.P. Jansen, Director of the International Agricultural Centre, and Prof. Dr P. Walstra, Professor of Dairying at Wageningen Agricultural University, who took great pains to ensure the publication of this book and who gave much assistance in its realization.

Abbreviations and terms

capacity of a dairy plant	–	amount of milk that can be processed in one shift (8 hours)
city milk plant	–	milk plant situated in urbanized area
CU	–	calculation unit, an imaginary monetary unit
dairy factory	–	dairy plant that mainly manufactures dairy products with a long keeping quality (butter, cheese, milk powder, etc.)
dairy plant	–	plant for the processing of milk
FAO	–	Food and Agricultural Organization of the United Nations
HTST	–	high-temperature short-time (in pasteurization)
IRR	–	internal rate of return
milk plant	–	dairy plant that mainly manufactures liquid milk (pasteurized and sterilized milk for consumption) and fresh liquid milk products (fermented milks, custards, etc.)
NPV	–	net present value
rural dairy plant	–	dairy plant (in most cases dairy factory) situated in rural area
SNF	–	solids-not-fat
throughput of a dairy plant	–	amount of milk that is received and processed in a dairy plant in one day
UHT	–	ultra-high temperature (in sterilization)
UNU	–	United Nations University
WHO	–	World Health Organization

1 Introduction

1.1 Geographical and climatological conditions

Most dairy-developing countries are situated in the tropics, that is the area between the tropics of Cancer and Capicorn (latitudes 23.5° North and 23.5° South), whilst almost all are situated in the area between latitudes 35° North and 35° South, which includes the tropics and subtropics, whereas all dairy-developed countries are largely or wholly outside this area. This could lead to the conclusion that the differences in dairying between dairy-developed and dairy-developing countries are exclusively due to differences in climate. This is not correct. Partly because there is a wide variation in climatological conditions, making any comparison with a 'standard climate' impossible, and partly because very many other factors are responsible for differences in development.

Temperature is probably the most important climatological factor in milk production, not only because it influences the milk-producing animals directly, but also because of its influence on plant growth, and hence on feed availability and feed quality. Although the temperature depends on the location of an area in relation to the equator (latitude), the location relative to sea level (altitude) is also important. Given an average decrease in temperature of 0.6 °C for every 1° latitude distance from the equator, and the same for every 100 m rise in altitude, considerable differences in temperature are to be expected in the tropical and subtropical regions.

Another very important aspect concerning climatological conditions is the difference in temperature between day and night. These differences are generally small in coastal areas (maritime climate), but are considerable further inland (continental climate). Insight into these daily variations, which are very important in the dairy industry, is not obtained from statistics on the average daily temperature for monthly or other periods. Even if variations are given, it should be clear whether these variations include those between day and night, or whether they refer to variations in average daily temperatures in a certain period of the year.

Apart from the temperature, the precipitation is very important. Like temperature, it varies greatly. In deserts it is extremely low, whilst it may be 2000 mm and more per year in rainy equatorial areas. Precipitation is important to animal husbandry, both directly as well as indirectly, for instance to vegetation, and consequently to feed availability. Apart from the annual amount, the seasonality of rainfall plays an important role. For a proper evaluation of the situation in a particular area, weekly or monthly data should be available.

Evaporation also plays a role, especially in areas where precipitation is scarce, becau-

se, ultimately, the amount of water available in the soil is important for plant growth. On the other hand, appreciable amounts of moisture may arrive from dew, allowing a modest vegetation to develop. Water from sources other than precipitation and dew, such as water from springs, may be important for dairy husbandry.

The humidity of the air is important too, because high humidities limit the possibility of the animal losing heat by evaporation of body moisture. Another climatological phenomenon of consequence to animal husbandry is air movement or wind.

1.2 Differences between dairy-developed and dairy-developing countries

The differences in dairying between dairy-developed and dairy-developing countries may be related to a large number of factors other than climatological ones, such as:
- the type of milk-producing animal: cattle, buffalo [1], sheep, goat or camel;
- production purpose of the animal: specialized in milk production or multi-purpose animal;
- milk production system: city, rural or nomadic dairy husbandry;
- seasonality and density of milk production;
- milk quality;
- infrastructure;
- standard of life of livestock owners and consumers;
- organization of the dairy industry, government policy and legislation;
- religious, social and traditional aspects.

Other differences may also be important, such as:
- developing countries and their inhabitants are generally poorer;
- illiteracy is more widespread in developing countries, and the general educational level is often lower;
- population growth is higher in most developing countries.

It should be clearly understood that climatological conditions as well as the above-mentioned factors not only determine the differences between dairy-developed and dairy-developing countries, but that they are also responsible for immense differences between the dairy-developing countries themselves. Therefore, it would be a mistake to try to develop the dairy-industry in dairy-developing countries along the same lines as in the dairy-developed countries. Moreover, it would be a misconception to believe that a uniform pattern can be used for the development of dairying in all countries of the Third World.

1.3 The milk chain

Efforts to safeguard the supply of liquid milk and milk products by the establishment of dairy plants are all but useless if the raw milk supply is not guaranteed; in other words, if

[1] The practice of classifying buffaloes as cattle is not followed in this book. Buffaloes are discussed in Section 3.2.2.

insufficient raw milk is available. On the other hand, it does not make sense to stimulate milk production if no market for the milk exists or is created; a market where the milk can be sold at acceptable prices. For the commercialization of milk, it may be found necessary to establish milk-collection systems and dairy plants. Therefore, dairy-development projects should always be integrated projects, including four main phases, which together form the 'milk chain', viz.:

- dairy farming and milk production;
- milk marketing and/or milk collection;
- processing of milk;
- commercialization of manufactured products.

Dairy projects or, in general, measures to improve dairy farming or milk processing that do not take the interrelationship of these four aspects sufficiently into consideration, run a great risk of leading to disappointing results and may even end in complete failure. Expected future developments must be taken into consideration as well. If it is not possible to include the whole milk chain in a project – for instance for financial or political reasons – and attention can only be paid to one or two aspects of it, planning and implementation should at least be done in such a way that these aspects (or aspect) fit in the existing milk chain, even if this chain is only rudimentary. In many cases it will prove to be fruitful to include the milk chain in an overall rural development project. The milk chain is always largely controlled by aspects such as price structure, government policy (and the consistency of this policy), legislation, etc.

In many cases it has turned out that for the farmers the most vulnerable and the most neglected part of the milk chain is the marketability, whereas for the dairy plants it is the milk availability. Unfortunately, there are cases where the stimulation of milk production as such proved to be successful, but ultimately turned out to be disappointing, because after the local market had been satisfied no profitable outlet for the 'surplus' milk existed. In the early days of the implementation of a dairy-development project it may be found quite easy to sell the milk in the local – usually rather restricted – market at a reasonable price, but as soon as this market is saturated there will be a surplus and the milk price will drop, unless measures for additional means of commercialization have been taken well in advance. For example, by the creation of facilities that allow for the disposal of the milk (or manufactured products with a good keeping quality) to other markets. If this is not possible or cannot be arranged at the appropriate moment, the development project may prove to be self-destructive.

On the other hand, dairy plants have had to close, because it was neglected to build up proper milk supply channels. This sometimes happened because the establishment of the dairy plant was merely a political issue.

The commercialization of agricultural products in general, and of fresh milk in particular, involves certain specific problems, such as:

- The highly perishable nature of the product, which creates serious problems, especially in warmer climates. Therefore, marketing channels should be short.
- Unlike most industries, there are very many producers, and every farmer is an independent entrepreneur.

- Milk production is often irregular and considerable variations may exist in the amounts produced in the lean (generally: dry) and flush (generally: wet) seasons. On the other hand, milk consumption is fairly constant throughout the year; and any fluctuations seldom coincide with the fluctuations in production. Hence surpluses and shortages are created.
- If milk is processed in a dairy plant, there is not one marketing channel, but two, i.e. the channel from the farmer to the plant and that from the plant to the consumer. This means that the plant is part of the milk chain from producer to consumer.
- Milk and milk products are important components in the human diet (Section 19). All classes of the community should be able to buy these products. This can be achieved by keeping the prices low. On the other hand, a higher income from milk production is one of the ways to increase the standard of life of the livestock owners. Moreover, the stimulation of dairy husbandry and the encouragement of milk production depend on their profitability. A compromise has to be found, to guarantee a reasonable price to the farmer and reasonable prices for the consumer. To achieve this objective, production, processing and distribution should be as efficient as possible.

Further reading

McDowell, R.E., 1972. Improvement of livestock production in warm climates. W.H. Freeman & Co., San Francisco.

Rangappa, K.S. & K.T. Achaya, 1971. Indian dairy products (2nd ed.). Asia Publishing House, London.

Rice, E.B., 1965. Milk production in warm climates. Dairy Science Abstracts 27:43.

Rice, E.B., 1965. Some aspects of the processing of milk and milk products in warm climates. Dairy Science Abstracts 27:569.

Rosenfeld, P., 1968. Production of milk under arid conditions. International Dairy Federation, Annual Bulletin IV, Document 41.

Siegenthaler, E.J., 1972. Milk handling and processing in the warm climates. In: R.E. McDowell (Ed.), Improvement of livestock production in warn climates. W.H. Freeman & Co., San Francisco.

Walshe, M.J., 1986. Criteria for success or failure of dairy development. In: Proceedings of the XXII International Dairy Congress (The Hague). D. Reidel Publishing Co., Dordrecht, p. 329.

WHO, 1962. Milk Hygiene. World Health Organization, Geneva.

Whyte, R.O., 1967. Milk production in developing countries. F.A. Preager, New York.

2 Systems of dairy farming

2.1 Systems of dairy husbandry

Four principal systems of cattle and buffalo husbandry can be distinguished (Table 1).

2.1.1 Nomadism and transhumance

In nomadism, migration takes place along routes determined by the availability of water and feed, the prevalence of diseases, etc. The herds of the nomads are generally made up of a variety of species. The herds are large, because the productivity of the animals is low. Moreover, they serve as an investment. In transhumance, migration takes place as well, but the livestock owners and their herds have a permanent camp.

Milk produced by the animals of these systems of animal husbandry forms a valuable component in the family diet. The milk is mainly preserved in the form of ghee and dried curd; the quantities available for marketing are, however, small. Moreover, since the owners of the animals have no permanent place of settlement, or for parts of the year are not present at this place, marketing of milk meets severe problems. Experiments with small mobile processing units have not been successful because these units are heavy and difficult to move.

The living conditions of nomads are becoming increasingly difficult. Originally, nomads wandered to provide perennial pastures for their animals, and often migrated over vacant land and over fallow land belonging to settled arable farmers. The latter tolerated the presence of the nomads on their fallow land, taking advantage of the manure produced by the animals. However, more and more land is being cultivated and – as a result of

Table 1. Systems of animal husbandry (cattle and buffaloes only).

System of husbandry	Percentage of animals
Nomadism and transhumance	15
Ranching	29
Mixed farming	54
Specialized dairy husbandry	2
Total	100

After Payne (1983).

the use of fertilizers – agriculture is intensifying. As a result, the importance of manure is declining and less land is available as fallow land, making crop farmers less inclined to allow nomads on their land. This is especially true if crop farmers start keeping animals of their own. This also means that the introduction of dairy husbandry on crop farms may endanger the position of nomads in the area.

2.1.2 Ranching

Ranching is labour-extensive and principally important for meat production. The animals are grazed in large herds, usually on land belonging to the owner of the animals.

Dairy ranching is a system of ranching in which the cows suckle their calves, but are milked only once a day. The milk production potential of these cows is used as a secondary source of income in addition to meat production and raising calves.

2.1.3 Mixed farming

Most cattle and buffaloes and many species of other dairy animals are kept under conditions of mixed farming. In most cases the animals are kept as multi-purpose animals for traction, meat, skins, hair and wool, milk and manure, and serving as a means of insurance and investment. They are mainly or exclusively fed with products or by-products produced on the farm. These products can be supplemented by grazing on communal pastures, by grass cut along roads and other places, by purchased concentrates, etc.

Although milk production as such is often economically not very important, it supplements the income from other farm activities, and forms an integrated part of the farming system. On the other hand, a lack of interest in the improvement of dairy husbandry may be observed, because it is not the only or even major source of income on the farm, and other reasons for keeping animals have higher priority.

Nevertheless, this system of milk production may provide large amounts of milk as soon as the confines of subsistence economy have been broken through and the animals are kept in a cash economy system. However, milk production is often very seasonal.

2.1.4 Specialized dairy husbandry

In the system of specialized dairy husbandry, milk is produced by highly productive animals under a high level of management. Production costs are generally high, as a result of large investments in very productive animals and the high costs of feeding. The system is labour intensive and particularly dependent on the skill of the farmers and – on large-scale farms – also on the labourers' skills. The net profit of intensive farming in dairy-developing countries is often disappointing. Nevertheless, there are many examples of large state and mammoth private farms that supply large amounts of fresh milk.

The number of animals kept in this system is comparatively low, as is shown in Table 1. Most animals kept in specialized dairy farming are found in the developed countries.

Landless owners of dairy animals

Finally, landless owners of dairy animals have to be mentioned. Their animals graze along roads and in other public places; sometimes grass is cut at these places and fed to the animals, which are kept under conditions of zero-grazing. Landless farm labourers may have the right to graze a number of animals on their employer's land.

Milk produced by these livestock owners may be very important in the diet of their families, or may be their main income or provide a substantial additional income.

2.2 Milk production systems

Under conditions of subsistence economy, hardly any market for milk is found. Such a situation used to exist in most rural areas of dairy-developing countries. Only the bigger cities, had an actual market for milk.

2.2.1 City and peri-urban milk production

This involves keeping cattle or buffaloes, and in exceptional cases, goats, on premises in or near big cities, on a large or small scale (Figure 1) The milk is either sold on the spot or it is distributed and sold on the doorstep. Sometimes, the animals are even milked on the doorstep to guarantee the consumer a fresh and unadulterated product. This system is only justified because it considerably shortens the distance between milking animal and consumer, which lowers the risk of spoilage of the milk. The system has a number of serious disadvantages:

- All feed has to be brought to the city (Figure 2) over long distances, which is expensve. Large amounts of concentrates are usually supplied.
- Dairy animals are bought 'up country' shortly before or after calving. At the end of the lactation, or rather at the moment milk production is no longer economically justified, the animals are either sent back to rural areas, or – and this happens in most cases – sold for slaughter. It is too expensive to keep the animals in the city during the period they are dry after having them served.

The choice between sending back and slaughter depends on many considerations:

- Cattle owners in rural areas are not very keen to buy non-productive or non-pregnant animals, so the price will be comparatively low.
- Cattle owners may send their animals to a 'guest farm', where they are mated and take them back after parturition. The guest farm is either paid on a 'daily basis', in which case the owner of the cattle bears the risk of a long and consequently expensive intercalving period (dry stand), or a lump sum is paid to the guest farm, in which case this farm runs the risk. Intercalving periods in the 'send-back system' are long anyhow, because the animals are mated after lactation.
- Cattle owners are usually reluctant to send their investment (the milking animal) to an area beyond their control and to leave it there for a certain period without any financial return.

For the reasons explained above, selling dry animals to the butcher is preferred in

Fig. 1. City milk production (India).

most cases, especially if meat prices are high. Indeed the farmer's choice of the type of animal may depend on that animal's value when slaughtered. For this reason, buffaloes may be preferred over cattle in areas where cattle are not slaughtered for religious reasons.

The decision to send livestock back may also depend on the availability of fresh cows. If they are plentiful in the hinterland, slaughter is more likely than when good fresh milking animals are scarce and consequently expensive.

Apart from the fact that milk production in cities is expensive, there are a number of other disadvantages, such as:

- The presence of dairy animals and their manure in cities is a hazard to hygiene. The disposal of manure creates difficulties.
- The system leads to a loss of genetically valuable material if the animals are slaughtered. In most cases, calves are lost as well, because they are only kept with the mother for milk let-down, but they do not receive sufficient milk to survive after the lactation period of the animal.

Sometimes, it is considered an advantage that there is market for highly productive animals.

Peri-urban milk production on separate dairy farms or dairy holdings, for instance within a radius of 25 km around the cities, has the advantage that roughage may be cheaper than in the city and less concentrate has to be fed, whilst there is no nuisance from animals in the city. Production costs are still high and there is no guarantee that the animals will not be slaughtered after lactation.

Fig. 2. Forage market (Pakistan).

2.2.2 Cattle colonies

One of the efforts made to remove dairy animals from the cities was the establishment of cattle colonies. In most cases, these colonies were sited in the neighbourhood of a city, with the objective of accommodating the city cattle owners and their animals in a rather restricted area. Facilities, such as water, electricity, veterinary services, housing for the cattle owners and sheds for the animals were often provided. Collective purchase of feed was possible.

Such concentrations of people and their animals seldom solved the problems connected with city animals. After the animals had been removed from the city, the open places were often immediately occupied by other owners of dairy animals, who consequently took over the market of the original milk producers. The latter objected to the loss of their customers and the increased distance between the animals and the milk consumers.

Problems related to feed provision, loss of genetic material, etc. were generally not solved by the establishment of the colonies. Moreover, large concentrations of animals may imply a serious latent danger for the outbreak of infectious diseases; especially as the result of the regular arrival of fresh animals from elsewhere.

Legal measures to terminate city husbandry, e.g. by the establishment of cattle colonies, have seldom proved to be successful. Only infrastructural and economic pressure may achieve the desired results. Burgeoning urbanization may cause dairy husbandry to disappear from the centre of the cities, because there is no longer anywhere to accommodate animals and the supply of feed is no longer possible as in the old way of city milk

production. Cheap recombined or toned milk may prove to be a successful competitor to the expensive fresh milk.

2.2.3 Rural milk production

Rural dairy husbandry is the most common system of milk production. Animals may be kept under conditions of 'grazing' or 'zero-grazing'. Most of the fodder is produced on the owner's farm, along public roads or on communal pastures. The amount of concentrate fed to the animals is usually small. In small-scale mixed farming – as it is usually practised – milk production is of modest importance, but contrary to cash crops, the sale of milk guarantees a regular, if not daily, source of income. The introduction of highly productive animals and lifting milk production out of this integrated operation may disturb the traditional balance, with technological, financial and psychological repercussions. The technological repercussions are that the level of management must be elevated; the financial repercussions are that higher inputs are required and higher risks are to be taken, and the psychological repercussions are that the division of labour in the farmer's family must change, which may not be readily accepted by all involved.

Further reading

Grigg, D.B., 1976. The agricultural systems in the world. Cambridge University Press, Cambridge.

Kropf, W. et al., 1983. Dairy ranching in Costa Rica. FAO World Animal Review 45:23.

Nestel B. (Ed.), 1984. Development of animal production systems. World Animal Science. Elsevier Publishing Co., Amsterdam.

Payne, W.J.A., 1983. Systems of beef production in developing countries. In: A.J. Smith (Ed.), Beef cattle production in developing countries. Centre for Tropical Veterinary Medicine, Edinburgh.

Sinha, R., 1984. Landlessness: a growing problem. FAO Economical and Social Development Series, No. 28. FAO, Rome.

3 Domesticated dairy animals

3.1 Distribution of animals

Domesticated dairy animals are – in the sense of this book – those mammals whose milk man consumes. The principal representatives are:
- cattle,
- buffaloes,
- sheep,
- goats,
- camels.

Not all female representatives of these breeds are kept for milk production. Between, and also within the breeds of the various species, there are considerable differences in purpose of production and performance. Besides many specific dairy breeds, there are breeds that are principally or exclusively kept for draught, meat, wool and hair, etc. and give only little (if any) milk for human consumption.

Statistics on the numbers of animals of various species and their milk production are compiled countrywise in the FAO Production Yearbooks. A distinction between total numbers and numbers in lactation is only made for cattle (Table 2). The FAO indication does not mean that the animals in lactation are kept exclusively for milk production; most of them are multi-purpose animals.

For species other than cattle, i.e. buffaloes, goats, sheep and camels, only statistics on the total numbers of animals are available and the importance of these animals for milk production is merely illustrated by the total milk production figures (Table 3).

The contribution of cow's milk to world milk production is paramount (Table 4). The contribution of the other species is of minor importance, but there are enormous differences between individual countries. In the dairy-developed countries and in Latin America, almost all milk produced is cow's milk, but the situation is completely different in dairy-developing countries, where buffaloes (especially in the Far East) and sheep and goats (especially in the Middle East) play an important role.

Differences in the prevalence of the various types of milking animals in various parts and even in various regions of the world are not accidental, and consequently the underlying causes of their prevalence deserves serious consideration if the species or type (breed) of animal has to be specified for a dairy scheme. The factors determining this choice of species and breeds include:
- climatological conditions;
- environmental conditions, including prevalence of diseases;

Table 2. World cattle population in 1987. After FAO Statistics.

Region[1]	Total numbers	Milk animals	
	(x1000)	(x1000)	(%)
Developed market economies	*257 925*	*53 130*	*21*
North America	113 691	12 080	11
Western Europe	95 912	34 764	36
Oceania	31 510	3 860	12
Other developed countries	16 812	2 427	14
Developing market economies	*785 861*	*110 059*	*14*
Africa	147 070	19 544	13
Latin America	311 494	36 192	12
Near East	51 347	15 996	31
Far East	275 363	38 273	14
Other developing countries	587	53	9
Central planned economies	*233 943*	*57 687*	*25*
Asia	79 401	2 607	3
Europe	154 542	55 080	36
World total	*1 277 729*	*220 877*	*17*

[1] FAO classification of countries by economic classes and regions (summarized):
North America: Canada, USA.
Latin America: all countries in America excluding Canada and the USA.
Western Europe: all countries in Western Europe.
Oceania: Australia, New Zealand.
Other developed countries: Israël, Japan, South Africa.
Africa: African countries excluding Egypt, Libya, South Africa and Sudan.
Near East: all countries in the Near East, up to Afghanistan and Iran; including Egypt, Libya and Sudan; excluding Israel.
Far East: all Asian countries not belonging to another region.
Other developing countries: Bermuda, Greenland, St. Pierre and Miquelon, and all islands in the Pacific Ocean not belonging to another region.
Countries in Asia with a central planned economy: China, Kampuchea, Korea, Mongolia, Vietnam.
Countries in Europe with a central planned economy: Eastern Europe and USSR.

- availability and kind of feed;
- risk-bearing capacity of the owners;
- the educational level and the skills of the owners;
- expected additional and sometimes principal functions of the animal;
- religion and tradition;
- consumer preferences for the animal products, be they meat or milk.

As already mentioned, animals are usually not kept exclusively for milk production in dairy-developing countries, but for a combination of purposes, such as draught, meat, hair, wool and manure. Moreover, animals can be used as a form of investment and insu-

Table 3. World milk production 1987[1] (1000 Mt). After FAO Statistics.

Region[2]	Cow	Buffalo	Sheep	Goat
Developed market economies	*234 479*	*56*	*2 812*	*1 564*
North America	72 883	-	-	-
Western Europe	137 353	56	2 791	1 540
Oceania	13 433	-	-	-
Other developed countries	10 860	-	21	24
Developing market economies	*79 485*	*32 014*	*4 412*	*5 745*
Africa	6 654	-	588	1 112
Latin America	38 703	-	38	481
Near East	10 262	1 664	3 726	1 907
Far East	23 802	30 350	59	2 246
Other developing countries	64	-	-	-
Central planned economies	*147 694*	*1 880*	*1 640*	*738*
Asia	3 680	1 860	573	188
Europe	144 014	20	1 067	551
World total	*461 658*	*33 951*	*8 864*	*8 048*

[1] Data relate generally to total production of fresh milk, excluding the milk suckled by young animals but including amounts fed to livestock.
[2] See footnote Table 2.

Table 4. Contribution of various species to world milk production (1987).

Species	Contribution (%)
Cow	90.1
Buffalo	6.6
Sheep	1.7
Goat	1.6

After FAO Statistics.

rance. The possession of a large number of animals is a measure of the wealth of the owner. This could explain why large herds are a token of prestige, and hence more attention is paid to quantity than to quality. The possession of large numbers of animals also diminishes the risk to the owner in cases of calamities. On the other hand, large herds must often share small amounts of low quality feed; the feed may be sufficient for the maintenance of the animal and a small milk gift, but does not allow for high productivity. Animals will grow slowly and first calving will be late, which also means that only a small percentage of animals in the herd will be in lactation.

Sometimes, animals are principally kept for manure, which is dried and used as fuel,

or is used for the production of biogas. The importance of animals as fuel suppliers should not be underestimated. Though available, kerosine and other mineral oils may be too expensive for the small farmer.

The multi-purpose character of an animal usually limits the possibilities of increasing milk production considerably. Usually, multi-purpose animals are not expected to give a high milk yield. A farmer keeping four poorly productive cows cannot be expected to replace his four cows with one highly productive animal, if his cows represent investment and insurance for his family.

If milk production of various breeds is compared, possible additional functions of the animals should be taken into consideration. Environmental conditions should also be looked into, because they largely influence production. Differences in milk production between various breeds may be reduced (sometimes dramatically) if the animals are kept under the same conditions of environment, management, etc.

3.2 Dairy animals

Below, a brief description will be given of the most important domestic dairy animals, including some of their major characteristics. For more detailed information, specialized manuals and textbooks should be consulted.

3.2.1 Cattle

This genus includes the species[1]:
- *Bos taurus* and *Bos indicus*,
- *Bos banteng* or Bali breed of cattle,
- *Bos grunniens* or yak.

3.2.1.1 *Bos taurus* and *Bos indicus*

Both varieties are spread over the entire world. *Bos taurus* (Figure 3) (sometimes called the European variety) is predominant in Europe, America and Oceania (Australia and New Zealand). *Bos taurus* breeds in Africa are either of ancient origin and now completely acclimatized, like N'dama cattle, or more recently imported and not, or only partly, acclimatized.

Bos indicus (Figure 4) (sometimes called the Asian or Zebu variety) predominates in Asia, but is also found in Africa in considerable numbers.

Both varieties have frequently been crossed, which in a few cases has led to new breeds, like the Damascus cattle in the Middle East (Figure 5).

Bos indicus is characterized by a large hump on its back, over the shoulders or on the posterior part of the neck. The possession of a hump is believed to be genetically recessi-

[1] The practice of classifying buffaloes as cattle is not followed in this book. Buffaloes are discussed in Section 3.2.2.

Fig. 3. *Bos taurus* on large farm (Syria).

ve, but not absolutely, and crosses of *taurus* and *indicus* either show a small hump or no hump at all. The absolutely humpless crosses may erroneously be taken as representatives of the *taurus* variety, as in the case of the Damascus cattle.

Although milk production varies widely with breed and environment, the production potential of *Bos indicus* may be found to be lower than that of *Bos taurus*. In both groups, excellent milking animals are found. The environmental conditions in the temperate zones, where representatives of *Bos taurus* are especially found, are better suited to increase milk potentials by breeding than the conditions in the tropical and subtropical zones. This may account for the high productivity of a number of *taurus* breeds. Moreover, it is not unlikely that specialized breeding started earlier in the temperate zones, whilst the all-purpose character was of predominant importance in the tropical zones, which discouraged breeding in any kind of specialized production, with the possible exception of draught animals.

It is important to know that the 'comfort zone' (the range of temperature at which the animal feels comfortable) of *Bos indicus* is about 10° C higher than that of *Bos taurus*, whilst milk production starts declining at a temperature 10° C higher than the top of the comfort range (Table 5). Furthermore, the so-called 'primitive' *indicus* breeds are more resistant to hardship conditions (disease, poor nutritional standards, etc.) than the *taurus* representatives, which are bred for high productivity under conditions where heat tolerance and disease resistance play a minor role. This means that when introducing dairy cattle in the tropics and subtropics, the high productivity realized under favourable conditions in the temperate zones, should not be overemphasized, unless such conditions can

Fig. 4a. *Bos indicus* (Madagascar). Photo: Mrs. M.C. van der Haven.

Fig. 4b. Milking *Bos indicus* cow with calf at foot (Nigeria). Photo: Mrs. A. Waters-Bayer.

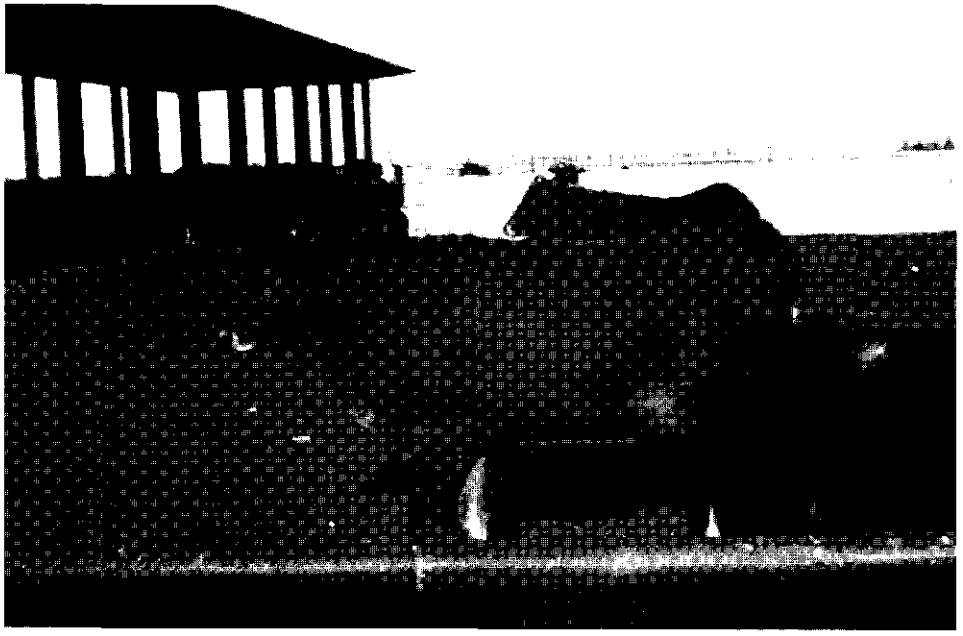

Fig. 5. Damascus cow (Syria).

be fully imitated in the tropics and subtropics. This also holds for other species, such as goats and sheep.

Whereas good milking animals of the *taurus* type easily reach 4000 l per lactation period in the temperate zones, productions of 3000 l per lactation period are considered excellent for breeds of the *indicus* type in the tropics. However, it must be noted that:

- Under practical conditions the production of the tropical breeds is usually much lower than 3000 l, because of environmental conditions. The high production of the *taurus* varieties reached in the temperate zones will generally not be reached under the more demanding conditions of climate, health, feeding and management prevailing in the tropical and subtropical zones. Cattle transferred from the temperate zones to the tropics will generally show a decrease in production, whilst the production level of their descendants may remain lower too.
- The main reason for dairy animals failing to produce up to their genetic potential is often the quality as well as the quantity of feed; the heat produced during the digestion of the feed, especially if large amounts of roughage are supplied and ambient temperatures are high, may cause much trouble to the animal. Heat stress may even limit feed intake and consequently milk production. The heat tolerance of the *indicus* varieties is generally higher than that of the *taurus* varieties.
- Milk production per lactation and annual milk production are different conceptions (Table 6). In the temperate zones, it is quite normal for milk cows to calve every 12 or 13 months, at which moment another lactation starts which may last about 10 months. Under tropical conditions, intercalving periods are usually much longer, even 2 to 3

Table 5. Comfort zones for *Bos taurus* and *Bos indicus*.

	Comfort zone (°C)	Temperature above which milk production declines (°C)
Bos taurus	5 - 15	25
Bos indicus	15 - 25	35

Table 6. The relation between milk production of cows per lactation and per year, and calving interval.

Intercalving period	Milk production (l)	
	per lactation	per year
14 months	2100	1800
30 months	2100	840

years, whilst as a result of heredity and environment, lactation is usually much shorter, for instance 5 to 7 months (although much longer lactations, e.g. 18 months, may occur if the animal fails to become pregnant again). Long intercalving periods should not always be seen as a disadvantage, because under hardship conditions short intercalving periods would not give the animal sufficient opportunity to recover after parturition and lactation. First calving in the tropics usually takes place at an older age (three years or older) than in the temperate zones.

By cross breeding the *taurus* varieties from the temperate zones and the *indicus* varieties from the tropics, it is tried to combine the higher production potential of the former with the higher resistance of the latter (Section 7.3.3).

3.2.1.2 Bos banteng

Bos banteng (Figure 6) originates from Bali. It is an important source of beef in some parts of Indonesia, but it is unimportant for milk production.

3.2.1.3 Bos grunniens

Bos grunniens or yak is found in Mongolia and Central Asia, where it lives at high altitudes. The animal is found in some Asian countries, like Nepal, but not in tropical countries. Milk production shows wide variations in quantity and length of lactation, e.g. from 100 to 3000 l over periods varying from 4 to 24 months.

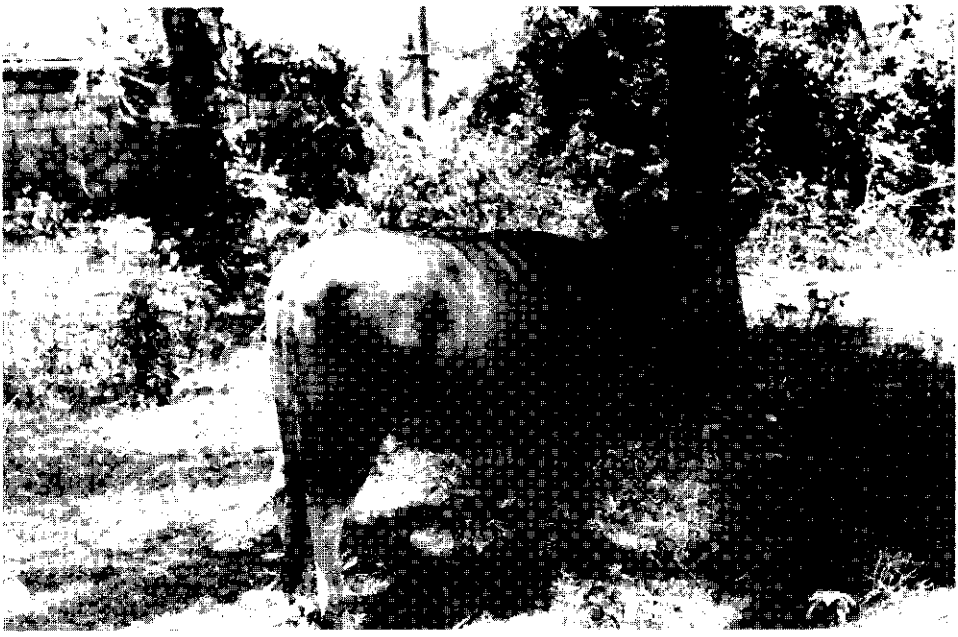

Fig. 6. Banteng cow (Indonesia).

3.2.2 Buffaloes

Although the buffalo (*Bos bubalis*) belongs to the same family, cross breeding with cattle is not possible[1]. Of the various species of buffaloes, only the Asian buffalo has been domesticated, and of these, only the water buffalo is important for milk production. It is mainly found in Asia and North East Africa; but some are also found in Latin American countries, such as Brazil and Costa Rica.

Buffaloes are not only excellent producers of meat and milk but are also excellent draught animals, but breeding for milk started much later than occured in cattle. Production varies from 750 to 2000 l per lactation, depending on genetic and environmental conditions, but much higher productions of up to 3000 l are claimed. Under 'practical' conditions, the yield remains restricted to 1000 l or less and hardly differs from that of the better breeds of local cattle.

High production is especially found in animals kept for fresh-milk production in or near large cities. Buffaloes are said to have some advantages over cattle, such as:

- A better and more efficient assimilation of coarse roughage. Whether this also leads to lower production costs of milk is unclear; no reliable cost price comparisons have been made.
- A higher tolerance of hot and humid climates. There is little uniformity of opinion about tolerance of hot and dry weather conditions, but it is generally believed that the

[1] The practise of classifying buffaloes as cattle is not followed in this book.

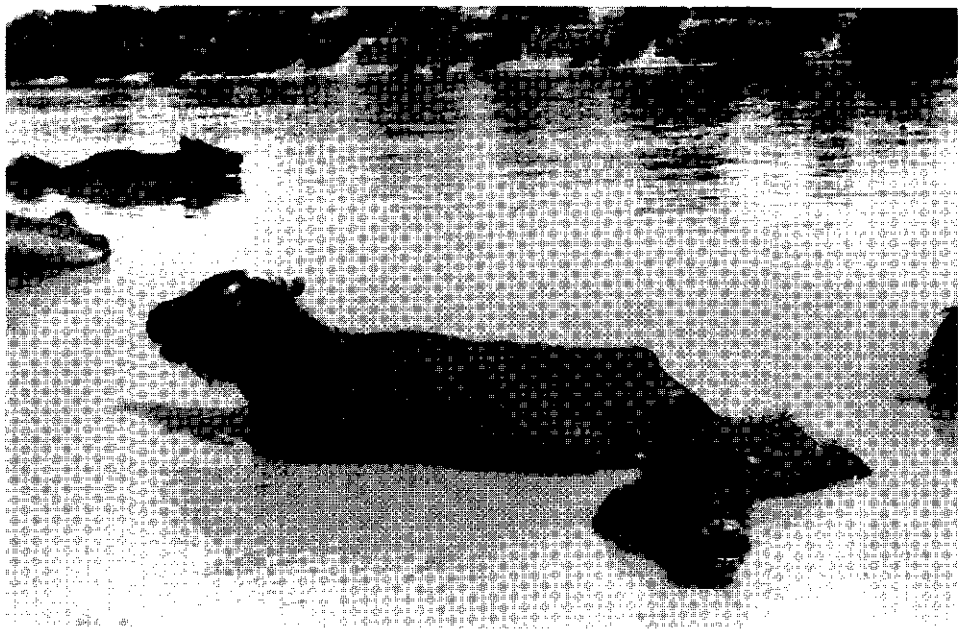

Fig. 7. Bathing buffaloes (Pakistan).

animals poorly endure blazing direct sunlight. The unfavourable influence of high ambient temperatures on milk production can be compensated for by regularly bathing the animals (Figure 7); although bathing is not strictly necessary.

- Advantages in efficient management in countries where the cow is a holy animal and consequently cannot be slaughtered. For this reason, buffaloes may be preferred for city-milk production, where the animals are slaughtered after lactation. Their greater docility than cattle is another advantage for city-milk production.
- The milk is richer in composition, and consequently many consumers prefer it to cow's milk. Moreover, it is believed to have better bacteriostatic properties.
- A higher birth, puberty and mature weight, and a faster growth rate.
- A longer productive life, i.e. a maximum of about 18 years, compared with about 14 years for cattle.

Buffaloes do have some disadvantages when compared with cattle:

- They freshen (mature) at a later stage. This means that they will calve at a later age. Although many factors determine the age of first calving, it is usually at least four years.
- They have a longer gestation period, viz. more than 10 months, as compared with 9 months for cattle. The period of heat is shorter under the same conditions, (about 12 hours in comparison with 18 hours for cattle), whilst heat is often difficult to detect. These phenomena and the fact that buffaloes are shy breeders leads to long intercalving periods.
- Cross breeding of local cattle with highly productive exotic breeds (*Bos taurus* in temperate climates) leads to descendants with markedly improved production potential. No

such possibilities exist for buffaloes.
- Buffaloes are less suited for machine milking.
- They cannot be milked in the absence of the calf (a phenomenon that also often exists with the *indicus* type of cows, but hardly ever with the *taurus* types).

3.2.3 Goats and sheep

Goats and sheep (Figures 8 and 9) are discussed simultaneously, because of their points of resemblance and their similarities. Sometimes, sheep resemble the picture that most people have formed of goats (Fulani sheep), and the opposite may also happen (Angora goat).

Goats and sheep have a number of advantages over cattle and buffaloes:
- They are less demanding in their feed supply and, especially in the case of goats, eat what is refused by cows and buffaloes. Sheep and goats, especially the latter, are very adept at finding feed. Sheep graze, preferring short grass and herbs, but goats even graze still shorter grass and browse foliage with high fibre content, which is not eaten by cattle, buffaloes or sheep. This enables them to survive under very poor feeding conditions. Since sheep and goats consume different parts of the vegetation, they are often kept in mixed flocks (herds). Such flocks are led by the goats, which are more adventurous and show more initiative in finding feed than the sheep.
- Both genera, but especially goats, thrive well in dry areas with a hard soil, although some breeds are especially adapted to humid tropical zones. Goats generally require more shelter against cold, wind and moisture than sheep, but the latter are claimed to be more susceptible to changes in feed and environmental conditions.
- The investment per animal is smaller than in the event of cows and buffaloes, and consequently, they carry a smaller individual risk to their owner, whilst they are more eligible for marketing and slaughter. They are especially valuable as a milk and meat animal to families who cannot afford to keep a cow or a buffalo. This justifies their designation 'poor man's cow'.
- They have a higher reproduction rate.

Sheep and goats freshen at an age of six months and sometimes even earlier, but they are usually mated at one year. Animals living in flocks mate at an earlier age.

Sheep and goats show a seasonal reproduction cycle, which 'depends' on the length of daylight. In the temperate zones mating takes place in autumn; the lamb is born after a gestation of 145 to 150 days. This results in a seasonal milk production. The seasonality also exists in the tropics, where day and night are equally long. Here it is due to a number of other factors, such as climate and availability of feed, and possibly also to breed. The females can be in heat at any time of the year in the tropics, making lambing or kidding theoretically possible twice a year. However, this is seldom achieved and two or three kiddings in two years is normal practice under controlled conditions. The birth of twins or triplets is quite common. Compared with large livestock, the rate of reproduction is very high and herds can be built up quickly after calamaties.

Goats have the reputation of browsing bare almost everything (especially brushwood

Fig. 8. Herding sheep (Syria).

left as the last vegetation in arid areas), thus contributing to erosion and the expansion of deserts. For this reason, several countries have adopted an anti-goat policy.

The lactation of sheep and goats often coincides with the lactation of cows and buffaloes, because of the availability of feed. This considerably worsens the lean/flush ratio of milk availability (Section 8.2.3).

The importance of both species for milk production differs from region to region, but it is small in the entire world (Table 4). In most cases, the animals are kept for meat, skins, hair and wool and sometimes manure. In such cases a high proportion of the goat and sheep milk is either used for home consumption or enters the informal marketing circuit. Typical breeds for milk production have seldom been selected or bred in tropical countries. The introduction of very productive breeds from the temperate zones has often led to disappointing results, because of failure to adapt to the climatological and environmental conditions. In this respect, there is some similarity with the introduction of dairy cattle from the temperate zones. Imported goats suffer particularly from lack of resistance to tropical diseases.

Milk production can be of enormous importance locally. Milk yields largely depend on breed, production purpose, feeding and other environmental conditions. Productions of 1 l daily as an average and a total production of 250 l in one lactation are excellent under tropical or subtropical conditions. The length of a lactation may vary from 3 to 7 months, but generally does not last longer than 4 to 5 months.

Two systems are followed in suckling the lamb:

- The lamb receives only part of the milk, the remainder is used by man.

Fig. 9. Flock of goats (Libanon).

- The lamb is left with the mother during the first – e.g. four – weeks and receives all milk. Thereafter, the milk is used by man until the end of the lactation.

The marketability of the milk largely depends on the system of exploitation. The four principal systems are:

- Small numbers of animals are kept at or near the owner's residence. This system is most common with goats.
- Small or large numbers are kept with the owner or owners under nomadic conditions.
- Large – usually mixed – flocks are kept under some form of migration (transhumance).
- Large flocks of animals go out for grazing during daytime, but return to their owner's residence in the afternoon or evening.

Only under the conditions of the first and the last mentioned systems can the collection and marketing of milk be easily organized.

3.2.4 Camelidae

The family of the camels (camelidae) includes the genus *Camelus* and the genus *Lama*.

3.2.4.1 Camels

Two varieties of the genus *Camelus* are known; the two-humped or Bactrian camel (*C. bactrianus*) and the single-humped camel or dromedary (*C. dromedarius*).

Fig. 10a. Camel with suckling young (Oman).

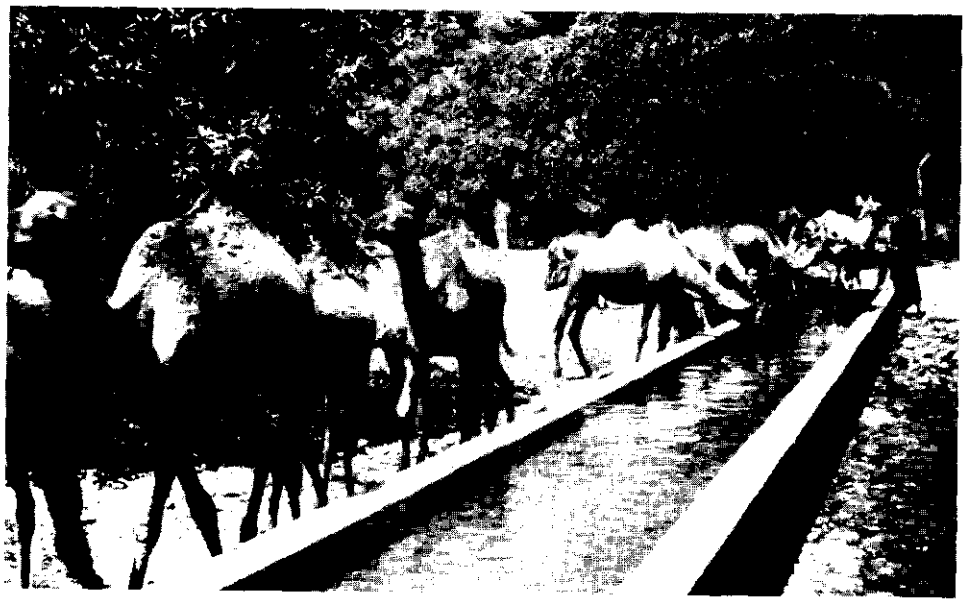

Fig. 10b. Watering camels (Oman).

The Bactrian camel. The Bactrian camel is found in Central Asia, from the Caspian Sea in the West to Manchuria in the East. Little is known about the utilization of their milk by man, except that milk production seems hardly important to man. Nevertheless, it can attain 5000 l per lactation in exceptional cases and under favourable environmental conditions. Under normal conditions the average production will be much lower, about 1000 l per lactation. Although Bactrian camels are found over a vast area, their total number is comparatively low. It can be estimated at about 1 250 000.

The dromedary (Figure 10). The single-humped camel, usually referred to as camel, is mainly found in Africa, North of the Sahara, North Eastern Africa, the Middle East, India and Pakistan. Their total number amounts to approximately 17 000 000. The camel was originally kept for riding, transport and labour, but it is losing its importance for these purposes. Its importance for milk and meat production is increasing. In several parts of Ethiopia and Somalia camel's milk forms an indispensable part of man's diet. Unfortunately, the milk is difficult to market, because of the nomadic pattern of life of many camel owners.

Production and reproduction largely depend on the availability of water and feed. Camels can survive long periods (10 to 20 days, against 2 to 3 days for cattle) without drinking, losing up to 30% of their live weight without much harm. During the severe period of draught in the Sahel in 1973, about 150 000 people and almost all cattle died, but about 75% of the camels survived. As they can live for a long period without water and feed, they are able to cover long distances in search for water and feed.

Camels thrive on feed that cannot be utilized by most other domestic animals. Therefore, they are not competitors with cattle, buffaloes and sheep. They browse on trees, shrubs and halophytes. Moreover, their height enables them to eat leaves and sprays of trees (up to 3.5 m) that other animals cannot reach.

Under proper conditions of feeding, camels may give birth every 18 months, whilst the milk yield can reach 5000 l per lactation. Under average desert or arid conditions, the milk yield will vary from 800 to 1200 l per lactation of 9 to 18 months.

It is often claimed that calf mortality is high (up to 35%), but it is believed that this is due to the struggle for milk between man and calf, rather than to a characteristic of this species.

Their excellent performance in arid and desert areas – that is: under hardship conditions – may make the camels the domesticated milking animals of the future in many areas where conditions are not good enough for cattle, buffaloes and even sheep. Too little attention has been paid to the introduction of camels for this purpose in hardship areas. It should be taken into consideration, however, that by eating or rather browsing the last vegetation resources, these animals may contribute to erosion and desertification.

3.2.4.2 Llamas

Llamas are kept in the Andes (Peru, Bolivia) at high altitudes for the production of meat, hair and pelt, and also for work draught. Little is known about milk production, but al-

though a daily production of up to 2 l by the species Alpaca (*Llama pacos*) is claimed, the milk is not utilized for human consumption.

Further reading

Charles, A.B., 1983. Sheep production in the tropics. Oxford tropical handbooks. Oxford University Press, Oxford.

Cockrill, W.B. et al., 1976. The husbandry and health of the domestic buffalo (2nd. ed.). FAO Agricultural Studies. FAO, Rome.

Cockrill, W.R., 1984-1985. The camelid: an all-purpose animal. Vol. 1: Proceedings of the Khartoum workshop on camels. Vol. 2: Bibliography. Scandinavian Institute of African Studies, Uppsala.

Devandra, C. & M. Burns, 1970. Goat production in the tropics. Technical Comm. No. 19. Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh.

French, M.H., 1980. Observations on the goat. FAO Animal Production and Health Paper, No. 80. FAO, Rome.

Gall, C., 1975. Milk production from sheep and goats. FAO World Animal Review 3:1.

Ganguli, N.C., 1981. Buffalo as a candidate for milk production. International Dairy Federation, Document 137.

Gaunthier-Pelters, H. & A. Dagg, 1981. The camel. University Chicago Press, Chicago.

FAO, 1977. The water buffalo. FAO Animal Production and Health Series, No. 4. FAO, Rome.

Haenlein, G.F.W. et al., 1980. International symposium on dairy goats (Delaware). Journal of Dairy Science 63:1591.

Knoess, K.H., 1977. The camel as a meat and milk animal. World Animal Review No. 22, p. 39.

Larsen, B.L.& V.R. Smith (Eds), 1974-1978. Lactation, a comprehensive treatise. Vol. I (1974) The mammary gland, development and maintenance. Vol. II (1974) Biosynthesis and secretion of milk, diseases. Vol. III (1974) Nutrition and biochemistry of milk, maintenance. Vol. IV (1978) The mammary gland, human lactation, milk synthesis. Academic Press, New York.

Larsen, B.L. (Ed.), 1985. Lactation. Iowa State University Press, Ames.

Manolkidis, C. et al., 1986. Production and utilization of ewe's and goat's milk. Proceedings IDF Seminar (Athens). International Dairy Federation, Bulletin No. 202.

Morton, H.H., 1984. Camels for meat and milk production in Sub-Sahara Africa. Journal of Dairy Science 67:1548.

Ragil, R., 1982. Camels and camel milk. FAO Animal Production and Health Paper No. 26. FAO, Rome.

Webster, C.C. & P.N. Wilson, 1980. Agriculture in the tropics (2nd ed.). Tropical Agricultural Series. Longman, London.

Williamson, G. & W.J.A. Payne, 1978. An introduction to animal husbandry in the tropics (3rd ed.). Tropical Agricultural Series, Longman, London.

Wilson, R.T., 1984. The camel. Longman Group Ltd., London.

4 Composition and properties of milk

There are considerable differences in the composition and properties of milk[1], not only between species, but also between and within breeds.
The composition of milk mainly depends on:
- genetic factors;
- environmental conditions;
- stage of lactation.

Consequently, data in publications about the chemical and physical characteristics of milk from various species and breeds should be accepted with some reserve. Moreover, the physiological condition of the animals and the level of management under which they are kept are seldom known, neither are the methods of sampling and analyses always mentioned. For these reasons, there is often little uniformity in the data found in literature, whilst information from various sources may even be contradictory.

Representative average values for some major constituents of good quality milk from various species are given in Table 7.

High temperatures may lower the milk yield of mammals coming from temperate zones, but usually do not significantly affect the composition of the milk, although the fat content may be increased.

Table 7 shows considerable differences in the percentages of the major components of milk from various mammals. Differences are also found in the minor components. These differences and chemical variations of the components themselves, lead to differences in physical properties of milks from various sources. This is important from a nu-tritional point of view and has its consequences for the milk-processing industry. Various reasons have been put forward to explain the differences in composition of milk from different species, but none is fully satisfactory.

It is noticeable from Table 7 that the composition of milk from ruminants differs distinctly from that of non-ruminants. This might be wholly or partly explained by differences in the digestive system. The milk of non-ruminants is lower in fat, protein and minerals, but higher in lactose.
Other causes responsible for differences could be:
- rate of growth of the young animal;
- ambient temperature;
- length of digestion tract;

[1] Detailed information about this subject is included in the companion volume 'Dairy technology in the tropics and subtropics'.

Table 7. Broad survey of the composition of milk (g/100g) of different species (after various sources).

Species	Fat	Casein	Whey proteins	Lactose	Ash
Human	4.6	0.8	0.7	6.8	0.2
Cow					
– *Bos taurus*	4.2	2.6	0.6	4.6	0.7
– *Bos indicus*	4.7	2.6	0.6	4.7	0.7
Buffalo	7.8	3.2	0.6	4.9	0.8
Goat	4.5	2.6	0.6	4.4	0.8
Sheep	7.6	3.9	0.7	4.8	0.9
Horse	1.6	1.3	1.2	6.2	0.4
Ass	1.5	1.0	1.0	7.4	0.5
Camel	4.0	2.7	0.9	5.4	0.7

- whether suckling is at regular or irregular intervals;
- stage of development of young at the moment of birth.

When these possible causes are compared with the composition of milk of a large number of species, many contradictory factors emerge. It is believed that a combination of factors plays a role in milk composition and that in this combination the influence of certain factors is wholly or partly overruled by other factors.

Further reading

Berg, J.C.T. van den, 1988. Dairy technology in the tropics and subtropics. Pudoc, Wageningen.
Bhimasena Rao, M. et al., 1970. Camels' milk and milk products. Indian Journal of Dairy Science 23:71.
Fox, P.F. (Ed.). Developments in dairy chemistry. Vol. I (1982) Proteins. Vol. II (1983) Lipids. Vol. III (1985) Lactose and minor constituents. Elsevier Applied Science Publishers, London.
IDF, 1979. Chemical residues in milk and milk products. International Dairy Federation, Document 113.
IDF, 1983. Production and utilization of goat's and ewe's milk. International Dairy Federation, Bulletin 158.
Jenness, R., 1972. A. Darwinian view of lactation. Hannah Research Institute, Report No. 1072, p.47.
Jenness, R. & A.H. Sloan, 1970. The composition of milks of various species. Dairy Science Abstracts 32:599.
Laxminarayana, H. & N.N. Dastur, 1968. Buffaloes' milk and milk products. Dairy Science Abstracts 30:177,231
Moore, J.H. et al., 1980. Factors affecting the yields and contents of milk constituents of commercial importance. International Dairy Federation, Document 125.
Parkash, S. & R. Jenness, 1968. The composition and characteristics of goats' milk. Dairy Science Abstracts 30:67 (review art. No. 143).
Ramoz, M. & M. Juarez, 1981. The composition of ewe's and goat's milk. International Dairy Federation, Bulletin 140.
Robinson, R.K. (Ed.), 1981. Dairy Microbiology. Vol. I: The microbiology of milk. Vol. II: The microbiology of milk products. Elsevier Applied Science Publishers, London.
Walstra, P. & R. Jenness, 1984. Dairy chemistry and physics. Wiley & Sons, New York.
Webb, B.H. et al., 1974. Fundamentals of dairy chemistry (2nd ed.). The AVI Publishing Co., Westport (Conn.).

5 Uses of milk

Milk produced by domesticated milking animals can be utilized for:
- young stock;
- the farmer's family;
- sales to third parties.

Milk is primarily produced by mammals for feeding their young, a well-known feature often forgotten by man. Some of the milk may be consumed by the livestock owner and his family. There are great differences in consumption patterns. In some regions, milk forms a substantial part of the family's diet, whilst in others no milk or very little, is consumed by the family and instead the milk is primarily destined for feeding the young stock, and only the occasional surplus is sold.

Since many of the indigenous breeds in tropical and subtropical countries have a low milk-production potential, little or no milk is usually available for sale after the young animal has been fed and the livestock owner's family has taken its requirements. Besides, difficulty is often experienced in finding a market. As a result, production and consumption take place entirely in the subsistence sphere. This situation may change as soon as a buyer, e.g. a dairy plant, enters the market. If an inviting price is paid to the livestock owner, he may be tempted to sell too much of the milk, to the detriment of his family and the young animal. It is possible for calf mortality to increase as a result of the creation of a market for milk. This can be prevented by collecting milk only once a day, preferably in the morning. The young animal can stay with its mother all day long, but they are separated overnight and milking takes place in the morning. Measures should be taken to prevent the evening milk being collected together with the morning milk. In many cases it is found difficult to prevent the evening milk from becoming sour if it is left until the next morning and is not cooled. Sometimes, attemps are made to reduce the increased acidity of evening milk by mixing it with the fresh morning milk, thereby 'averaging' the acidity. It has been proven that the acidity of such a mixture increases very rapidly, with the result that the mixture is spoilt by the time it is delivered to the dairy plant or other buyer.

The livestock owner may have a number of good reasons for processing the milk on the farm and for selling milk products, in stead of fresh raw milk. These reasons are:
- The market for fresh milk is restricted, but there is a special demand for milk products. Because of the non-availability of the perishable fresh milk, the population has not developed the taste for it and the demand will be low. Milk preserves were originally often accidentally manufactured. The population is traditionally used to these preserves and a 'farmhouse industry' has been developed to satisfy this demand.

- A higher profit can be made. This is of special interest if there is a surplus of labour on the farm (e.g. in the case of large families). The transfer of milk processing from the farm to a dairy plant requires paid labour at the plant. This seemingly increases the processing costs if labour at farm level is unpaid or cheap. Consequently, factory-made products are often more expensive than farmhouse-made products.
- The amount of milk available for sale daily is only small, but it pays to manufacture products with an improved keeping quality every day, and to sell these products once or twice a week.
- There is no market for fresh milk nearby, so – to avoid spoilage during transport and sales – milk is preserved by processing it into products with improved keeping quality.

In many countries, the various milk preserves are far more popular than fresh milk, because the consumer is not only historically and traditionally used to these products, but also feels embarassed to drink milk, because he believes that milk is a special product for children and sick people. This embarassment is not felt for milk products. This psychological reserve should not be underestimated when planning dairy plants and introducing or promoting the consumption of milk and milk products. In many cases, products other than 'sweet' milk, such as fermented milks like yogurt, are more readily accepted, at least in the intial stage of operation of a plant.

5.1 Farmhouse and industrial processing of milk

Farmhouse processing of milk takes place for reasons explained before. Moreover, milk is also preserved to transfer milk surpluses from periods of high milk production to periods of low milk production. Nomades manufacture products that they can take with them on their journeys.

The milk products originating from the farm can be subdivided into four categories, which will be discussed briefly [1]:
- raw milk;
- fermented milks;
- butter and ghee;
- concentrated and dried products.

5.1.1 Raw milk

Raw milk is usually sold without any processing. It may be sieved or partly skimmed. Sometimes it is packed in plastic sachets.

5.1.2 Fermented milks

The most 'natural' milk preserves originate from the inability of the livestock owner to

[1] The processing of milk and the manufacture of milk products at farmhouse and industrial level is discussed in detail in the companion volume 'Dairy technology in the tropics and subtropics'.

control the keeping quality of the milk. Bacteria that produce lactic acid ferment the milk sugar, causing the milk to acidify (become sour). Acidification prevents milk from being spoiled by putrefying bacteria, and suppresses pathogenic bacteria (see Section 20.2).

The characteristics of the sour products depend on the kind of milk and the kind of fermentation. In turn, the latter depends on the type of contaminating micro-organisms, or the kinds of micro-organism that are added to the milk (inoculation with cultures or starters) and the environmental conditions, principally the temperature. A large number of different groups of bacteria are usually found in indigenous fermented milk products traditionally manufactured on the farm. It is not always clear whether all these bacteria are essential for the product, or whether some or most of them are accidental contaminants. Five groups of fermented milks can be distinguished:

- the sour-milk group (produced by mesophilic bacteria);
- the yogurt group (produced by thermophilic bacteria);
- the alcoholic sour-milk group (produced by lactic acid bacteria and yeasts);
- the diluted sour-milk products;
- the concentrated sour-milk products.

In the sour-milk group, fermentation takes place at a moderate temperature, e.g. between 15° and 30° C. This group is only important for tropical and subtropical areas where such temperatures are experienced. Characteristically, the acid production is by mesophilic bacteria like *Streptococcus lactis* and *S. cremoris*, and the aroma production (principally diacetyl) is by species like *S. diacetylactis* and *Leuconostoc cremoris*.

In warm (tropical and subtropical) zones, the conditions favour thermophilic lactic acid bacteria, like *Streptococcus thermophilus* and *Lactobacillus bulgaricus* (together called yogurt bacteria), which will produce yogurt and yogurt-like products, such as yoğurt (Turkey), laban (Jordan), dahi (India), zabad (Egypt), etc. Characteristic aromatic compounds are acetic acid and diacetyl. The more flavourless, but sour products like acidophilus milk and Bulgarian milk also belong to this group.

Some sour-milk products, like koumiss (made from mare's milk) and kefir (made from cow's milk and other milks) are produced by the fermentation with lactic acid bacteria and yeasts, which results in acid products containing a low percentage of alcohol and some aromatic compounds.

Yogurt-like products may be very viscous, especially if they are made from sheep's milk. They can be made drinkable by dilution with water, e.g. ayran (Turkey) and doogh (Iran). Sometimes, small quantities of salt, sugar or flavourings are added to improve the taste of the product. The addition of water lowers the acidity of the product.

Since it is very difficult to stop fermentation at the right moment, farmhouse produced fermented milks may become too sour. By packing the product in a cloth and hanging it up, some of the acid-containing whey will drain off and the drained (concentrated) product will have a milder taste, like labeneh (Jordan).

Products with an improved keeping quality are produced by drying or heavily salting the concentrated fermented milk. Drying drained yogurt is a well-known method of preservation. Salt may be added to the drained product before drying, e.g. kurut (Turkey), which consists of small pieces of sun-dried yogurt. Milk may be concentrated over an

open fire before fermentation, or the fermented product may be concentrated by simmering, as in the case of kiş yoğurt (Turkey). The concentrated yogurt is mixed with salt and packaged in pots or jars and covered with a layer of vegetable oil to protect the product from the oxygen in the air.

5.1.3 Butter and ghee

Butter is the fatty product obtained by churning sour milk, or sweet or sour cream. Churning is the process whereby milk or cream is vigorously agitated in such a way that air is incorporated in the liquid (Figure 11). The milk-fat globules collect on the surface of the air bubbles, collide and form butter granules. After the churning process is completed, the granules are separated from the liquid (the buttermilk) and are kneaded to a homogenous mass (the butter).

According to international standards, butter should not contain more than 16% water and not less than 80% milk fat. It contains a small amount of non-fat milk solids and it may be salted. Good quality butter made from sour milk or cream has a pleasant sour aromatic flavour. Diacetyl is the main flavour compound. Sweet-cream butter has a more 'neutral' creamy flavour.

Fig. 11. Churning butter in gourd (Nigeria). Photo: Mrs. A. Waters-Bayer.

Butter has a low keeping quality, as a result of its high moisture content, and it easily spoils. The principal defects are rancidity and a mouldy surface. Butter is very soft and even melts in high tropical temperatures.

The disadvantage of the high water content can be circumvented by heating the butter in order to remove as much water as possible by evaporation. The resulting product, called 'ghee', should – after cooling to 'room temperature' – consist of large butter-fat crystals, suspended in liquid milk fat. The water content should be less than 1%. Ghee can also be manufactured by melting butter or destabilizing heavy cream by heating it and then separating the fat and the liquid by decantation.

Ghee should have a mild, nutty flavour, although a more pronounced caramelized or 'burnt' flavour may be appreciated and consumers may even not object to a rancid taste.

Sometimes, butter is saved up from daily productions over a longer period of time, until there is a sufficiently large amount to be used to manufacture ghee.

The keeping quality of ghee mainly depends on the quality of the raw material it is made of, the production process, the contamination during and after manufacture and how much water it still contains. Generally, the product will turn rancid after storage for some time.

Anhydrous milk fat or butter fat is a kind of ghee that contains hardly any components other than pure milk fat that has not undergone any appreciable micro-biological or chemical changes. Ideally, it is produced from high quality fresh cream in well equipped dairy plants. Sometimes, fresh sweet-cream butter is used. The product is especially suitable for the production of recombined products (Section 10).

5.1.4 Cheese

Cheese is the fresh or matured product obtained by coagulating milk of different fat content and by draining the coagulum. The numerous cheeses that exist can be classified into three categories:

- hard and very hard cheeses, like the English Cheddar, the Dutch Gouda, the Italian Parmesan and the Turkish Kaşar cheeses;
- semi-soft cheeses, like the French Brie and Camembert;
- soft cheeses.

Cheeses of the first two categories require a ripening period before they are ready for consumption. The third category is mostly consumed fresh, although some kind of ripening may be introduced.

Since the hard and semi-soft cheeses require high-quality milk and very hygienic standards of production, whilst moderate temperatures are necessary for a successful ripening and storage (Figure 12) of the cheese, most of the cheeses produced in warm and hot climates belong to the soft cheeses, which are consumed fresh. In general, their keeping quality is extremely limited, although their storage life may be extended by heavy salting, (like the Egyptian Damietta cheese), storage in brine, (like the Turkish Beyaz Peynir), drying (like the Iranian Kashk), or smoking (like the Indian Bandal cheeses).

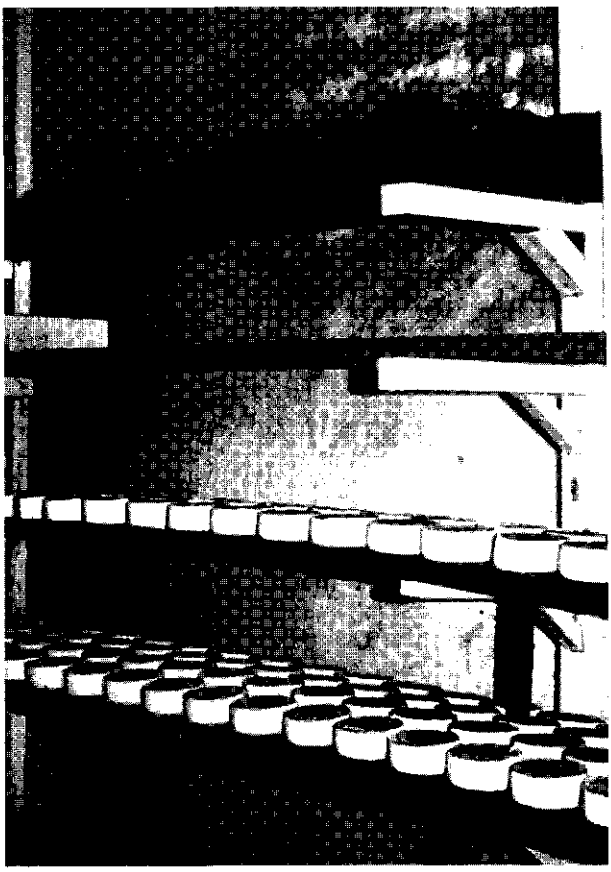

Fig. 12. White cheese in store (Colombia). Photo: Mrs. M.C. van der Haven.

Milk for cheese making can be coagulated in two ways:
- by acid coagulation,
- by rennet coagulation.

For the production of acid-coagulated cheese the milk can be soured by lactic acid bacteria (bacterial acidification) or by the addition of an organic acid. Cottage cheese is a typical example of an acid-coagulated cheese. The coagulum obtained by bacterial acidification (this includes milk that has gone sour and buttermilk) is often drained in a cloth, which is put on a table or on the floor, or hung up. After drainage, the curd (cheese) is consumed fresh or preserved in some way, e.g. by drying, by ripening in a bag made of the skin of a sheep or goat, by smoking, or by putting it in heavy brine, etc. The coagulum obtained by the addition of an organic acid (e.g. lactic acid, acetic acid or citric acid), with or without increasing the temperature of the milk, is generally treated in a similar way, but sometimes the coagulum is drained in moulds under pressure.

For the production of rennet-coagulated cheeses the milk is coagulated by animal or vegetable rennets, in which enzymes are the active compounds. They are able to curdle

the milk, to contract the coagulum under whey expulsion (syneresis) and to break down the proteins in the cheese, thus contributing to the ripening process.

The principal animal enzymes are rennin or chymosine and pepsin. Rennin is most widely used. It is an extract from the stomach (abomasum) of suckling calves. As the calf grows older, the production of chymosine decreases and the production of another enzyme – pepsin – increases instead. Bovine pepsin and pepsins from other mammals, principally goats and sheep, are also used in cheese making, although chymosine is preferred. Pepsins from other animals, like swine and poultry are definitely inferior.

Vegetable enzymes, extracted from various plants, such as *Ficus* (ficine), *Papaya* (papain) and *Bromelia* (bromelin) are sometimes used, either for religious or traditional reasons, or because animal rennets are not available or are too expensive. Vegetable enzymes generally have the disadvantage that the breakdown of the proteins proceeds in a different way – in most cases too quickly – and an unpleasant taste (bitterness) develops in the cheese. Therefore, these enzymes are especially used for the production of fresh cheeses.

In the production of many cheese varieties satisfactory results are obtained with extracts from certain species of fungi (mould). In most cases, the coagulum of rennet-coagulated cheeses is drained in moulds after being cut into small pieces (the curd) to promote whey expulsion. The curd in the moulds may be pressed to promote further whey expulsion and to obtain a homogenous loaf of curd (cheese), which can be matured, preferably in a store where the humidity and temperature can be controlled. The coagulum obtained by renneting may also be drained in a cloth. The curd obtained from rennet-coagulated milk may be preserved in ways similar to those used to preserve curds obtained by acid-coagulation of milk.

5.1.5 Concentrated and dried milks

5.1.5.1 Concentrated milks

A large variety of concentrated products is produced on farms and at cottage-industry scale by boiling or simmering milk over an open fire, like the Indian khoa (without added sugar) and kheer (with added sugar). The manufacture of these products requires much energy (wood) contrary to the production of sweetened and unsweetened condensed milk in large dairy plants.

5.1.5.2 Dried milks

On the farm, milk is usually dried by concentrating the milk first, in most cases by draining rennet- or acid-coagulated milk. This means that the composition of these products will not be representative of the composition of the milk.

In large factories, most milk is dried in spray dryers, where the milk is sprayed in a stream of hot air. After the milk droplets have been dried, the minute particles of powder are separated from the air.

5.2 Sales channels

A cattle owner may sell his milk or milk products through various different channels:
- directly to the consumer,
- to an intermediary,
- to a dairy plant.

5.2.1 Direct sale to consumers

Direct sale to a consumer – either a private family, a restaurant, a teashop, etc. - has a number of advantages:
- The farmer receives the full benefit of his produce. He will generally receive a higher price for doorstep sales than a dairy plant can pay (Section 8.2).
- Extra employment is found for the members of the farmer's family (Figure 13), especially if the milk is delivered on the doorstep.
- The farmer is independent of third parties.

In general, the farmer has no facilities for the heat treatment of the milk, so the consumers are supplied with raw milk and raw milk products.

5.2.2 Sale to an intermediary

There are a number of reasons why in many cases the farmer does not sell his products directly to the consumer, such as:
- the amounts he produces are too small;
- nobody is available at the farm to sell the produce to the consumer or at the market;
- the consumer or the market is too far away;
- the farmer has not built up a market for his produce and does not know where to sell it.

In these cases, he may sell the milk and the milk products to a middleman (a collector; Figure 14) who collects the products at the farms, or the farmer may bring and sell his milk and products to a distributor. The middleman may sell the products directly to the consumer or to a distributor, in which case the latter takes care of the sales to the consumer. Shops are included in the sales channel whenever the consumers buy the milk and milk products in a shop. It is not exceptional for milk to be processed into products by middlemen, distributors or shopkeepers. Milk left over at the end of the day is often preserved by converting it into butter and/or yogurt or other fermented products for the next day's sales.

Sometimes, a chain of intermediaries takes part in the marketing channel, such as agents who collect the milk from middlemen 'up country' and take it to the city for sale to the distributors.

Although intermediaries may accomplish an important task, if there are too many of them – each making a profit for his contribution to the channel – either the price obtained by the farmer will decrease too much or the price for the consumer will increase too

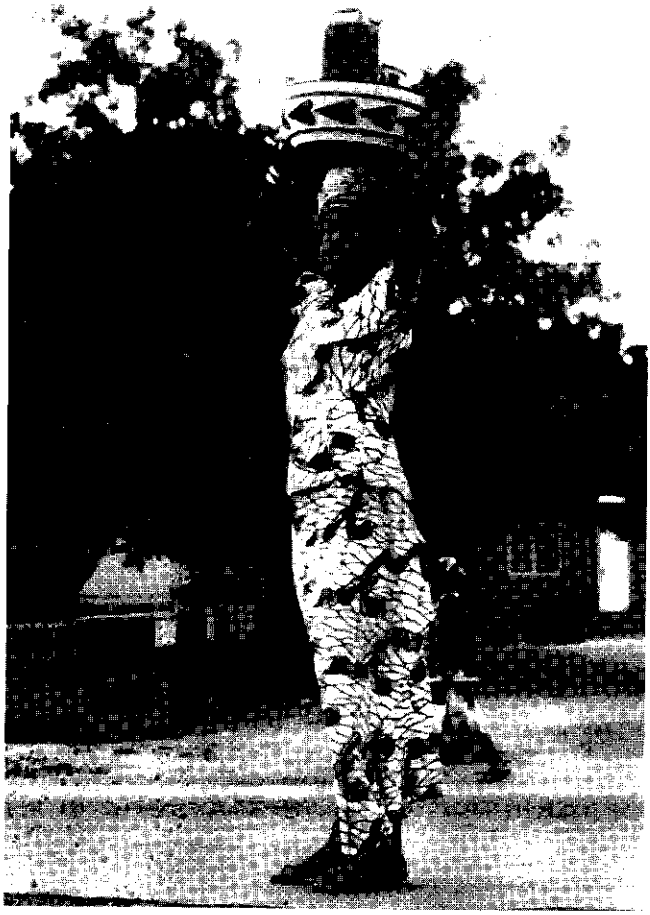

Fig. 13. Fulani girl transporting milk to market, with separate containers for fermented milk (large calabash bowl), fresh milk (plastic canister) and butter (small enamel bowl) (Nigeria). Photo: Mrs. A. Waters-Bayer.

much. Unfortunately, it is no exception for the individual intermediaries to take too high a profit.

Middlemen can make mutual agreements, thus holding a monopoly in the raw milk market. In doing so, they can set maximum prices, and can divide the area of milk collection amongst themselves, in this way avoiding competition.

In some cases, advance payments are granted to poor farmers. This happens at the beginning of the period of the year when such farmers have little or no income. This can be the winter period or the dry season. The advances are given on the condition that the farmers supply all their milk to the money lender to pay off their debts as soon as the production period starts again. Generally, these farmers receive a lower milk price, which

Fig. 14. Young milk collector on donkey back (Pakistan).

is quite acceptable if a fair compensation is calculated for risk and interest. Too often this 'compensation' is far too high. It may amount to as much as 30% of the value of the milk to be supplied. Farmers that have no reserves and are dependent on the annual advances cannot break free from this vicious circle.

Middlemen often have a very strong position; not only because they give advance payments, but also because there is a very strong traditional and personal connection between them and the farmers.

Advance payments may be given throughout the whole marketing channel: in other words, the farmer will be in debt to the middleman, the middleman to the distributor and the distributor to the shop.

Farmers may also request advance payments to have a guaranteed outlet for the milk.

Several other sales systems exist; for instance, those where the distributor or the shop sells the milk on behalf of the farmer or the middleman, and receives a certain commission.

5.2.3 Sale to a dairy plant

Dairy plants receive milk from farmers for processing. Although many have facilities for the heat treatment of milk, large numbers, especially the smaller private cheese and butter factories, do not.

The milk may either be supplied to the dairy plant by the farmers themselves or through middlemen, or the dairy plant may collect the milk from the farmers' or middle-

men's homes (Section 9.1). The dairy plants can, like the middlemen do, pay advances to the farmers. In some countries this system is especially applied by the smaller private seasonal cheese and butter factories.

Milk collected in far-off areas can be taken to a collection centre prior to transportation to the dairy plant. Spoilage of the milk can be prevented by cooling the milk at the centre.

Further reading

Berg, J.C.T., van den, 1988. Dairy technology in the tropics and subtropics. Pudoc, Wageningen.

Abbott, J.C. & J.P. Makehan, 1979. Agricultural economics and marketing in the tropics. Intermediate Tropical Agricultural Series, Longman Group Ltd., London.

Jolliet, F.E., 1987. Marketing aspects of dairy products in developing countries. In: Proceedings of the XXII International Dairy Congress (The Hague). D. Reidel Publishing Co., Dordrecht, p. 299.

Roon, D.E. de, 1987. Market and marketing of dairy products in developing countries. In: Proceedings of the XXII International Dairy Congress (The Hague). D. Reidel Publishing Co., Dordrecht, p. 285.

6 The desirability of initiating or stimulating milk production

There are various reasons why many countries are trying to initiate or to stimulate dairy husbandry. The main ones are:
- to increase the milk availability per capita[1];
- to increase the standard of life in the rural areas;
- to save on foreign currency;
- to become self-supporting in milk.

Sometimes, stimulation of dairy husbandry is a political rather than a financial or an economic issue. If in such cases the climatological and other conditions are not favourable for the development of a successful dairy industry, the investments in terms of capital, manpower and land might have been better used to stimulate other activities, whether agricultural or non-agricultural. Under such circumstances, an existing demand for milk and milk products may be satisfied by the importation of dairy products, provided sufficient foreign currency can be made available. In this respect, it should be realized that establishing or promoting a dairy industry and subsequently maintaining it generally requires a substantial amount of foreign currency as well (Section 6.4).

6.1 The demand for milk and milk products

Even though milk is produced in a country, individuals may not be in a position to satisfy their demand for milk and milk products, because:
- they cannot afford to buy these products;
- the available quantity of milk is insufficient.

In many circumstances, milk will be too expensive for a large part of the population, and the unsatisfied demand can only be met by increasing the financial position of the population or by making milk and milk products cheaper. Lowering the price of milk will – in most cases – mean a lower price to the farmer (Section 11.5). This, in turn, may mean that the incentive for milk production will diminish.

The increase in production and decrease in demand are plotted against the price of milk in Figure 15. The two lines intersect at point A, where there is an equilibrium between the production and the demand (i.e. the demand that can be paid for, called the

[1] Nutritional and health aspects of the consumption of milk and milk products are discussed in Section 19 (Milk in human nutrition) and in Section 20 (Milk products and human health).

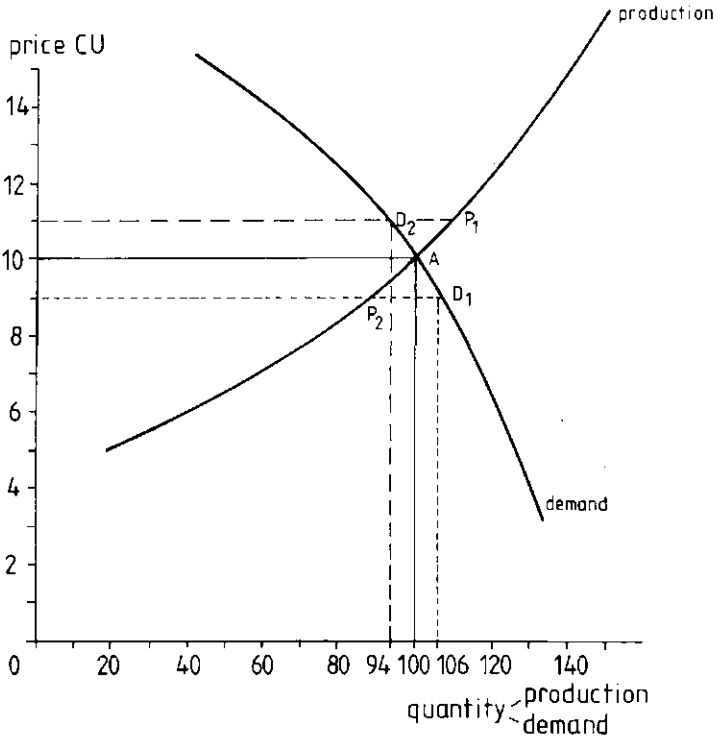

Fig. 15. Influence of price setting on production and demand of milk. CU = calculation unit, an imaginary monetary unit. A, P_1, P_2, D_1, D_2: see text.

commercial demand). The actual demand may be much higher, but the population is too poor to buy. If the price of the milk is 10 CU at the point of equilibrium and the price is reduced by 10%, to 9 CU, the commercial demand would increase by 6% to D_1, if there is a price elasticity[1] of 0.6. However, as a result of the lower price, the production would decrease, for instance to point P_2 in the diagram and a milk shortage would be the result. This means that government interference in the price structure will not necessarily improve the availability of milk for the financially vulnerable part of the population. On the other hand, increasing the milk price for the farmers by, for instance, 10%, will decrease the demand for milk (point D_2) and will accordingly create a surplus, because the production will rise to P_1.

The increase in the consumption of milk and milk products will depend on:
- changes in the consumption pattern of the population brought about by advertising; introducing the products in new areas, and so on;

[1] The price elasticity indicates the percentage by which the sales of milk will increase if the price decreases by 1%. Or, conversely, will decrease if the price increases by 1%. The price elasticity for milk usually varies from 0.5 to 2.0.

- the increase in population and its purchasing power.

It is difficult to predict the magnitude of the first mentioned causes. The results of the increase in population and purchasing power can be calculated if the annual increase in population (B, %), the annual increase in purchasing power (W, %) and the income elasticity[1] are known (E).

The annual increase in consumption (I, %) can be estimated as[2]:

$$I = B + EW$$

The estimation of the increase should be based on fixed prices, otherwise corrections for price fluctuations should also be taken into consideration. The calculation merely gives a rough estimate of the real increase in demand. In particular, long-term estimates should be adjusted annually to the actual situation.

The inaccuracy of this kind of calculation mainly results from:

- changes in the consumption pattern of the population (as explained already);
- uncertainty about the future increase of the purchasing power, that is the development of salaries and wages; instead of the wages and salaries, the Gross National Product per capita (GNP) is often taken;
- differences between low- and high-income families.

It may make a difference whether the purchasing power of the low-income or of the high-income families increases. The unsatisfied demand of the lower income groups will be larger than that of the higher income groups; the former may not buy milk or milk products at all. The inclusion of new groups of consumers (e.g. the lower income groups with a sufficient increase in income to start milk consumption) will complicate the calculations. The same holds for high-income groups whose demand is fully or almost satisfied. For these reasons, estimates are sometimes made for different income groups, each having their own elasticity figure.

It seems easier to satisfy the increasing demand in rural areas where dairy husbandry is possible, than in areas where no dairy husbandry exists, or where dairy husbandry cannot be expanded. This particularly holds for urbanized areas, because often almost unsurmountable and costly transportation and distribution problems have to be solved. Calculations of the national increase in demand for milk will not bear any indication to this effect and consequently are unsatisfactory indicators of the necessity to promote milk production in certain, perhaps remote, areas.

Besides stimulating the local production, increasing demand can also be met by an increased importation of milk products (Section 10).

[1] The income elasticity indicates the percentage by which the commercial milk demand will increase if the income increases by 1%. For milk, it usually varies between 0.5 and 1.5.

[2] The formula for the calculation is actually: $I = \frac{(100 + B) \times (100 + EW)}{100} - 100$

6.2 The improvement of the standard of life in rural areas

Governments may try to improve the standard of life in rural areas. Although general social considerations may be the motive, special emphasis may be laid on the rural areas with the objective of diminishing urbanization, which is catastrophic in many countries. Before such sweeping measures are taken, some investigations should be done:
- is there a market for the milk that will be produced?
- are there any restrictions to the amount that can be sold?
- what price will be paid for the milk, and does this price cover the production costs?
- what demands will the purchasers of the milk make on quality, cooling, etc.?
- who will organize the milk collection?

The answers to these questions will show the present and future possibilities for milk commercialization and the profitability of milk production to the farmers.

Programmes for improving the standard of life are often especially directed to the small farmer. The term 'small farmer' is difficult to define. It cannot exclusively refer to the number of animals he has, especially not in the event of mixed farming. Neither is the total area of his land – whether freehold or leasehold – an appropriate measure, because it is the quality of the land that is crucial. Often, undefined parameters are used, with emphasis on the fact that a small farmer is a poor farmer, who possesses little or no capital and other means of production, with the exception of labour.

However, one can ask at what level a small livestock owner should be regarded as a small farmer or rather as an unemployed person who owns one or a few animals and perhaps a small piece of land. In this case, efforts to create more employment may be more justified than efforts to raise his marginal agricultural income. However, raising employment in rural agricultural areas usually creates unsurmountable difficulties, because of poor infrastructure, the lack of industries, services, raw materials, know-how, marketing possibilities, etc., etc. On the other hand, the population density in areas with many small farmers usually increases rapidly, with the result that the carrying capacity of the land is exceeded and employment must be found anyhow.

Improving the position of small farmers will meet special problems by comparison with big farmers; the latter being in a better position, because:
- it may be easier for them to get loans or credit, e.g. for farm improvement and the purchase of cattle and feed;
- they may own more reserves and be less vulnerable;
- they may own more means of production, such as an adequate water supply, means of transportation, etc.;
- in most cases, they are better educated or trained and will be more inclined to accept new and improved methods of production;
- they will generally be more receptive to advice given by the extension service and others;
- their costs of production and marketing are usually lower and they may be able to obtain higher prices, because they can offer larger amounts;
- it will be easier for them to become members of boards of cooperatives, societies, etc.,

where they may forget the specific problems of the small farmers.

However, it would be a mistake to direct programmes for rural development exclusively to small farmers. Large farmers may act as a nucleus for the introduction of new production methods. Moreover, they may considerably contribute to the supply of raw material, in this case milk, to processing units, thus making such units financially viable. On the other hand, dairy development programmes will fail if they lead to the position of small famers being neglected.

6.3 The creation of labour

Stimulation of dairy husbandry may also be regarded as a means (usually modest) of creating labour in rural areas. Combating 'hidden unemployment' at family level may be found to be especially important. This need not be the case if animal husbandry takes the place of other agricultural activities, especially not if the latter are more labour intensive.

6.4 The saving of foreign currency

The importation of milk and milk products requires foreign currency. Since foreign currency is often scarce and other priorities for importation are set, domestic production of milk may be considered as an alternative. However, the costs and efforts of implementing such an alternative are often underestimated. Gross savings on foreign currency are not equal to the amount found by multiplying the amount of milk produced by the local raw-milk price, but rather to the amount produced multiplied by the price of the imported commodities (disregarding possible import duties).

Net savings are usually much lower, because all imports necessary for the increase of local production – these also require foreign currency – should be deducted from the gross savings. Such imports may consist of:

- know-how; foreign experts;
- equipment and building materials;
- medicines and feed.

Moreover, replacement costs should be taken into consideration as well, such as the use of land or other means of production for dairy husbandry, which were originally used for products that were exported, or that are to be imported, because they are no longer produced. Examples are:

- the use of oil-seed cakes, which were originally exported;
- the production of food crops that were originally exported;
- the importation of food crops needed for local consumption and that are no longer produced because land and other means of production are used for dairy husbandry.

It should also be realized that the imported commodities are usually cheaper than those produced locally. This will result in higher consumer prices if imported products are replaced by locally produced milk. Moreover, lower returns on import duties must be expected (Section 10.3).

6.5 Becoming self-sufficient

Countries may wish to be self-sufficient in milk for political reasons. Land-locked countries consider it especially important to be independent of the importation of their basic needs.

Another important consideration may be the desire to have a certain quantity of locally produced milk available for vulnerable groups, in case of calamaties. It should, however, be realized that it may prove to be very difficult to channel milk under such circumstances.

Further reading

Anonymous, 1980. The majority of poor peasants are bypassed by rural development programmes. Ceres 13(1)3.

Mason, I.L. & V. Buvanendran, 1982. Breeding plans for ruminant livestock in the tropics. FAO Animal Production and Health Paper, No. 34. FAO, Rome.

Simpson, J.R., 1988. The economics of livestock systems in developing countries. Westview Special Studies in Agriculture Science and Policy. Westview Press Inc., London.

7 Possibilities and conditions for stimulating milk production

If it is desired to stimulate milk production, a few questions may arise:
- where should the stimulation take place?
- how should the stimulation take place?
- which conditions should be satisfied?

7.1 Where stimulation should take place

It may be expected that the stimulation of milk production will be most successfully and quickly realized in areas where dairy husbandry is practised and milk is already commercialized. It will be more difficult in areas, where animal husbandry is practised, but where no milk or only insignificant amounts are sold. In such cases, milk is often exclusively produced for family use, and only surpluses – if any – are sold to others. If in this subsistence economy a market for milk comes into existence, the production for this market will basically change the production pattern and – in many cases – the social structure of the community. The specialization towards milk production will make the farmer more dependent on marketing conditions, that is on the outside world.

Stimulating milk production in areas with an existing dairy industry which is already producing for the market, is usually more promising, although it may be found difficult to change and improve traditionally rooted systems of management, milking and milk handling, marketing, etc. For this reason, project proposals that contain recommendations that assume that the farmers are already experienced in animal or dairy husbandry should be treated with caution.

The introduction of dairy husbandry in areas where animal or dairy husbandry is unknown, or where animals other than the type of animal to be introduced are kept, is not easy and requires intensive training and extension programmes.

7.2 How stimulation should take place

In areas with an established dairy industry, dairy husbandry may be stimulated by fundamentally changing the existing production pattern, or by gradually improving this pattern.

The first method allows for planning and organization to be completely directed towards what is thought to be the optimal situation which can – at least on paper – be

quickly achieved. However, drastic changes usually make too high demands of inexperienced governmental and private agencies and require certain infrastructural improvements to be realized. Moreover, farmers are often unable or unwilling to accept fundamental alterations, and political resistance is to be expected.

The second method allows more account to be taken of the human factor, which usually results in better cooperation from the participants.

Sometimes, very large dairy farms are established under the guise of stimulating dairy husbandry. It is of course possible to increase the availability of fresh milk considerably in this way. But such farms are often of little importance for the development of local dairy husbandry. They can hardly ever serve as model farms or training institutions because their management is completely different from that of the comparatively small farms. Local cattle owners – especially the small farmers – will find little on these large farms of any relevance for their own system of animal husbandry. The radiating power of very large farms is limited.

The establishment of large farms can even be counterproductive if this occurs on land that is already occupied and the farmers who are settled on such land are forced to move (especially if their new land is of poorer quality and the infrastructure is poorer).

The often claimed importance of large farms for research is usually negligible.

Their importance for breeding is sometimes overstated, although farms can differ in their method and quality of management. If it is intended to breed female animals – in most cases pregnant heifers – for sale to local farmers, than the number of these animals that will become available may prove to be disappointing, as is shown in the hypothetical example (Table 8).

Table 8. Livestock production farms.

Number of cows	100	
Percentage pregnant/calving	76	
Births	38 fem.	38 male
Mortality and other losses	6	6
Yearlings	32	
out of which:		
Pregnant heifers (90%)	29	
Replacement (20%)[1]	20	
available for sale:		
Pregnant heifers (29–20)	9	
Non-pregnant heifers (32–29)	3	

[1] The replacement percentage is often lower than 20% in which case more heifers will be available for sale.

Moreover, it usually takes some years, before the first heifers are available for sale. Because of initial poor management and high mortality and the need to cull diseased animals and other animals unfit for breeding, the original number of animals will first decline. In most cases it will take at least 5 years before the original number of animals is reached again by replenishment by the offspring of the starting herd.

It is often difficult to find purchasers for the animals other than large farmers, unless loans or subsidies are made available to small farmers (Section 7.3.9). Large farms can be important for the production of improved bulls; as a matter of fact, apart from imports these farms are often the only source of such bulls. The availability of these animals is of special importance, because properly functioning AI centres are difficult to organize (Section 7.3.8). Communal village breeding centres are often mentioned as a destination for young bulls from large farms. In this case, a place for the animals must be found in the village and their upkeep must be organized; in many cases this will encounter unexpected difficulties. Sometimes, good results are obtained by stationing the bulls on the premises of the veterinary services (who thereby assume responsibility for these bulls).

7.3 The conditions for the stimulation of milk production

Various conditions should be taken into consideration and fulfilled for the stimulation of dairy husbandry. Some, the 'on-farm conditions and improvements', are mainly or exclusively controlled by the farmer, whereas others, the 'off-farm conditions and improvements', are completely or almost completely controlled by the government and other official authorities. Obviously, the contributions from both sides must be properly attuned. The remainder of this chapter deals with the most important conditions for the stimulation of dairy husbandry.

7.3.1 The milk price

Farmers should receive an attractive milk price to make dairy husbandry attractive (Section 14.1). Special emphasis should be laid on 'receive', because the economic incentive of an inviting price will have little if any effect if too much of this price is taken by middlemen or other third parties (Section 5.2.2).

7.3.2 The market

A market that guarantees an outlet for all milk produced now and in future should exist or be created (Section 11.4.3).

7.3.3 The dairy animal

Before it is decided to introduce a new species or breed of milking animal, the advantages and disadvantages of the existing local animals should be carefully examined. The historical existence of particular species or breeds in a certain area usually has good rea-

sons. These reasons may be based on climatological conditions, availability of feed, what the animals are used for, the way of life of the stock owners, etc.

A change-over to another species or breed of mammal – even if this mammal is expected to be a better milk producer – may interfere in farm management, tradition and social structure.

Too much emphasis is often laid on the genetic quality of the animals, and too little – even apart from the climatological conditions – on environmental circumstances: on the farmer's side the latter include all aspects of management including feeding and health care; and on the government side the supporting agencies, such as extension and veterinary services.

This misplaced emphasis also occurs if the possibilities are examined for upgrading local cattle by cross breeding.

Before it is decided to replace the existing local milking animals by more productive, usually pure bred animals, the following questions should be answered:

- Does the local animal serve a multi-purpose function? And if so, will the animal to be introduced satisfy the multi-purpose requirements in the same way? What will be the consequences if this is not the case?
- Are the conditions of climate, management, feed availability (in short, the environmental conditions) such that the 'new' animal can reach the expected productivity? It should be realized that the introduction of very productive animals will never compensate for poor management and feeding, and health risks; on the contrary! It should also be borne in mind that the introduction of very productive animals usually means higher costs of production (higher investment and higher costs of feeding) and greater risk of disease. Can it be expected that all extra costs incurred will be compensated for by the better performance of the animal, resulting in higher yields, better prices for the offspring, etc.?
- How will the local animal react if it is kept under the conditions of improved management and feeding required by the very productive animal, and how will this animal react if it is kept under conditions that are worse than it requires for its optimal production? Milk yields of local animals often increase surprisingly if the conditions of management and feeding are improved.

Cross breeding

Cross breeding local animals with very productive animals to take advantage of the local animals' better resistance to hardship conditions and of the potential for higher production of the very productive animals only makes sense if:

- The conditions of management, feeding, health care, etc. are sufficient to satisfy the requirements of the crosses;
- The owner is prepared to make investments, to accept a higher risk and to pay the higher costs of raising the crosses. These are serious considerations, because in cattle the possible profit can only be expected after about 4 years, that is at the moment the first female cross-bred cow starts her lactation.
- The owner is convinced that the cross will serve his requirements in the same way as his present multi-purpose animal. For instance, *Bos indicus* cows may especially be kept

for the production of draught animals. Since the hump is considered to be essential for a draught animal, farmers may not accept humpless crosses of local *Bos indicus* cows and exotic *Bos taurus* animals.

- A good breeding programme exists and is controlled. A first-cross cow (F_1) usually has a milk production level that is about equal to the average of the two parent animals, or even higher. The continuation of the breeding programme often presents disappointing results if crosses are continuously back-crossed with the very productive animals. In many cases, the second cross (F_2) will show no or little further improvement, whereas the third cross may already show a regression.

The production level of local animals can be improved by selection for genetic improvement if:

- a good breeding programme exists and is meticulously observed;
- a proper milk-recording and milk-inspection service and some kind of registration system (herd or flock book) is operational;
- bulls for breeding or a properly functioning artificial service system are available;
- no bulls or rams other than those selected for breeding, or only the AI service, should be used.

These four conditions are also applicable to a successful cross breeding programme.

In selection programmes, an improvement of only 1-2% can be expected for every generation. This means that with an average intercalving period of one year, the annual improvement can be 1-2%, but with an average intercalving period of 3 years, this improvement can only be realized in 3 years.

7.3.4 Management

The educational level and the skill of the farmers and the quality of their management must correspond with the anticipated level of animal husbandry. Replacing local poorly productive animals by highly productive ones may cause a serious 'management shock'. This shock is usually less serious in the case of cross breeding than in the case of the introduction of highly productive pure-breds. If a system of genetic improvement by selection is followed, it may be expected that the managing capacity of the farmer will develop concomitantly with the production and the requirements of the animal. However, the educational level of the farmer should be high enough for him to accept and carry out a breeding programme.

7.3.5 Animal health

Animal health services deserve much attention. The introduction of very productive animals increases the risk of animal diseases, because these animals are more vulnerable to diseases in general, and parasites and unhygienic conditions in particular, especially if these animals come from temperate zones, where many diseases of the tropics do not exist or are better controlled.

It may take time to gain the confidence of farmers for the introduction of animal

health programmes. It is not exceptional for farmers to be unwilling to accept the services of veterinarians. Remarks like: 'Don't touch my animal, it's healthy' are heard.

Private veterinarians are often scarce in rural areas, because they prefer to establish themselves in the urban areas. Moreover, their services are generally comparatively expensive, and consequently, only the large, financially stronger farmers, can make use of their services. Governmental veterinary services are often understaffed and short of medicines. Health care made available by cooperatives and farmers' associations has often proved to be more effective than governmental agencies.

7.3.6 Animal nutrition

Ruminants are looked upon as excellent converters of low-quality roughage and agricultural or crop by-products, thus giving value to land not fit for arable farming and products not fit for human consumption. This is correct with respect to feed for maintenance and low production levels. To achieve higher yields in milk production, higher-grade fodder and feed (green fodder and concentrates) must be made available. This creates a number of problems:

- As a result of the increasing growth of the population, more and more 'uncultivated' land will be brought into cultivation for the production of human food, if this is economically viable. This process, is stimulated by the use of fertilizers. It means that less land will be available for grazing, and that this land will at the same time be the poorest land, on which more animals will be concentrated. On the originally arable land, the production of food for human consumption will also have priority and the production of feed for animals will decline.
- Pasture or grazing land is often communal land, and nobody is responsible for its maintenance and no limit may be set to the number of animals that graze this land. This means that the carrying capacity of the land will be exceeded and overgrazing will take place.
- Tropical roughages rapidly decline in quality with increasing maturity. This means that production on tropical grasses will generally be much lower than production on the grasses available in the temperate zones. Dairy cows on good quality grasses in the temperate zones may be able to produce 2500 - 3000 l of milk per lactation, and sometimes even more, without any additional feed (e.g. concentrates). On tropical grasses (and herbs!) the maximum production will be about half this amount (under otherwise similar conditions).
- The animal will generate heat as a result of the digestion of its feed. Under tropical conditions, when the temperatures are high, and especially if the humidity of the air is also high, the animal will have difficulties in dispersing this heat. This limits the animal's ability to digest large quantities of feed; especially roughage, with the result that feed intake drops below the animal's requirements for satisfactory production. This phenomenon is probably the major cause of 'heat stress'. In an effort to solve this problem to a certain extent, animals are fed at night, when it is cooler.
- During long seasonal dry periods, little if any forage will grow and the quality of the

roughage that is still available on the land will quickly deteriorate to the level of 'standing hay'.

If no special measures are taken, the problems mentioned above will result in low production in general and little or hardly any production during long dry periods. These measures include not exceeding the carrying capacity of the land, and producing and preserving high quality roughage and ensuring that concentrates are available.

The supply of concentrates is very important to compensate for the shortage and the poor quality of roughage and the heat stress of the animals. Unfortunately, the supply of concentrates also poses a number of problems:

- Farmers are often not aware of the necessity of feeding concentrates, but if they are, they do not know how much must be given, or they start the feeding too late in the lactation, or they do not feed regularly.
- If milk production decreases during a lactation as a result of temporary poor feeding conditions, it will not recover afterwards.
- Farmers are not knowledgeable about the compositional quality of the feed they have at their disposal nor of that of the feed they must buy in order to prepare a correct feeding programme for their individual animals. Often the composition of concentrates bought at the market is not known.
- The milk price is not high enough to allow for expensive concentrates.
- The farmer has a marginal income and is not prepared to buy extra feed, certainly not if he expects that the benefits will be lower than the costs of this feed. This especially holds if the feed is required during periods that milk production is low and there is hardly any income from milk sales. Sometimes, cooperatives, such as cooperative collection centres or dairy plants, buy feed when it is comparatively inexpensive and sell it at cost price to the farmers during periods of high prices.
- The policy of many governments is directed to the export of concentrates (or the products that serve as raw material for concentrates, e.g. oil-seed cakes) in order to obtain foreign currency, rather than to channeling these products into local animal husbandry, which they profess to be stimulating. As a result, concentrates are scarce and expensive.
- Too often, the small amount of raw material that is made available is used for the production of feed (concentrates) for chicken and pigs, with the idea that milking animals only need grass.

7.3.7 Extension service and training

The stimulation of animal husbandry by the introduction of highly productive animals, improved production methods, etc., will only be possible if the farmer has reached a certain educational level and has acquired certain skills. Training will be necessary in most cases, either in some kind of institution (Section 16) or on his own farm. On-farm training and also the follow-up and guidance after training in an institution requires a properly organized extension service.

7.3.8 Artificial insemination

Artificial insemination (AI) is useful in all sorts of breeding programmes, yet its introduction and execution often meets with resistance. For all sorts of reasons farmers are not immediately inclined to accept this method of insemination, whilst it is common practice not to accept it by putting forward the opinion that it will result in more male than female calves being born. This idea is very persistant and accepted by some as statistically proved. Yet there is no scientific reason for doubting that there is an equal chance of producing a male or a female calf.

AI requires that the animals are meticulously monitored for heat detection and that the AI service is informed immediately once heat has been detected. It has been proven that heat detection under tropical conditions is a major bottleneck. Symptoms of oestrus are more difficult to detect under these conditions, because they are weaker and usually of shorter duration than in the more temperate zones. Buffaloes in heat are especially difficult to detect.

If heat is detected, it may be very difficult to inform the AI service in time if this service is not nearby and the farmer cannot communicate by telephone. One alternative is for inseminators to ride a certain round every day with car or motorbike. This is rather inefficient, and the inseminator is frequently too late. Often, the mistrustful farmer takes the artificially inseminated animal to a bull for mating too! Clearly, this completely undermines the breeding programme.

Sometimes, the calving period is restricted to one or a few months only, in most cases the first months of the rainy season when roughage will be plentiful. As a result, AI is only made available during a restricted period as well. This policy is contrary to the interests of the milk processing industry, which requires a well balanced milk supply throughout the year (Section 8.3.3).

Although the cost/benefit ration of AI is extremely difficult to assess, it is believed that in many cases the costs outweigh the benefits.

7.3.9 Credit and insurance

Credit facilities are often required for the implementation of improvements in dairy husbandry in general and for the purchase of animals in particular.
Bank loans are more likely to be granted to large farmers than to small farmers, because:
- large farmers are considered to be more credit-worthy, because they can give security;
- the costs of granting the usually small credits needed by small farmers are very high and many banks are unable to cope with this problem.

This means that the law of 'economics of scale' will operate. In other words, 'the higher the scale the easier it will be to reach a still higher scale', unless special facilities (e.g. credit cooperatives) are created for granting small credits.

Granting cheap credit for the development of projects deserves much caution. It may disturb the existing 'informal credit circuit', which often functions very well, and it may tempt farmers to alter the priorities in their spending pattern to an extent that is actually

not in their interest.

The incorporation of insurance in projects, to limit the farmers' risks (such as the death of expensive animals) is often forgotten, or simply omitted because facilities are lacking.

7.3.10 Government policy

Stimulation of milk production is a long-lasting procedure and consequently it requires an explicit and consistent government policy (Section 17).

Protection against the importation of cheap commodities (skimmed milk powder and anhydrous milkfat is often advocated (Section 10.4).

7.3.11 Other aspects

Certain aspects other than the ones mentioned above are also important. They include a fair infrastructure and a properly operating milk-collection system.

Further reading

Adams, D.W. et al., 1984. Undermining rural development with cheap credit. Westview Special Studies in Social, Political and Economic Development. Westview Press Inc., London.

Bachmann, M., 1974. Organization of activities in building up milk production in developing countries. In: Proceedings XIX International Dairy Congress (New Delhi), New Delhi, p. 38.

Balch, C.C. & A.J.H. van Es, 1986. Recent advances in feed evaluation and rationing systems for dairy cattle in extensive and intensive production systems. International Dairy Federation, Bulletin 196.

Barret, M.A. & P.J. Larkin, 1974. Milk and beef production in the tropics. Oxford University Press, Oxford.

Crotty, R., 1980. Cattle, economics and development. Commonwealth Agricultural Bureaux, Farnham Royal.

Crowder, L.V. & H.R. Chheda, 1982. Tropical Grassland Husbandry. Tropical Agriculture Series. Longman Group Ltd., London.

Devendra, C. & G.B. McLeroy, 1980. Goat and sheep production in the tropics. Intermediate Tropical Agricultural Series. Longman Group Ltd., London.

FAO/CARIPLO, 1975. Agricultural credit for development. World conference on credit for farmers in developing countries. FAO, Rome.

Gravert, H.D., 1987. Dairy-cattle production. World Animal Series. Elsevier Publishing Co., Amsterdam.

Hendry, P., 1987. Legislation seeks to reduce livestock pressure. Ceres 20(3):3.

Holmes, C.W. & G.F. Wilson, 1984. Milk production from pasture. Butterworths of New Zealand Ltd., Wellington.

Humphries, L.R., 1987. Tropical pastures and fodder crops. Intermediate Tropical Agricultural Series. Longman Group Ltd., London.

IDF, 1987. Dairy development in East Africa, milk production. International Dairy Federation, Bulletin 221.

Kearl, L.C., 1982. Nutrient requirements of ruminants in developing countries. International Feedstuffs Institute, Utah.

Lindley, E.P., 1978. Maintenance of health. In: G. Williamson & W.J.A. Payne. An introduction to animal husbandry in the tropics (3rd. ed.). Tropical Agricultural Series. Longman Group Ltd., London, p. 29.

Lindström, U.B., 1976. Milk recording in developing countries. FAO World Animal Review 19:34.

Mason, I.L. & V. Buvanendran, 1982. Breeding plans for ruminant livestock in the tropics. FAO Animal Production and Health Paper, No. 34. FAO, Rome.

Maynard, L.A. et al., 1979. Animal nutrition (7th. ed.). McGraw-Hill Publishing Co. Ltd., New York.

Nyholm, K. et al., 1975. Dairy development in South India. FAO World Animal Review 15:14.

Ristic, M. & I. McIntyre, 1981. Diseases of cattle in the tropics. Martinus Nijhoff Publishers, The Hague.

Smith, A.J. (Ed.), 1985. Milk production in developing countries. Proceedings of the conference for tropical veterinary medicine. Centre for Tropical Veterinary Medicine, University of Edinburgh, Edinburgh.

Schmidt, R.H. & E. Kropp, 1987. Rural finance: guiding principles. Rural Development Series. Bundesministerium für Wirtschaftliche Zusammenarbeit, Bonn.

Timon, V.M. & J.P. Hanrahan (Ed.), 1986. Small ruminant production in the developing countries. FAO Animal Production and Health Paper, No. 58. FAO, Rome.

Velarde, R., 1981. Management of milk production systems in the tropics (In Spanish: Manéjo de sistemas de producciòn de leche en el Tròpico. Serie Materiales de Enseñanza). Centro Agronómico Tropical de Investigación y Enseñanza, Turrialba.

Williamson, G. & W.J.A. Payne, 1978. An introduction to animal husbandry in the tropics (3rd. ed.). Tropical Agricultural Series. Longman Group Ltd., London.

8 The desirability of establishing dairy plants

Although there are numerous (mostly small-capacity) dairy plants where dairy products are produced without heat treatment of milk, this section will deal solely with those plants in which the milk receives a heat treatment before or during processing. If properly performed, such a treatment is of great importance, because:
- all pathogenic bacteria and viruses are killed, making the milk and the milk products safe for consumption;
- the keeping quality of the milk and the milk products will be improved, because all or most of the deleterious micro-organisms and enzymes are destroyed;
- characteristics essential for the quality of the product can be obtained.

Urbanization opened the way for the establishment of dairy plants in most of the tropical and subtropical countries. It was no longer possible to satisfy the milk needs of the densely populated areas in the traditional way, because:
- Milk and milk products had to be procured over long distances. This required complicated distribution systems.
- A higher standard of living and the awakening desire for better and more hygienic products created a market for industrial products. In most cases it also necessitated the packaging of the products.

On the other hand, many consumers were reluctant to accept the 'new' products as a result of unfamiliarity and suspicion, and it often took a long time before consumers fully appreciated the new developments.

8.1 The purpose of establishing dairy plants

Dairy plants are established to:
- supply the population with high-quality liquid milk (consumption or liquid milk) and milk products;
- create a market for fresh milk, thus supporting the rural milk producers.

Apart from the main objectives, a number of 'side effects', may play a decisive role. They include:
- the establishment of a dairy industry creates employment;
- the establishment of a dairy plant often stimulates industrial development in the area.

8.1.1 Milk plants

To achieve the first objective, city milk plants are established in or near densely populated cities. These plants mainly produce pasteurized or sterilized milk, cream and fresh milk products, like yogurt and other fermented liquid milk products. Surplus fat can be used for making butter and surplus milk for the production of fresh cheeses, such as cottage cheese. The supply of sufficient quantities of fresh milk to meet the demand of the plants often creates severe problems. For this reason, many urban milk plants partly depend on the supply of skimmed milk powder and anhydrous milk fat for recombining (Section 10).

8.1.2 Dairy factories

The second objective is achieved by establishing dairy factories in rural areas, where large amounts of milk are produced and no sufficiently large markets for liquid milk and fresh milk products exist. Therefore, dairy factories should principally specialize in the manufacture of milk preserves, like butter and cheese, and if the supply of milk is sufficiently large, also in milk powder and perhaps condensed milk. These products are less perishable and consequently they can be distributed over larger areas and be stored for longer periods. Moreover, they are less bulky than milk, which facilitates distribution and storage. However, if there is a good infrastructure, it may be preferable to produce liquid milk and fresh milk products in rural areas and to transport the products to distribution centres in or near the densely populated consumption areas. In this way, one rural milk plant can serve more than one city (Section 11.4). The introduction of long-life (UHT) products in one way-packages has facilitated the distribution of milk over long distances without the necessity for expensive cold chains.

8.2 Availability of milk

8.2.1 The amount of milk produced

Before a dairy plant is established it is important to know how much milk is produced in the area serving that plant. If statistical information is unavailable or unreliable, it may be found extremely difficult to make proper estimations. Sometimes, veterinary services have records of the numbers of animals treated in vaccination programmes. If these figures are available for various categories of animal, the numbers of milking animals may be known. Otherwise the number of milking animals has to be estimated as a percentage of the total dairy herd. This percentage depends on the species and the principal use of the animal, e.g. the percentage will be much higher in specialized dairy herds than in all-purpose herds where the animal is mainly held for meat, wool, draught or investment. If all else fails, it can be assumed that on mixed farms 40% of cattle are milking animals. Assumptions for other species are difficult to make.

The statistics on numbers of animals supplied by the veterinary services may be lower

than the actual numbers, because not all farmers offer their animals, or all their animals for vaccination. This can be explained by lack of interest or tax evasion.

Knowing the number of milking animals and their average milk yield, the total milk production in the area can be calculated by multiplication. Various aspects should be taken into consideration if milk production is calculated in this way, e.g.:
- milk yields are usually given per lactation period and the inter-calving period must be included in the calculation;
- milk yields per animal often do not represent the average yield of the farm animals, because the data have been supplied by research stations or large farms where conditions of animal husbandry are better than on small local farms;
- although lactation periods may be much shorter, yields may be converted into yields per standardized period of e.g. 300 days.

8.2.2 The amount of milk available for sale

Although it is important to know how much milk is produced in a certain area, and even more important to know the production potential (i.e. the amount of milk that can be produced if the milk can be sold for an attractive price) the amount of milk that is available for marketing is another matter. This amount can be far less than the production (Table 9). Some of the reasons are:
- Although the total milk production in a certain area is considerable, the milk production per family is low, so little milk is available for sale if the family is in the habit of consuming milk. The latter is not always the case.
- Some of the milk will be used to feed young stock. Sometimes, the feeding of young stock is found more important than the sale of milk, whereas on other occasions calf

Table 9. Estimation of the annual milk production and milk availability for marketing. Hypothetical example for cow's milk.

Total number of animals		100 000
Number of milking animals (40%)		40 000
Inter-calving period 3 years; number of cows in lactation		13 500
Recorded milk production on institutions:	1500 l/lactation	
Actual milk production at farm level:	1000 l/lactation	
Milk for calf and family:	300 l/lactation	
Available for marketing:	700 l/lactation	
Total annual availability for marketing	(13 500 x 700)	9 450 000 l
Average amount available daily for marketing		26 000 l
If the long inter-calving period and the milk consumed by the calf and the family are not taken into consideration, and the recorded production figure of the institution is used, the amount available daily would have been estimated at about		164 000 l

mortality is high because too much milk is consumed by the owner and his family, or too much is sold.

It is often believed that the amount of milk that is available to the farmers to sell will be equal to the amount of milk that can be bought by a dairy plant. This is a serious mistake. In many cases it has been found that the amount of milk that is offered to the plant is merely a small percentage of the milk available on the farms, especially during the first years of operation of a plant. There are a number of reasons:

- There may be strong competition in the raw-milk market and the milk producers are reluctant to sell the milk to the newly established dairy plant, because:
  - traditional marketing channels are strong and farmers are unwilling to break them off on behalf of a new plant;
  - the new plant's motives are viewed with suspicion; this may especially be the case if the staff of the plant come from 'elsewhere';
  - the farmers have accepted advance payments from milk dealers – middlemen – and are not free to sell their milk to the dairy plant (Section 5.2.2);
  - milk dealers are often able to pay a higher price than a milk plant, because they sell milk directly to the consumer, without the costs of processing, and with the possibility of adding water, thus making an extra profit.
- Farmers may not sell milk for religious reasons.
- Farmers may object to the standards of quality set by the dairy plant, or may not agree with certain regulations of the plant, e.g. that all milk supplied must be cooled.
- Milk is not reguilarly available in the collection area of the plant, either as a result of seasonal fluctuations in production (Section 8.3.3) or because of the nomadic life of the owners of the milking animals.
- Milk collection is hampered by a poor infrastructure.

From what has been said, it must be concluded that it is vital to carry out detailed field surveys and proper marketing analyses before it is decided to establish a dairy plant, and before a decision is made about its capacity. It is equally important to carry out market research on the products to be made by the plant and the sales potential of these products (Section 11.3). It is also important to investigate future developments in milk availability and sales potential. The magnitude of a spontaneous increase in milk availability as a result of increased milk production after the establishment of a dairy plant should not be overestimated. There are many examples of the actual increase remaining far behind the expected increase. The milk plant should have an 'over-capacity' in the beginning, in order to be able to process the expected increase in the years to come. The magnitude of the initial 'over-capacity' depends mainly on the speed and the extent of the increase in milk intake. Planning the capacity too high will mean costs of depreciation, interest and maintenance that are too high. This means that the processing costs will also be higher than necessary. Planning the capacity too small will mean that processing facilities will have to be extended at an early date (Section 11.4).

Sometimes a question mark is placed against the desirability of starting milk collection in the vicinity of cities with the objective of supplying city milk plants, because:

- Raw milk is almost always expensive in these areas; the plant has to compete with pri-

vate milk dealers who can pay a high price. If the milk plant competes successfully against private milk dealers, it is because it pays a high price for raw milk.
This means that:
- There will be a general increase in the price of milk and milk products, because the products of the plant will be expensive after processing. Consequently, the plant only serves the higher income groups, whilst less cheap milk will be available for others.
- Many traditional milk dealers and distributors will cease operations, thus losing their source of income.

Therefore, many believe that the competition in the raw-milk market around urbanized areas should be avoided as much as possible and that urban milk plants should try to collect milk in more remote agricultural areas, which are too far away for collection by city-milk dealers. Generally, the raw-milk prices in these areas are lower, unless milk is collected by local industries. Cost price analyses must be done to ascertain whether the extra costs of milk collection, milk cooling and milk transportation, which are usually very high, will be outweighed by the lower milk price in the rural areas. An increase of throughput of the city milk plant as a result of large amounts of milk from rural areas will lower the operating costs of the plant.

8.2.3 The lean/flush ratio of milk production

In most countries, and especially in countries with a developing dairy industry, milk production shows considerable seasonal fluctuations. During the flush season the production is high because the conditions are favourable; during the lean season it is low because the conditions are poor. The availability of sufficient feed is one of the major factors determining the level of milk production. Since under conditions of poor management the animals are almost completely dependent on natural grazing on pastures, on fallow land and anywhere else where green roughage is found, the production is highest in the 'green season'. Therefore, it will be highest during the months of moderate temperatures and/or the months with sufficient rainfall. This means that milk production will be low during cold winters and during hot and dry seasons. During periods of low milk production and shortage of milk, prices may rise steeply and milk producers will be inclined to sell the milk to the highest bidder. Since dairy plants are often bound to a rather strict and non-flexible system of price setting, suppliers may stop their deliveries to the dairy plant and switch to other marketing channels. Some milk cooperatives insist that their farmers deliver all the milk they produce. In practice, it has been found extremely difficult to enforce such an obligation. On the other hand, during the flush season there may be a surplus. Farmers who do not normally supply the plant, may meet difficulties in selling their surplus milk or even the whole amount of it through their usual channels. As a result, they may supply this milk to the dairy plant. An official (government or semi-government) dairy plant is expected to accept all milk offered. The same applies to cooperative plants, as far as their members are concerned. This actually means that the lean/flush ratio of milk intake may even be worse than the ratio of milk production.

The dairy plant must be planned to cope with the maximum quantity of milk that has

to be processed on any day of the year, which depends on:
- the lean/flush ratio of milk intake;
- the amounts available on days following 'non-working days', such as holidays and commemorative days when milk may be received but will not be processed.

Figures 16 and 17 show examples of the monthly milk intake of an African and an Asian dairy plant (A and B, respectively). In each of the diagrams, the monthly amounts of milk are given as percentage of the average monthly intake.

$$\text{Monthly intake} = \frac{M}{A} \times 100$$

in which:
M = total milk intake in one particular month,
A = average monthly milk intake (annual intake divided by 12).

It can be seen that the monthly variations of plant A (Figure 16) are very small, but that those of plant B (Figure 17) are considerable (although not unusual).

Because of the variations in milk intake, dairy plant B must have a theoretical capacity that is about 70% higher than the average intake, whereas in the month of lowest intake only about 25% of this capacity will be used.

One way of reducing the disadvantages of seasonal variations is to operate in one shift (that is about 8 hours daily) during the lean season and in two shifts (that is twice 8 hours daily) during the flush season. This means that two shifts of operators and labour are required during the flush season. Whether a higher investment (one shift) or higher labour costs (two shifts) are more economical and acceptable depends on local conditions. Whether it is advisable to employ labourers during only part of the year, or whether they should remain on the pay roll, even if there is not sufficient work, is a social and technical problem. Moreover, it is sometimes extremely difficult to find sufficiently trained and skilled operators to man two shifts, especially if they are only employed for a few months in the year.

The demand for liquid milk and fresh milk products is relatively constant throughout the year. Since the keeping quality of these products is limited, milk plants, especially city milk plants, require a fairly constant supply of milk from day to day. It is only possible to increase milk sales and expand the group of customers if there is proper sales promotion and a sufficient supply of high-quality products. This objective will be thwarted by seasonal milk shortages. On the other hand, a city milk plant may find it extremely difficult to dispose of a surplus, as discussed in Section 8.2.5.

Rural dairy factories are less vulnerable than urban milk plants, because they produce products that can be stored for sale during the lean season.

A regular supply also depends on local conditions, because under certain circumstances, milk production and/or milk collection will not be possible for part of the year.

There are several possible ways of overcoming the disadvantages of a poor lean/flush ratio, which will be discussed in the next sections.

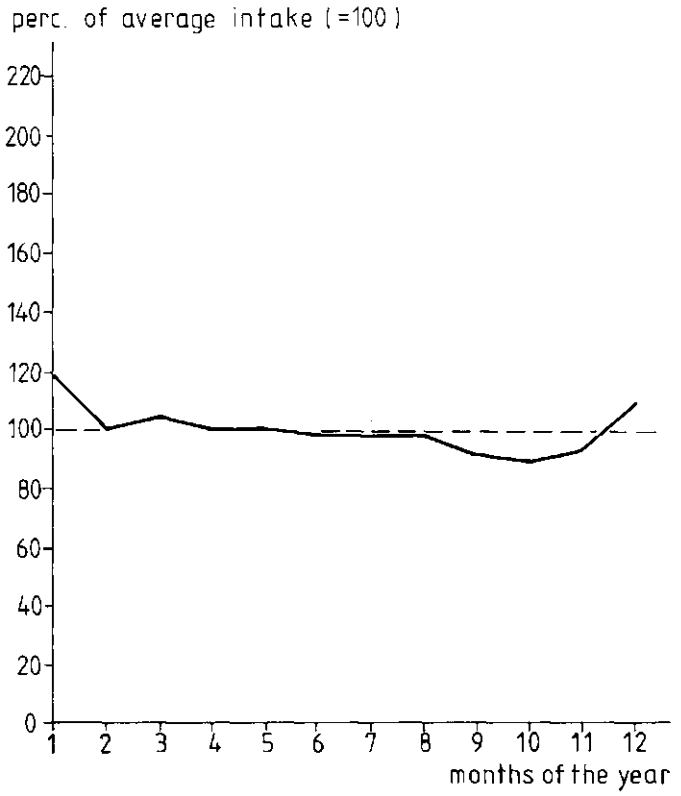

Fig. 16. Diagram of monthly milk intake of an African dairy plant (A).

8.2.4 Stimulation of milk production in the lean season

To improve the lean/flush ratio of milk, the milk production and the milk supply in the lean season should be stimulated. Although this seems to be the simplest way, in practice it is often very difficult to realize. It must be carefully considered whether the efforts to promote milk supplies in the lean season are economically justified, although the continuation of a regular supply of milk throughout the year may be of decisive importance for a milk plant. The better service to the consumer in the form of a regular supply of milk and fresh milk products cannot be expressed in terms of money.

The principal methods for the promotion of lean season milking are a combination of efficacious propaganda with an intensively operating extension service and a proper system of price setting. Price differences between lean and flush season should encourage milk delivery during periods of short supply. The price difference should be high enough not only to cover the extra expenditures of milk production, mainly costs of feeding, but also to reward the farmer with a premium for his extra efforts. The higher price paid by the plant and the costs of other actions should be covered by the economy resulting from a better lean/flush ratio.

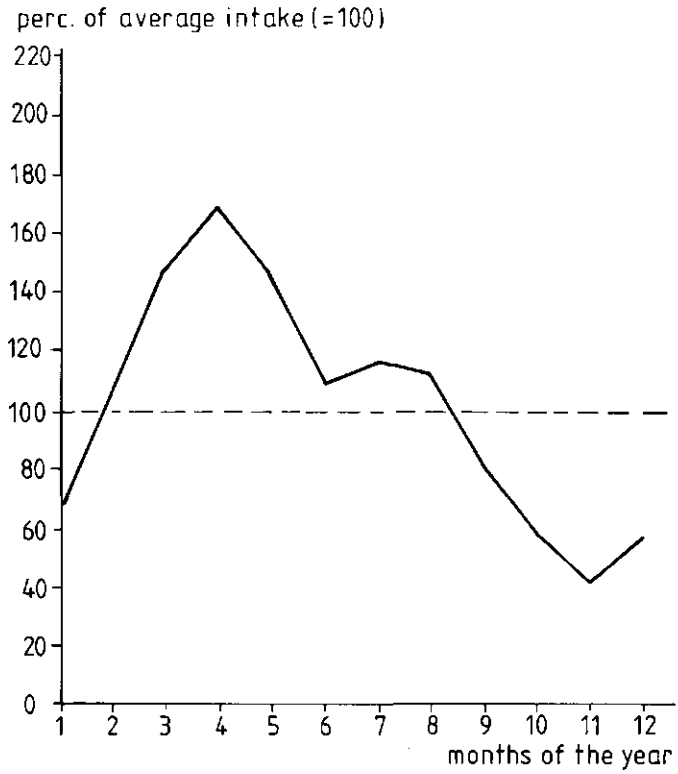

Fig. 17. Diagram of monthly milk intake of an Asian dairy plant (B).

If the lean/flush ratio is unfavourable, a considerably higher price may be paid in the lean season, without affecting the average annual price too much (Table 10), but the difference in price between lean and flush seasons will have an important psychological effect. If the milk supply in the lean season increases gradually, and there is a corresponding decline in the flush season, the usual annual increases in milk price can be mainly used to maintain the price difference.

As mentioned before, official and semi-official milk plants and co-ops (as far as the members are concerned) are 'morally' obliged to accept all milk offered in the flush season, even if the milk is actually in surplus and a dairy plant may find it difficult to find an appropriate use for it. Such milk surpluses may depress the revenue of the plant. This may result in lower proceeds from the milk and a lower milk price to all farmers. To prevent farmers with a well balanced lean/flush ratio of milk supply from suffering from farmers with a poor ratio and to encourage milk production in the lean season, the possibility of introducing two milk prices in the flush season could be considered. The 'normal' milk price will only be paid for the amount that corresponds with the amount supplied in the lean season. A lower milk price, corresponding with the value of the surplus milk will be paid for any milk over and above this amount (Table 11).

Table 10. Arithmetical and weighted average milk price.

Season	Amount of milk (kg)	Price per kg milk supplied (CU)	Money received for milk (CU)
Lean	25	15.0	375
Flush	100	10.0	1000
Total			1375
Average price:			
- arithmetical		12.5	
- weighted		11.0	

The system is complicated, but it guarantees a fair price setting, it may stimulate milk production in the lean season and may prevent the milk plant from being used as a reservoir for all surpluses in the flush season.

Although price differentiation is justified from the point of view of economics, such systems may be rejected on grounds of social considerations. Small farmers with little financial clout often depend completely or to a large extent on the seasonal production of green fodder and on the availability of agricultural by-products. During the season that little or no fodder is available, the animals are poorly nourished and milk production is minimal, the farmer having no money to purchase additional feed.

Compared with small farmers, large farmers are generally in a better position to purchase extra feed and concentrates or to make investments for feed preservation and other improvements required for milk production in the off-season. Thus they will benefit more from price differentiations than the small farmers.

Sometimes, dairy plants try to bind farmers by lending aid and services. Farmers who supply milk to the plant could be provided with feed, especially concentrates, at cost price, if necessary on credit (Section 7.3.6). This may at the same time improve the feeding of the animals and may promote milk production in the lean season. There could be a correlation between the amounts of feed that can be bought at low (or even subsidized) prices and the amount of milk supplied to the plant.

Table 11. Milk price based on the ratio of lean / flush milk supply.

Farmer	Daily amount in lean season (kg)	Daily amount in flush season (kg)	Amounts (kg) in flush season receiving	
			normal price	lower price
A	150	200	150	50
B	10	100	10	90

Other services could be veterinary assistance, extension and AI.

Making AI services available during a certain period of the year only (Section 7.3.8) is contrary to the aim of achieving a properly balanced milk supply throughout the year.

8.2.5 Extra processing facilities

City milk plants receiving too much milk may establish processing facilities for the manufacture of products other than liquid milk and fresh milk products, e.g. for butter or cheese, and if large amounts of milk are available, for milk powder and even condensed milk. In the event of seasonal surpluses, such industrial dairy products will be produced in the flush season only, after which they can be sold when and where prices are most profitable. The cost price of such products produced by city milk plants is often higher than that of the same products produced in the typical rural dairy plants because:

- the raw milk price in the collection areas of city milk plants is usually higher;
- labour costs and some other production costs may be higher in urban areas;
- the extra processing facilities of the city milk plants are used for short periods of the year only.

It is often believed that the use of these surpluses for the production of ice cream is very lucrative. Although this may be true under certain circumstances, one should be very careful in this respect because:

- ice cream is a luxury product; only the 'well-off' can afford to buy the product, so the market is limited;
- the product will have competition from cheaper edible ices, such as 'water ice';
- marketing expenditures are high, because an expensive cold chain is required, not only during transportation, but also at the sales points.

The production of sterilized milk instead of pasteurized milk will not solve the problem of storage and surplus. Sterilized milk in paper packs (UHT milk or 'long life milk') has a better keeping quality than pasteurized milk and can be kept without cooling, but not for an unlimited time.

Sterilized milk in bottles has an almost unlimited keeping quality (from a bacteriological point of view), but the storage creates problems. The numbers of bottles and the space required for storage are enormous, and the consequences of the sterilized milk not being fully sterile are mind-boggling.

8.2.6 Feeder-balancing dairy plants

The establishment of a system of feeder-balancing dairy plants can greatly solve the problem of city milk plants. In such a system, a city milk plant closely collaborates with one or more rural dairy plants. If there is a milk shortage, the city plant will receive milk from the rural plant(s), whereas during periods of surplus the city milk plant will send the surplus to the rural plants. If there is more than one rural plant and there is sufficient milk, the plants may specialize in certain products and the milk may be directed to the plant making the most profitable products at that moment. This can best be achieved by a

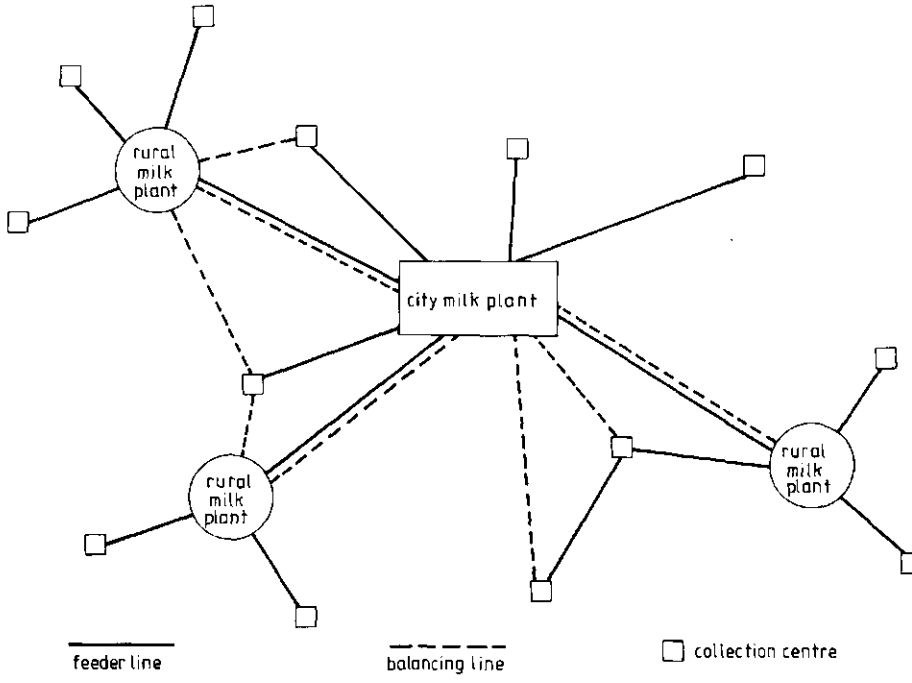

Fig. 18. Feeder-balancing system for a city milk plant.

complete integration of the plants. As shown in Figure 18, milk from favourably situated collection centres can be sent directly to the plant where the milk will be processed.

Sometimes, milk plants try to collect milk in the lean season in remote pockets of milk production, without taking the milk in the flush season. Objections could be made to this mode of action if there is no market for the milk in the flush season in those areas.

8.2.7 Milk powder as a substitute

Milk powder and, if necessary, anhydrous milk fat, can be used as a substitute for fresh milk during periods of shortage (Section 10).

8.2.8 Stimulating milk production without improving the lean/flush ratio

Stimulating milk production as such does not always give a satisfactory solution to the problem of milk shortages. In Figure 19, where the same milk intake is plotted as in Figure 17, it is shown that such efforts may fail if shortages are not permanent but merely seasonal. If dairy husbandry expands, as can be achieved by increasing the number of milking animals or replacing poorly productive animals by highly productive ones, without spreading the calving period more evenly over the year, the milk production will increase in a lean/flush ratio identical to the existing one. This is shown in the figure,

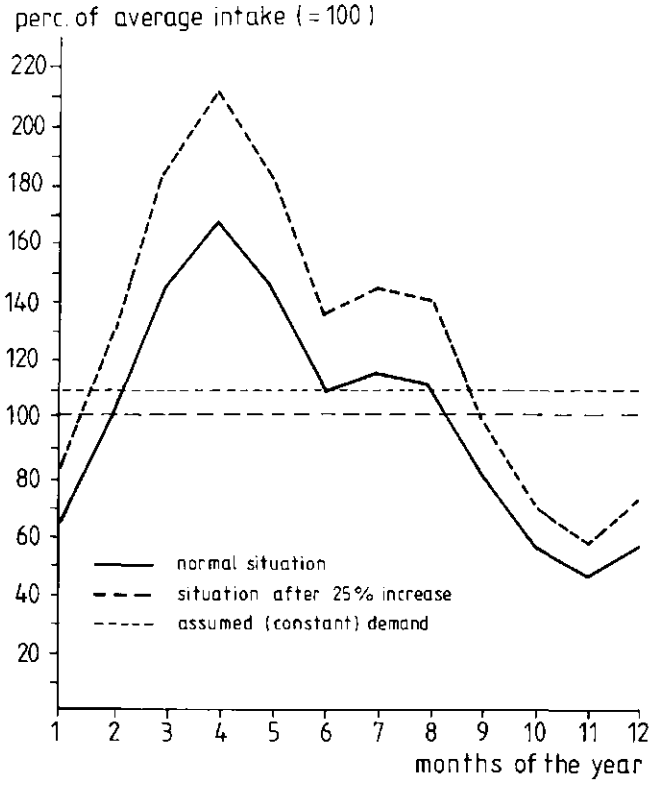

Fig. 19. Influence of increased milk production on monthly availability of milk.

where a 25% increase is assumed throughout the year. Such an increase will result in a higher surplus in the flush season, whereas the shortage in the lean season will be solved insufficiently, if at all. If the low milk production in the lean season is caused by feed shortage, the situation may even be worse than shown in the example, because more animals have to be fed with the same amount of feed. Since there are more animals, more feed will be needed for maintenance in the lean season, with the result that less feed will be available for milk production. Expansion of the dairy industry should go hand in hand with promotion of milk production in the lean season.

Further reading

Bachman, M., 1979. Adapted techniques for the collection, processing and marketing of milk in developing countries. Milchwissenschaft 34: 267, 538.

NDDB, 1984. Milk and technical inputs manual. National Dairy Development Board, Anand, India.

See also 'Further reading' Section 11.

9 Milk collection

9.1 Organizing milk collection

Milk can be taken to the dairy plant by the farmers themselves, or it can be picked up by the plant at the farm or at certain collection points. Which system is preferred will largely depend on local conditions. Farmers who bring their milk to the plant (Figure 20), may expect to obtain a higher price than farmers whose milk is picked up, because the plant is spared the expense and problems of collection. Farmers' willingness to take the milk to the plant varies greatly. In certain areas they may be prepared to walk an hour or longer with their milk, whilst in other areas a distance from over 10 minutes seems to be unsurmountable. This is not only a matter of mentality, but also depends on the importance of dairy husbandry in comparison with the total farm activities and the amount of milk available for sale. Sometimes, farmers organize a system for collective supply of milk to the dairy plant. They may establish a cooperative, equipped with one or more vehicles, which will also be used for other purposes, such as distribution of feed and fertilizers and the collection and transportation of other agricultural products. It is also possible to entrust the collection of milk to third parties. Sometimes, one farmer undertakes to transport his neighbours' milk together with his own milk. In this case he will expect his neighbours to remunerate his activities. In many cases, such farmers actually act as middlemen; they are in a strong position.

The organization of the milk collection by the dairy plant itself has the advantage that the plant has full control of running the collection according to a certain time schedule. Since, on the one hand milk is a very perishable product, whilst on the other hand the plant has to keep to a certain work programme, it is very important that the milk is picked up at the farm on time and delivered at the plant on time. However, organizational problems and the high costs of collection (especially if no employment can be found for manpower and material outside the time of collection) discourages many plants from setting up their own collection system.

The costs of milk collection depend on various factors, such as:

- the milk density, that is the amount of milk produced per square kilometre;
- the average amount of milk offered by every farmer;
- the distance of the collection area from the plant;
- the total distance the collection vehicles have to drive (i.e. distance between farms);
- the necessity of establishing collection centres;
- the capacity and the number of centres and the necessity of cooling the milk in these centres;

Fig. 20. Queuing up for milk delivery at the collection point (China). Photo: M.A. Luijkx.

- the infrastructure of the area, especially the quality of the roads.

The costs of milk collection vary enormously, but they easily amount to 10% of the milk price and may go up to 25% under unfavourable conditions.

To avoid complications and high expenditure on milk collection, many plants contract out the collection and transportation activities to third parties, in most cases professional transporters. This, however, carries a certain risk if there are several dairy plants or other potential purchasers in the area. As a result of their daily contact with the representative of the milk-transport service, the farmers are under the impression that they supply the milk to this representative rather than to the dairy plant, especially if the plant also entrusts the delivery of the 'milk money' to the transport service. If this service makes a contract with another plant or buyer, few objections are to be expected on the farmers' part if the milk of the particular collection round is taken to the new buyer. But the 'old' buyer will lose part of his original milk intake. The same risk exists – and to an even larger extent – whenever a plant buys milk from independent milk collectors or middlemen. Plants may be inclined to buy milk from such persons, because this is often the easiest or only way to obtain a share in the raw milk market.

Although it may sometimes seem to be unavoidable to make use of the services of col-

lectors (even if these are farmers themselves) and middlemen or other third parties, direct contact between the dairy plant and the farmers should be preferred. If no such contact exists, the dairy plant has no guarantee that the farmers will receive a reasonable price. Often, middlemen and other collectors deliver the milk in bulk to the plant. In this case it is very unlikely that efforts of the plant to improve the quality of the milk of the individual farmers by the introduction of a system of payment for quality will have any result.

The cost of milk collection can be borne by the plant, or can be charged to the farmers, either depending on the quantity of milk or on the distance of collection, or on a combination of these two. The system whereby the total costs of a collection round are allocated to the farmers in proportion to the milk they supply, will discourage milk production in the lean season. Farmers who take pains to supply milk in the lean season will be heavily charged if the total amount collected is small.

It is generally considered incorrect to make the chargeable contributions for collection dependent on the distance over which the milk must be collected and transported.

The quality of all milk should be tested for acceptability. Milk of apparently acceptable quality at the moment it is picked up, may spoil during long collection rounds and reach the dairy plant in a regrettable state. Extremely unpleasant conflicts may arise between the plant and its suppliers if the milk is rejected in such a situation if the plant is responsible for the collection. Therefore, it may be worth considering checking the quality of the milk at the point of pick-up instead of at the reception dock of the dairy plant or collection centre. In this case the risk of spoilage during collection must be taken by the plant.

9.2 The acceptability of milk

The quality of milk offered to dairy plants is often disappointing, either as a result of lack of skill or simply as a result of negligence. This is especially true for farmers in the subsistence sphere, where the milk – if there is any – is consumed shortly after milking, or is sold directly to the consumer, who boils it immediately. If such milk producers start supplying milk to collectors or to the milk-processing industry, it may turn out that they are completely unaware of hygienic milking and milk handling.

The large variety of unsuitable containers that are often used for milk, like wooden buckets, calabashes, kerosine tins and milk cans that are not seamless, largely contribute to the poor quality of milk, especially because these containers are not and cannot be properly sanitized.

A clear perception of the hygienic quality of the milk can only be obtained after several long-lasting laboratory tests are performed (Section 13.4). It is not possible to perform such tests before it is decided whether or not the milk can be accepted. It is only possible to sort out milk that is too poor for processing. This is done with 'platform tests'[1], which give an immediate result, so that the operation of the milk reception at the collection

[1] The sanitization of equipment and the performance and interpretation of platform tests is comprehensively discussed in the companion volume 'Dairy technology in the tropics and subtropics'.

point is not interrupted. These tests examine the milk for:
- acidity,
- smell,
- abnormalities,
- density.

Acidity
Milk of above-normal acidity is not fit for the production of high-quality milk products. Since tests to ascertain of the exact acidity cannot be carried out at the milk reception, tests that enable milk that exceeds a certain acidity to be sorted out are administered. These tests are the alcohol test and the clot-on-boiling test.

For the alcohol test, equal volumes of alcohol and milk are mixed. Depending on the strength of the alcohol, milk with an acidity higher than a certain limit will clot. Usually, 68% alcohol is used. However, not all kinds of milk are equally suitable for this test.

In the clot-on-boiling test a small amount of milk is boiled. If the milk curdles, it is not fit for pasteurization or sterilization.

Smell
Milk may acquire off-flavours from strongly-smelling materials, either by direct absorption or by indirect transfer through the body of the animal. Bacterial activity may be another cause of objectionable flavours. At the milk reception a flavour test can be performed by smelling the inside of a milk can immediately after the lid has been removed.

Abnormalities
All milk should be checked for abnormalities, such as abnormal colour, caused by blood (red) or large quantities of dirt (greyish), and a high viscosity or destabilization (sweet or acid curdled milk).

Density
The density of milk is often used to test whether milk has been adulterated by the addition of water. Water added to milk lowers the density. Milk is often considered to be adulterated if the acidity is lower than 1.028. However, the result of the test is not reliable (Section 13.3.2).

Poor-quality milk which is rejected may enter the market along other channels, thus competing with the products from the dairy plant. Sour milk – for instance – may be neutralized and sold on the doorstep as fresh raw milk. It is often suggested that such milk be denatured at the reception dock, for instance by administering powdered charcoal or grass meal. It is questionable whether this is legally acceptable. Another option could be to accept such milk at a much lower price and to use it for the manufacture of ghee or other (in this case, low - quality) products.

Fig. 21. Milk collection with a milk pick-up truck. Photo: M.A. Luijkx.

9.3 Collection and chilling centres

It is troublesome to collect milk in areas far from the dairy plant and to take it directly from individual farmers to the plant. It is better to take the milk to one central point first, especially if there are many small suppliers. The milk will be transported to the plant from this point. Such a point could be merely an open spot along the roadside (Figure 21), or a real collection centre. The latter consists of a building with collection equipment, and – if necessary – cooling facilities. It can be supervised by permanent or part-time staff.

Collection centres may even be established in the vicinity of a dairy plant if there are many suppliers and they produce small amounts of milk. In this way, congestion at the dairy plant can be avoided.

Even if milk collection is properly organized and road conditions are good, the radius of an area of collection should not exceed 10 km, otherwise it will take too long for the milk to reach the place where it is cooled or processed. The time of collection can be speeded up if the farmers take the milk to collection points, from where it is transported to the central chilling or processing centre.

If milk has to be transported over long distances, or better said, if it will take a considerable time after milking before the milk reaches the plant, it is advisable to cool it as soon after milking as possible. It is difficult to say how quickly milk must be cooled or processed after milking to avoid spoilage. It depends on the initial hygienic quality of the

Table 12. Theoretical example of the development of bacteria with generation times of 20 and 60 minutes.

Time after the logarithmic phase of massive reproduction started (min)	Number of bacteria	
	species with a generation time of 20 min	species with a generation time of 60 min
0 min	1	1
20 min	2	
40 min	4	
60 min	8	2
1h 20 min	16	
1h 40 min	32	
2h	64	4
3h	512	8
4h	4 096	16
5h	32 768	32
6h	262 144	64
7h	2 000 000	128
8h	16 000 000	256

milk and the generation time of the bacteria, i.e. the time a certain bacterium or strain requires to double its number. This, in turn, depends on the type of bacterium and the environmental conditions, mainly the temperature. Table 12 gives a hypothetical example. If conditions of growth are favourable, the rapid growth starts after two hours. Consequently, to be on the safe side, an attempt should be made to cool milk produced under tropical and subtropical conditions within two hours after milking.

The milk can be cooled on the farm, but in most cases the amounts involved are too small and the costs would be too high, and therefore centralized cooling in cooling centres is preferable. The type of cooling centre depends on the amount of milk to be handled and can range from a very simple structure managed by a part-time supervisor to a building with a manager and labourers.

Before the capacity of the centre is decided, careful surveys should be done to ascertain the present and expected future availability of milk. The costs of running a centre are high and it should be avoided that centres operate far below their capacity for long periods. Sometimes, it is advisable to start with a modest centre with simple equipment and extend the centre as the intake increases. The simple equipment can be moved to other areas where a collection system is being introduced[1].

In simple centres, milk will usually be cooled in cans (churns) either by the use of immersion coolers, by inserting the cans in a tank with ice water or by pouring the milk over an open cooler and collecting it in cans again. The various systems have their

[1] Topics relating to the keeping quality of milk are comprehensively discussed in the companion volume 'Dairy technology in the tropics and subtropics',

advantages and disadvantages. A typical disadvantage of storing milk in cans is the fairly rapid increase in temperature after cooling. This can be prevented by putting the cooled milk cans in a tank with ice water or in a refrigerated room or cold store. Protection against increases in temperature can also be provided by placing insulated domes over the cans. Insulated cans slow down the increase in temperature but do not protect the milk for a long time. Cans of milk placed in the open air should always be protected against direct radiation of the sun by a covering shed.

In the larger centres a farm tank cooler may be used. The farmers pour the milk into the tank, where it is cooled. It takes some time for the milk to cool in such a tank, but if absolutely necessary, the process can be speeded up by installing an open cooler on top of the tank.

High-capacity cooling centres should have an open cooler over which the milk is poured, or a more modern tubular or plate heat-exchange cooler, through which the milk is pumped. The milk will be stored in a separate insulated tank.

It may be worthwhile equipping the centres with facilities for cleaning the emptied milk cans, although this will increase the costs of operation considerably.

Milk cooled in cans will be transported to the milk plant by truck. If necessary, the rise of temperature during transport can be minimized by insulating the body of the truck or by using refrigerated trucks.

Milk that has been cooled at the farm is generally a few degrees Centigrade warmer by the time it is received at a collection centre or at a dairy plant. Such milk should be recooled immediately. The same applies to milk received by a dairy plant from a collection-cum-chilling centre. Recooling in the plant can be avoided by the application of a proper heat treatment of the milk immediately after reception.

9.3.1 The milk-storage capacity of a collection-cum-chilling centre

The milk-storage capacity of a milk collection-cum-chilling centre depends on the daily milk intake and the frequency of the milk-pick up by the dairy plant. The capacity should be equal to at least 150% of the daily intake in the flush season if the milk is picked up every day, to overcome the risk of the milk pick-up truck not arriving on time. If the milk is picked up every other day, the capacity should be equal to 250% of the daily intake, for the same reasons. In all cases where there is a considerable difference between morning and evening intake, the extra capacity should be equal the largest intake (usually the morning intake and may, consequently be more than 50%).

If there is a large difference between flush and lean season it may be advisable to use two farm tank coolers or two storage tanks together forming the 'full capacity'.

Collection centres may act as a balancing unit for the dairy plant, i.e. allow the supply of milk to the plant to be regulated; especially on public holidays. However, under tropical conditions (and depending on the quality of the milk and the time it takes between milking and cooling) it is not advisable to store milk for periods longer than 48 hours. Since the milk is often stored at the dairy plant for periods of 12 to 24 hours before processing, this acually means that a daily milk pick-up may be found necessary.

Long storage periods of deep-cooled milk may give rise to the development of psychrotrophic (cold-tolerant) bacteria, which produce heat-tolerant putrefying enzymes.

9.3.2 Alternative systems of milk preservation[1]

If cooling of milk is absolutely impossible, other systems of preservation are used, such as a treatment with hydrogen peroxide or activation of the lactoperoxidase system. These methods of preservation may extend the keeping quality of milk by 5 to 8 hours at tropical temperatures (30-35°C), depending on the quality of the milk and the temperature of storage. Preservatives should only be used in collection centres and dairy plants, not by farmers.

Sometimes, large collection centres and dairy plants practise a system of mild heat treatment, e.g. 15 seconds at 63°C to 65°C, called thermization, followed by deep cooling. This heat treatment does not affect the properties of the milk, but kills many bacteria, thus improving the keeping quality of the milk considerably, especially in the case of deep-cooled milk (as a result of the absence or reduction of psychrotrophic bacteria).

9.4 Transportation of milk

Milk collected in a farm tank cooler or in storage tanks should preferably be transported to the dairy plant in bulk, that is in tanks placed on a truck or by road tanker.
To minimize the increase of temperature during transport, the tanks must be insulated and covered with a shed for protection against direct exposure to the sun.

The advantage of tanks is that a single large volume of milk increases slowly in temperature, whereas the temperature of the rather small amounts in milk cans rises quickly. If high-capacity tanks must be filled with comparatively small amounts of milk from a large number of centres, the rise in temperature of the first volumes of milk cannot be ignored. These volumes will be warmed up by the warmth of the inner surface of the tank.

Increases in temperature during transport should be avoided as much as possible. As soon as the milk is warm enough, the interrupted growth of bacteria, achieved by the preceding cooling of the milk, may resume, although non-psychrotrophic micro-organisons in milk that has been deep-cooled for long periods may be in a dormant state which prevents immediate regeneration at higher temperatures. Moreover, such changes in temperature increase the risk of the development of a rancid flavour.

Baffles are put in large and in long tankers, to prevent surging of milk during transport.

Occasionally, milk is transported by railtankers (Figure 22). This involves more complications than road tankers, especially if the dairy plant has no rail connection, and therefore the milk must be pumped over into road tankers for transportation from the rail

[1] Milk cooling and alternative systems of preservation are comprehensively discussed in the companion volume 'Dairy technology in the tropics and subtropics'.

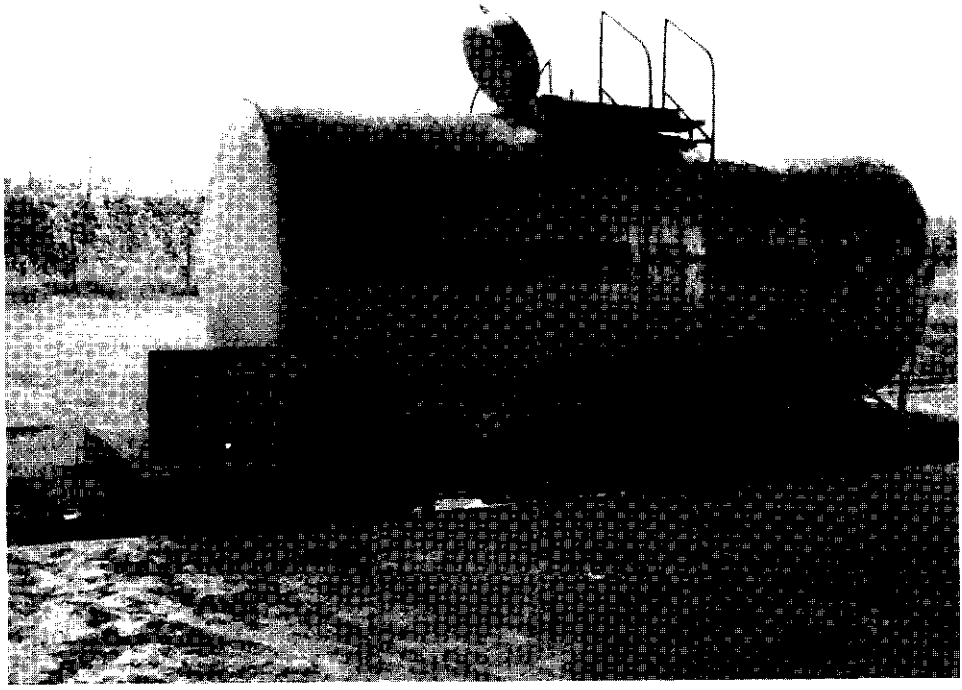

Fig. 22. Rail tanker for milk (Kenya). Photo: M.A. Luijkx.

terminal to the plant. Moreover, it may be difficult to provide sanitizing facilities for the rail tankers at the terminal. Milk transport by rail often suffers severely from alterations in train arrangements.

Further reading

Bachman, M., 1986. Milk collection in developing countries. International Dairy Federation, Bulletin 205.

Berg, J.C.T. van den., 1988. Dairy technology in the tropics and subtropics. Pudoc, Wageningen.

Berg, M.G. van den, 1984. The thermization of milk. International Dairy Federation, Document 182.

Fagard, P., 1980. Guidelines for dairy accounting. FAO Animal Production and Health Paper, No. 21. FAO, Rome.

Harper, W.J. & C.W. Hall, 1976. The fluid-milk industry. The AVI Publishing Co., Westport (Conn.).

IDF, 1970. Refrigerated farm tanks. Standard No. 55. International Dairy Federation.

IDF, 1987. Dairy development in East Africa: milk collection, preservation, quality control and payment. International Dairy Federation.

Kaman, D.N. & M. Krogger, 1984. Preservation of raw milk by treatment with hydrogen peroxide and by activation of the lactoperoxidase (LP) system. Milchwissenschaft 39:658.

Lawrance, C.H., 1980. Code of practice for design and construction of milk collection tankers. International Dairy Federation, Document 128.

Marsden, A.W., 1972. Hydrogen peroxide as a temporary preservative for liquid milk. World Animal Review No. 3.

Moll, J.J., 1987. Collection, transport, compositional and quality control. In: Proceedings of the XXII International Dairy Congress (The Hague). D. Reidel Publishing Co., Dordrecht, p. 223.

Wälholz, G. (Ed.), 1970. Bulk collection of milk. International Dairy Federation, Annual Bulletin IV, Document 55.

Weber, F., 1985. Refrigeration of milk at farm level and organization of the transport (in French: Réfrigération du lait à la ferme et organisation des transports). FAO Animal Production and Health Paper No. 47. FAO, Rome.

10 The use of milk powder and milk fat

Many dairy plants in tropical and subtropical countries use milk powder and milk fat for the production of milk and milk products. In this way they avoid shortages or compensate for high raw-milk prices. Shortages may be:
- permanent, because milk is not sufficiently available to meet the demand the whole year round;
- seasonal, because the lean/flush ratio of milk production is poor;
- initial, because, after its establishment, a milk plant will not be able to buy sufficient milk in the first period of operation. Milk plants that are expected to satisfy the demand of the consumers will be especially prone to shortages (Section 8.1.1).

If the raw milk price is high, and cheap – for instance imported – milk powder and milk fat can be bought, dairy plants may make a mixture from fresh milk and the low priced commodities to obtain products that can be sold at a reasonable price (Section 10.3). Sometimes, liquid milk and milk products are made exclusively from cheap imported commodities (Section 10.2.2).

10.1. The quality of milk powder and milk fat

The taste of full-cream milk powder may deteriorate during storage as a result of fat oxidation, because the fat is finely dispersed through the powder and offers an excellent contact surface with oxygen in the air. Pure milk fat is packed in drums and the contact with the air is negligible. Skimmed milk powder, which because of its almost complete lack of fat does not suffer from deterioration by oxidation, is very hygroscopic and must be packed in impermeable material to prevent moisture absorption which would lead to rapid deterioration. Paper bags with an inner bag of polyethylene are very suitable for this purpose, provided the plastic bag is hermetically sealed after filling.

Because of their excellent keeping quality, skimmed milk powder and milk fat are very suitable to be used as a substitute for fresh milk. However, only high-quality products can be used. No off-flavours are acceptable. The milk powder should be completely soluble.

For good preservation, the milk fat should be absolutely pure and the water content should be negligible. This quality milk fat is called anhydrous milk fat. The water content of the skimmed milk powder should be below 4%, preferably 3%.

World surpluses in milk are almost always converted into skimmed-milk powder and anhydrous milk fat because of the excellent keeping quality. As there is a surplus, these commodities are usually offered at low (often subsidized) prices on the world market.

The keeping quality of milk powder and milk fat declines with increasing temperature. Therefore, the keeping quality under tropical conditions, and especially at temperatures above 30 °C should not be over-estimated and storage periods over 3 months should be avoided if possible.

10.2 The types of product

The three different ways of using milk powder and milk fat are by:
- reconstituting,
- recombining,
- toning.

10.2.1 Reconstituted milk

By dissolving milk powder in the correct quality of water, milk of the same composition as the milk used for the manufacture of the milk powder is obtained. In this way skimmed milk powder can be reconstituted to reconstituted skimmed milk, and full-cream milk powder can be reconstituted to full-cream milk.

The amounts of skimmed-milk powder and water that must be mixed to obtain 100 kg of reconstituted skimmed milk can be calculated with the formulae:

$$P = \frac{100 \times SNF}{100 - H}$$

$$W = 100 - P$$

where:
P = kg of milk powder
SNF = percentage of SNF in reconstituted milk
H = percentage of water in skimmed-milk powder
W = kg of water.

If full-cream milk must be made by reconstitution, the same formula can be used, but:

$$P = \frac{F_p}{F}$$

$$W = 100 - P$$

where:
F_p = fat content of full-cream milk powder
F = fat content of full-cream reconstituted milk

The fat content of the skimmed-milk powder (less than 1%) is ignored in these formulae.

10.2.2 Recombined milk

Recombined milk is obtained by dissolving skimmed-milk powder in water and emulsifying anhydrous milk fat in the reconstituted skimmed milk – thus recombining the components of milk. The fat content of this milk depends on how much milk fat has been added to the reconstituted skimmed milk.

The quantities of milk fat, skimmed-milk powder and water to be mixed to obtain 100 kg of recombined milk can be calculated with the formulae:

$$P_s = \frac{100 \times SNF}{100 - H}$$

$$M = F$$

$$W = 100 - P_s - M$$

where:
P_s = kg of skimmed-milk powder with a water content H(%)
M = kg of milk fat
F = percentage of fat in recombined milk
SNF = percentage of SNF in recombined milk.

Various products can be manufactured by the recombining process. They include liquid milk, fermented milk products, condensed milk, butter and even full-cream milk powder. The manufacture of full-cream milk powder pays if the commodities can be bought cheaply. In this case the recombined product may be cheaper than imported full-cream milk powder.

The production of rennet-coagulated cheese is difficult because the rennetability (coagulation of the milk by the enzyme) and the syneresis (curd formation from the coagulum) are reduced, and the cheese ripens poorly, if at all.

10.2.3 Toned milk

Usually, milk is standardized to a certain fat content for the manufacture of liquid milk. In the event of milk shortages, fresh milk with a high fat content can be standardized by the addition of reconstituted skimmed milk to obtain liquid milk of the required fat content. The product thus obtained is called toned milk.

The amounts of full-cream milk and reconstituted skimmed milk that must be mixed for the production of 100 kg toned milk can be calculated with the formulae:

$$R = \frac{F_t}{F_f} \times 100$$

$$R + Q = 100$$

where:
F_t = percentage of fat in toned milk
F_f = percentage of fat in full-cream milk
R = kg of full-cream milk to be mixed with Q kg of reconstituted skimmed milk to obtain 100 kg of toned milk.

The fat content of the reconstituted milk is ignored.

The amounts of skimmed-milk powder that have to be mixed to obtain the reconstituted skimmed milk can be calculated with the formulae in Section 10.2.1.

The advantage of using reconstituted skimmed milk for standardization is that:
- there are no surpluses of milk fat that are difficult to use appropriately;
- the total availability of milk is increased;
- reconstituted skimmed milk is often cheaper than skimmed milk manufactured by skimming full-cream fresh milk.

If the fat content of the fresh milk is high, for instance in buffalo's milk, considerable amounts of skimmed milk can be used.

For human nutrition, the milk proteins are often considered to be the most valuable part of milk. If, moreover, the price of skimmed-milk powder is low, a cheap high-protein product is manufactured in a number of countries by mixing the local milk with reconstituted skimmed milk in such a way that the resulting product has a low fat content, e.g. 2%, but an increased SNF content, e.g. 10%. The product thus obtained is called double-toned milk.

The amounts of full-cream milk, skimmed-milk powder and water that have to be mixed to obtain 100 kg 'double-toned milk' can be calculated with the formulae:

$$R = \frac{F_d}{F_f} \times 100$$

$$P_s = (SNF_d - \frac{F_d}{F_f} \times SNF_f) \times \frac{100}{100 - H}$$

$$W = 100 - R - P_s$$

where:
R = kg of full-cream milk
P_s = kg of skimmed-milk powder with a water content $H(\%)$
F_d = percentage of fat in double-toned milk
SNF_d = percentage of SNF in double-toned milk
F_f = percentage of fat in full-cream milk
SNF_f = percentage of SNF in full-cream milk.

10.3 Pros and cons of using imported skimmed-milk powder and anhydrous milk fat

On the world market, milk powder and anhydrous milk fat are often available at prices which, in terms of milk equivalents, are lower than those of locally produced fresh milk. The costs of raw materials for the production of liquid milk and other products if either fresh milk or recombined milk is used can easily be compared, as is shown in the example below:

Example. Fresh raw milk as well as skimmed-milk powder + anhydrous milk fat are used for the production of pasteurized milk. The costs of raw material for the production of 100 kg of pasteurized milk with a fat content of 3.5% are (in CU[1]):
- in the event of fresh milk:

$$3.5 \times B + 96.5 \times S \quad \text{(Section 14.2.2)}$$

- in the event of recombined milk:

$$3.5 \times F + \frac{9}{100} \times P \quad \text{(assuming the SNF content of the recombined milk is 9.0\%)}$$

where:
- the local skimmed-milk price is S (CU/kg) and the local milk-fat price is B (CU/kg),
- the landed cost (after customs clearance) of imported skimmed-milk powder is P (CU/kg) and that of anhydrous milk fat is F (CU/kg).

The fat and water content of the skimmed-milk powder are ignored.

If it is assumed that the transportation costs of the commodities from the harbour to the plant plus the cost of recombining are equal to the costs of raw-milk collection plus the reception of this milk at the plant, the two formulae will show whether fresh milk or recombined milk will be cheaper. For more accurate comparisons the exact costs of collection, reception, transportation and recombination must be taken into consideration.

In an effort to create jobs and to save on foreign currency, countries may stimulate the manufacture of cheap recombined products from imported commodities, rather than importing more expensive end-products. Governments may also deliberately allow the importation of cheap commodities to provide cheap recombined milk and milk products to the population, rather than more expensive products made from locally produced fresh milk (see also Section 18). Moreover, it is sometimes felt that full protection of the local dairy husbandry will lead to inefficiency.

Other governments prefer to protect their own milk production by rationing imports or by imposing import duties to equalize the prices of fresh milk and recombined milk, or to

[1] CU = calculation unit, an imaginary monetary unit.

make the price of the latter even higher. The money received from such import duties may be put in a special dairy fund, which can be used:
- to stimulate country's own dairy industry;
- to subsidize liquid milk, either only for vulnerable groups, or for the whole population.
In the event of the latter, it may be found advisable to restrict the subsidy to one or two of the most common products, e.g. pasteurized milk or yogurt, depending on the eating habits of the population and to leave the other 'luxury products' unsubsidized. In this case more money will be available to subsidize the common products.

Example. If a milk plant uses a mixture of raw materials consisting of 80% fresh milk (price 6.0 CU) and 20% recombined milk (price 4.0 CU), the price of the mixture will be:

$$\frac{80 \times 6 + 20 \times 4}{100} = 5.6 \text{ CU/kg}$$

After imposing an import duty on the imported commodities to equalize the prices of fresh and recombined milk, CU 2.0 per kg of recombined milk will be available for the dairy fund. This allows for a subsidy on the mixture of raw and recombined milk of:

$$\frac{20 \times (6 - 4)}{100} = 0.4 \text{ CU/kg}$$

which brings the price to 6.0 - 0.4 = 5.6 CU/kg again. If 50% of the mixture is used for pasteurized milk and only this product is subsidized, a subsidy of 0.8 CU/kg is possible.
A careful policy of import duties and subsidies to protect the local dairy husbandry must be exercised, otherwise it will still pay for milk plants to use large amounts of imported milk powder and milk fat, because in this case more money will flow into the dairy fund and, in theory, higher subsidies can be given, further decreasing the costs of the raw materials. This can be prevented by pegging sales prices.

The level of the import tax on the commodities must be carefully assessed; too low a level will insufficiently protect the local dairy husbandry, too high a level will condone and even enhance inefficient milk production.

If a system is chosen whereby consumption milk or another product is subsidized out of a dairy fund as explained before, an increase in the country's production of milk and consequently a decrease in the amount of recombined milk will mean that less money will be available for subsidies, and the price of the subsidized products must increase, unless other funds are made available. This is also the case if world market prices for the commodities rise. Several milk plants have run into difficulties for these reasons.

There is a danger that the unrestricted use of cheap commodities will lead to the neglect of the local dairy industry, or at any rate, the neglect of efforts to set up an intensive milk-collection system. This especially holds because the use of milk powder and milk

fat has a number of advantages apart from financial ones, such as:
- A guaranteed constant good quality of the raw material. This may not be the case if fresh milk is bought.
- No need for troublesome and expensive milk collection.
- No intensive advertising campaigns and elaborate extension services for the promotion of dairy husbandry.
- The amounts of milk powder and milk fat that are recombined can be adjusted to the daily needs. There are no surpluses or shortages of raw material (fresh milk).

It may happen that milk plants will not accept all fresh milk offered, because of the advantages of recombined milk. This is especially likely if the milk is difficult to collect (small amounts, long collection rounds, etc.). Legal measures requiring that all offered milk must be accepted, can be obviated by imposing unrealistic quality standards or regulations, e.g. requiring that milk must be deep cooled on the farm, which is practically impossible to achieve on small farms. In this case special measures may be advisable such as imposing quotas on purchases of milk powder and milk fat, which depend on the intake of fresh milk.

In some countries, vegetable oils and reconstituted skimmed milk are used for the production of various types of product (e.g. filled milk and filled-milk products).

Further reading

ADMI. Standards for grades of dry milks, including methods of analysis. American Dry Milk Institute. Chicago (Ill.)

Barròn del Castillo, L.A., 1987. Social and economic aspects of recombination and indigenous milk production. In: Proceedings of the XXII International Dairy Congress (The Hague). D. Reidel Publishing Co., Dordrecht, p. 305.

Bauzon, J.A., 1978. Reconstitution of milk using coconut milk and non-fat dry milk. Philippine Journal of Coconut Studies 3(2)1.

Berg, J.C.T. van den., 1988. Dairy technology in the tropics and subtropics. Pudoc, Wageningen.

Bøjgaard, S.E., 1987. Recombination of dairy ingredients into fermented products, including cheese, butter and ice cream. In: Proceedings of the XXII International Dairy Congress (The Hague). D. Reidel Publishing Co., Dordrecht, p. 259.

IDF, 1977. Anhydrous milk fat, anhydrous butteroil or anhydrous butterfat, butteroil or butterfat, ghee. Standards of identity, No. 68A. International Dairy Federation.

IDF, 1979. Monograph on recombination of milk and milk products. International Dairy Federation, Document116.

IDF, 1982. Recombination of milk and milk products. International Dairy Federation (Seminar), Document 142.

Jensen, G.K. & P. Nielsen, 1982, 1985. Review of the progress of dairy science: milk powder and recombination of milk and milk products. Journal of Dairy Research 49(1982)515; 52(1985)451.

Mann, E.J., 1982. Recombined milks and dairy products. Dairy Industries International 47(4)32.

Sjollema, A., 1987. Recombination of dairy ingredients into milk, cream, condensed milk and evaporated milk. In: Proceedings of the XXII International Dairy Congress (The Hague). D. Reidel Publishing Co., Dordrecht, p. 251.

Wade, R.A. et al., 1984. Storage temperature and quality of raw materials used for recombined and reconstituted milk. Egyptian Journal of Dairy Science 12:1.

11 Establishing dairy plants; financial consequences

11.1 Selecting the location

11.1.1 Dairy factories or city milk plants

A few important points should be taken into consideration when choosing the site of a dairy plant:
- the area of milk production and the market for the products;
- the infrastructure (especially the roadconditions) for the collection and transportation of the raw milk and the distribution of the manufactured products;
- the availability of water and electricity;
- the facilities for the disposal of dairy effluents;
- the availability of labour and technical services from third parties.

In principle, dairy plants should be established in or near areas of high milk production. Here, collection rounds are short and it will not be necessary to establish expensive collection centres with cooling systems. This is certainly the correct strategy for dairy factories that mainly produce dairy products like butter, milk powder and condensed milk. These products can be stored over long periods, and most of them are less bulky and less heavy than the milk from which they are manufactured. Moreover, their keeping quality is better and they can easily be distributed over large areas.

Proper research should be done, before it is decided whether a few large dairy factories or a large number of small factories should be established. Large factories have the disadvantage of long and expensive collection channels, often with collection-cum-chilling centres, whereas the set-up of the collection system for the smaller plants may be much simpler and cheaper. However, the investments required for a large number of plants, each with its own equipment, will generally be higher than the investment for one large plant. Large plants also allow for a higher labour productivity; in other words, less labour will be required for processing the same amount of milk. This is not only an advantage from a financial point of view, but it is also important if skilled labour is difficult to find. Moreover, the manufacture of certain products, such as condensed milk and milk powder, requires high-capacity plants. The establishment of laboratories for proper quality control of raw milk and manufactured products only pays in comparatively large plants.

If the milk plant is to produce liquid milk and liquid milk products, such as pasteur-

ized milk and fermented milks, a location may be chosen in the vicinity of the consumption area, that is a city or another urbanized area, because it is easier to transport large volumes of bulk raw milk in tankers than processed milk products in refrigerated vans. If not sterile, the products may require refrigeration during transport. Products in retail packages require more space than bulk milk, although modern one-way packaging materials allow for very efficient loading of vehicles. The trend towards products with a prolonged keeping quality and the use of one-way packaging materials mean that there is a tendency to locate milk plants in the milk-producing area, where land is cheaper and facilities that are not available in large cities may exist. If the areas of milk production are too far from the city milk plant and the costs of transportation would be too high, the milk plant will be forced to produce recombined milk and milk products in addition to the milk collected from nearby.

It is not advisable to site a milk plant within the boundaries of a city. A site chosen in the environs may soon be engulfed by that city.

Milk plants for the production of recombined milk and milk products may be built in the vicinity of the main consumption area. Dairy factories for the production of recombined dairy products may be built in industrial areas close to the place of importation, mostly the port of clearance.

11.1.2 Other considerations

The choice of the location of a dairy plant may depend on the availability of water and electricity and on the reliability of the supply. Facilities for disposing of dairy effluents are of extreme importance. Small-capacity plants in rural areas often dispose of their effluents in streams or other water bodies, such as lakes, or simply discharge the effluent on waste or unused land. Large plants may find it difficult to find an outlet for their effluents, especially because authorities are imposing increasingly stringent restrictions on waste disposal. The possiblities of discharging the effluents into a public sewer, or of establishing facilities for the treatment of the effluents, should be taken into consideration.

The availability of managerial and administrative staff, and skilled labour may also play a role in the choice of site, as will the presence of service staff for the maintenance and repair of buildings, equipment and vehicles.

11.2 Processing patterns and equipment

Small-scale 'cottage industry' processing units will generally continue to co-exist with the introduced industrial processing plants, especially in areas that fall outside the range of interest of the large-scale plants. Nevertheless, industrial development usually leads to a worldwide standardization of products, because:

- The know-how (the experts and the dairy companies) required for the planning, the establishment and the initial operation of the processing industry usually originate from countries with a developed industry; in most cases Western or industrialized countries.

This leads to the manufacture of products popular in these countries.
- The available dairy equipment is mainly produced in the dairy countries and conforms with the products of those countries.
- The persons responsible for the introduction and the establishment of a dairy-processing industry in their country have usually been educated or trained in the dairy-developed countries. They are acquainted with the processing techniques and the products of these countries and identify these with dairy development.

Only a limited number of products are able to maintain their place in the product mix of the modern plants, and even then, they may lose their traditional character. The introduction of industrial milk processing leads to large-scale operations, mainly because the equipment is manufactured for high capacities. This means that in order to obtain sufficient milk to feed this equipment, milk must be collected over long distances, which is costly (Section 9.3), or plants must operate below their capacity. When deciding how to equip the plant, it should be taken into consideration that the labour costs are high in the industrialized countries but energy costs are comparatively low. This has led to a high level of mechanization and automation (computerized dairy plants). In contrast, in developing countries, labour is cheap and energy is comparatively expensive. The introduction of energy-intensive and highly automated techniques does not seem to be advisable, unless the aim is to exclude the human factor. It should also be realized that mechanization and automation requires highly qualified service staff, which may not always be readily available.

Points to note
When introducing industrial milk processing in tropical countries, certain circumstances sometimes need to be taken into consideration, such as:
- The electricity supply may be irregular and the voltage may be variable.
- The available water may be of poor quality and the supply may be irregular.
- More cold is needed than in the temperate zones.
- Heavier insulation of cold stores will be required than in temperate zones; more attention must be paid to the ventilation of processing areas. It is often recommendable to build an 'open' boiler house.
- A large vehicle fleet may be necessary. This will require more maintenance and more spare parts if road conditions are poor.
- Maintenance and repairs of equipment may require more care.
- Skilled labour may be scarce and it may be necessary to send trainees abroad.
- If the foreign currency position of the country is weak, the administrative road for obtaining import permits for equipment, spare parts and chemicals may be long.

11.3 The product mix

11.3.1 Preliminary considerations

When a dairy plant is being established, it is extremely important that the proper product

mix (the products to be manufactured in the correct quantities) be chosen. Points of consideration could be:
- The quality of the raw milk. Some products require a higher quality milk than others, and the manufacture of certain products makes specific demands on the bacteriological and enzymatic quality of the raw milk.
- The profitability for the dairy plant. However, the potential sales of highly profitable products – in most cases luxury products – are generally limited. Moreover, the manufacture of such products gives the plant an élitist character, and could mean that raw milk that could otherwise become available for the lower income families is withdrawn from the market.
- The consumer's preference. This point will often prove to be the most decisive. In general, a dairy plant should start with the manufacture of those products that are known to and accepted by the majority of the consumers. Too often, the example of countries with a well established milk processing industry is followed and products that do not belong to the everyday diet of the population are manufactured.

Surveys need to be done in all classes of the population, to ascertain preferences and possibilities and patterns of spending. However, surveys are difficult to perform and the results are often not very reliable, because:
- consumers cannot give their opinion about products they do not know, e.g. about pasteurized or sterilized milk, if they have always consumed raw milk or have never consumed milk;
- consumers may not fully realize the consequences of their reply, e.g. the higher price they will have to pay for processed products than for raw milk.

Differences in appreciation between 'higher income classes' and 'lower income classes' of the population are not exceptional. The choice of the former group is not only determined by the larger sums of money they are able to spend, but their representatives are often more familiar with or more accustomed to the eating patterns prevailing in countries with a developed milk-processing industry. Since more senior government officials usually belong to this group (they may have studied in such countries, or they may have contacts with representatives of such countries), there is a risk that these officials will be inclined to choose a product mix, that meets foreign consumption habits rather than the local demand.

It is very possible that the initially chosen product mix will change gradually, either as a result of the introduction of new highly appreciated products, or to remedy wrong planning and/or to reflect changes in the consumption pattern.

Apart from the types of product that will be manufactured, the kinds of packaging material that will be used is important. The main considerations that may play a role in the choice of products and the kind of packaging material will be mentioned briefly below.

11.3.2 Liquid milk

A dairy plant established in the vicinity of an urbanized area, i.e. a city, will usually be a

milk plant and the tendency will be to think in the first place of the manufacture of liquid milk for consumption. Sales figures of milk powder and condensed milk are often taken as an indication of the amount of consumption milk needed. This is not necessarily correct, because milk powder and condensed milk often have their own mode of use, in which case they are not used as an alternative for liquid milk. Condensed milk is often used in tea and coffee. Moreover, condensed milk and milk powder have an excellent keeping quality and are useful in households that do not have a refrigerator. Once a tin of condensed milk or milk powder has been opened, the contents can be used in small amounts over an extended period of time, although milk powder has to be protected against moisture absorption. Uncooled liquid milk, either pasteurized milk or sterilized milk after the container has been opened, has a limited keeping quality and should be consumed on the day of purchase (pasteurized milk) or opening the container (sterilized milk).

Kind of consumption milk

Generally, dairy plants seldom sell raw milk for direct human consumption. Collecting milk from a large number of suppliers, with all the risks of contamination with pathogenic bacteria, and then mixing this milk in large storage tanks and thereafter distributing this raw milk over a large number of consumers, may easily lead to an outbreak of infectious diseases amongst the population. Therefore, milk must first undergo a heat treatment to kill all pathogenic micro-organisms and viruses. In properly pasteurized milk, all pathogens and most of the putrefying bacteria and enzymes have been destroyed, but it still contains bacteria and therefore it is perishable if stored at room temperature. Under tropical conditions this kind of milk will usually spoil within one day. The keeping quality can be considerably prolonged if the milk is kept under refrigeration. This means that to sell pasteurized milk requires a cold chain from milk plant to household.

In sterilized milk all bacteria and enzymes have been destroyed and it has an excellent keeping quality without cooling, provided no recontamination takes place. This means that it can be transported and stored without artificial refrigeration. It also means that the number of sales points (shops and stores) can easily be extended without the necessity of refrigeration.

Packaging of liquid milk

Most milk plants will prefer to sell heat-treated milk in some kind of closed or sealed container, thus preventing the product from being recontaminated or adulterated. However, the consequences of contamination of unpacked milk should not be overestimated, at least not in those regions where it is customary to boil the milk before use. The costs of packaging pasteurized and sterilized milk are high and as such they increase the price of the product considerably. Therefore, serious consideration must be given to whether the advantages of packaged milk justify the higher price, especially because the lower income groups may be unable to pay such a price or to buy sufficient amounts of milk for such a price. Moreover, for practical reasons, a milk plant must limit the number of packages of different size and since the costs of packaging increase with decreasing

capacity of the containers, very small packs will not be very popular in the plant. Contrary to the views of the plant, the consumer, especially if poor, may wish to buy very small amounts.

Milk and fluid-milk products can be put in containers that will be returned to the milk plant, the 'returnable pack', or in containers made from materials that cannot be re-used, the 'non-returnable' or the 'one-way pack'. Glass milk bottles are the main representative of the first category. One-way packaging is made from various materials. The most important are the plastics and the cartons lined or coated with other materials. The 'plastic sachet' is considered to be the cheapest non-returnable milk package. The well-known tins for the packaging of condensed milk and milk powder also belong to this category. The choice of the material will in the first place depend on the availability of the material in the country. Imports require foreign currency, and a regular supply demands very careful planning.

Generally speaking, glass bottles are more expensive per unit than the one-way packages, but since milk bottles can be used up to 40 times, they are generally cheaper per litre or kg of product sold. The higher costs of the one-way packaging materials must be compensated for by certain advantages, such as:

- The one-way packages are less heavy than bottles and some are easier to handle.
- No expensive bottle-washing equipment is required. Since the material is new, there is less chance of contaminating the milk. This can happen with poorly cleaned 'returnable packaging'.
- Neither vast amounts of water nor detergents will be required for bottle washing, and less dairy effluent will be produced.
- No collection and transportation of empty bottles is necessary.
- No sorting out of returned bottles and administration of the 'bottle flow' is necessary.

A special advantage of one-way packaging materials is that it is not necessary to ask for a deposit, to ensure that the containers will be returned to the milk plant. If they are not returned, the milk plant is compensated by the deposits. Sometimes, consumers are not inclined or financially unable to pay a deposit. Therefore, one-way packs, even if more expensive, may be preferred.

In the past, sterilized milk could only be produced by sterilizing the milk in the packaging material, because it was impossible to bottle sterilized milk without recontamination. Glass bottles and tins were the only materials that could stand such sterilization of milk, and sterilized milk was always packed in one of the two. This process gave the milk a more or less pronounced flavour. Plastic bottles for in-bottle sterilization have also become available. More recently, systems for the continuous sterilization at very high temperatures (ultra-high temperatures) during very short periods, after which the milk is aseptically packaged in one-way packaging have become popular. This UHT milk has a guaranteed keeping quality of at least 4 - 6 weeks. Although it is sterile, this product has a restricted shelf life, because:

- chemical off-flavours may develop;
- certain enzymes present in poor-quality raw milk may survive the heat treatment and may cause a bitter taste and even gelling of the milk in the course of time.

Although UHT milk, also called 'long-life milk' has a number of advantages, it should be borne in mind that plants for the manufacture of this product are complex and depend on delicate instruments instead of manual control to activate electrical and pneumatic mechanisms. The advanced processes of sterilization and aseptic packaging require skilful operation and maintenance. Consequently, skilled technicians and service agencies should be available. If these are situated at a great distance from the milk plants, expert help in cases of emergency may be delayed. The production costs are high: the packaging material is especially expensive. But these costs will often be compensated for by the superfluity of a cold chain and the increased possibilities for marketing (more sales points). The system is not suitable for low capacity operation.

11.3.3 Fermented milks

In spite of the numerous different names, the various fermented liquid milks can be classified in a few groups (Section 5.1.2), depending on:
- the type of milk used;
- the type of fermenting flora;
- the way the milk is processed before or after fermentation.

11.3.4 Butter and ghee

Sour milk or cream is churned for the manufacture of butter, the product containing about 80 to 85% of the highly valued milk fat (Figure 23). The buttermilk, which is left after the removal of the butter, is used for direct consumption or is concentrated by draining, thus obtaining curds and other cheese-like products. Because of the high water content and contamination with putrefying micro-organisms, which can cause defects like rancid and cheesy taste, the watery phase may be removed from the butter by evaporation or decantation after melting, thus obtaining a product which consists almost completely of milk fat, and is called ghee (Section 5.1.3).

11.3.5 Cheese

Milk may be curdled by acidification or by the activity of vegetable or animal enzymes. The curd is separated from the liquid, the whey, and either consumed fresh or preserved by ripening, drying, smoking or pickling.

From import statistics it is often concluded that the production of cheese as a preserve would be a feasible possibility for the commercialization of milk if sufficient marketing possibilities for liquid milk and fresh milk products cannot be found. This proposition may turn out to be wrong, because:
- the quality of the milk is too poor to make varieties other than fresh cheese;
- import figures seldom mention the varieties of the cheeses that are imported and/or their amounts.

In dairy-developing countries, cheese is generally consumed by a small minority of

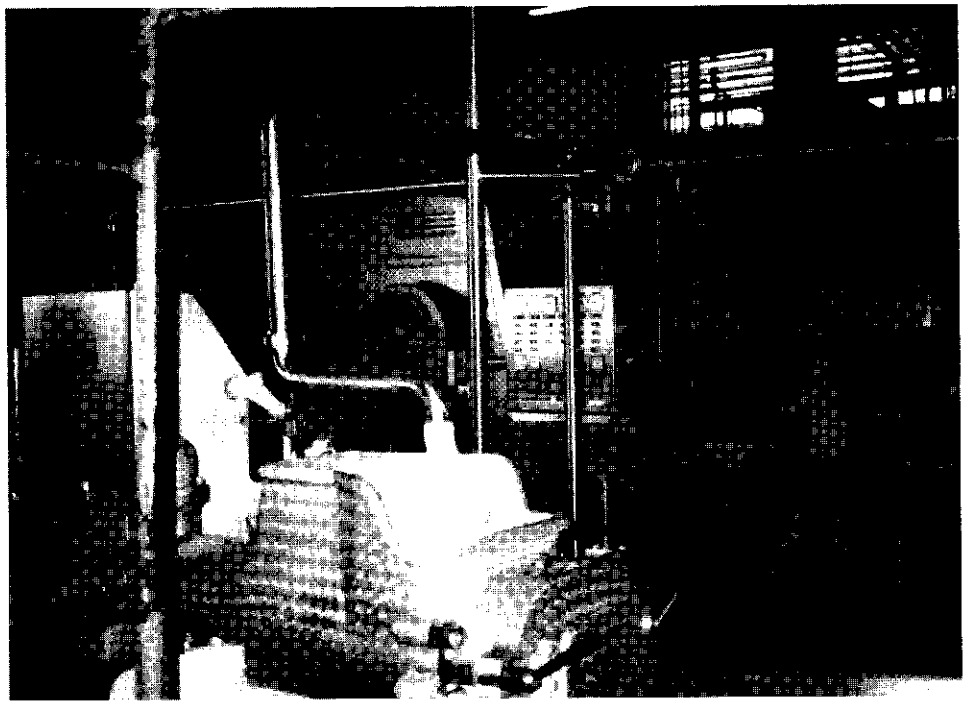

Fig. 23. Continuous buttermaking in high-capacity dairy plant (Kenya). Photo: M.A. Luijkx.

the population, who consider cheese as a luxury product and desire a wide variety of cheeses. It will prove unpractical to replace this wide variety by one or two standard products, and consequently to satisfy the consumer. The production of a great variety of cheeses will prove to be technically and economically infeasible (Section 5.1.4).

11.3.6 Concentrated and dried milk

Concentrated products are manufactured by evaporating off part of the water in specially designed evaporators. Concentrated milk is either preserved by adding sugar, to give sweetened condensed milk, or by sterilization, to give evaporated milk.

Dried milks are manufactured by drying concentrated milk in specially designed drying chambers, where the milk is sprayed into a stream of hot air (Section 5.2.5).

11.3.7 Edible ices

There is a large variety of edible ices. Some varieties contain hardly any or no milk or milk solids. Dairy ices are usually produced by freezing a mixture of various ingredients, called the ice mix. During freezing, air is beaten into the mix in order to obtain a product with a foamy structure. Apart from milk, the mix for dairy ices may contain cream, condensed milk, milk powder, sugars and colourings and flavourings (Section 8.2.5).

11.4 The capacity of dairy plants

11.4.1 Introduction

If it is decided to establish a dairy plant, its capacity must be determined. This mainly depends on the milk intake and the sales potential of the products. Too often, milk plants of far too large a capacity are built, with the result that the costs of investment and maintenance and consequently the processing costs of the milk, are much too high. On the other hand, it may happen that the throughput of the plant increases rapidly and extension of the capacity of the plant is already necessary after a couple of years, which may mean new costs for buildings and equipment. These costs generally prove to be higher than the extra costs of a higher investment right at the beginning and an initial underloading of the plant. This means that not only the situation at the moment of establishment but also the prognoses of the future development is important.

11.4.2 The milk intake

The estimation of the milk intake, actually the milk availability, has already been discussed in Section 8.2. Apart from the estimation of the milk availability at the moment of establishment, prognoses should be made of its future development. It is no exception for the availability in the first period (which may last a couple of years) to be small, and to increase gradually thereafter. It is also possible for the milk availability to develop explosively. A proper prognostication is often extremely difficult, but a few points should be taken into consideration, such as:

- is there much competition in the raw milk market?
- is it possible to pay an attractive price for milk?
- is the dairy plant to be established in an area where the farmers are interested in animal husbandry in general and in milk production in particular?
- are conditions and facilities (such as climate, availability of pastures and feed, extension services, etc.) favourable for an extension of milk production?
- is a special programme for the stimulation of milk production in progress, or is such a programme planned?

City milk plants producing liquid milk and liquid-milk products may meet special problems, because as explained already they must reckon with a fairly constant demand throughout the year (Sections 8.2, 8.3, 10).

Contrary to the liquid milk and milk products of the city milk plants, the milk preserves manufactured by the rural dairy factories have a long storage life, so they can easily be stored, transported and distributed. This makes it possible to sell the products when and where the demand is highest (Sections 8.2, 8.3).

In general, the capacity of a milk plant should depend on the quantity of milk that is offered, rather than on the demand for consumption milk and liquid milk products. Only if the demand is higher than the supply and it is decided to meet shortages by the use of milk powder and anhydrous milk fat for the manufacture of recombined or toned pro-

ducts, should the capacity be attuned to the demand.

If there are considerable differences between the intake in the lean and the flush seasons, the plant may decide to work in two or even in three shifts in the flush season to limit investment costs. This decision may also be taken if the milk supply increases to such an extent after the establishment of the plant, that the original capacity is insufficient to process all milk.

Working in shifts to cope with increased supplies does mean that more skilled labour must be available, and that certain sections of the plant still must be sufficiently enlarged, e.g. milk reception, storage of fresh milk and cold stores for manufactured products.

11.4.3 Sales possibilities

Dairy plants must sell their products at a price acceptable to the consumer, but on the other hand they must pay a competitive price to the farmer. The margin in between must cover the processing costs and other expenditures, as will be explained in Section 14.4.

Milk plants selling liquid milk may face considerable difficulties if there is competition in the market from independent peddlers of raw milk (Section 5.2.2). There are a number of reasons why raw milk can be offered to the consumer at a lower price than the milk plant can sell its heat-treated, properly packed product:

- The costs of collection and distribution of the raw milk are generally lower, because the aids and appliances of the independent milk peddler are simpler, e.g. no cold chain, simple means of transportation, etc. (Figure 24). Moreover, no actual charges may be made for the persons involved in collection, transportation and distribution of the milk.
- The raw milk does not bear the costs of processing and packaging.
- The quality of the raw milk offered to the consumer may be lower than the minimum standard the milk plant has set for its milk supplies. The distributor and the milk peddler receive a high profit, especially if they dilute milk with water. This creates the possibility of paying a higher price to the farmer and/or offering the milk at a lower price to the consumer. Milk plants are not in a position to adulterate their milk deliberately. In many cases, milk plants are subject to regular quality inspection, because sampling is easy at the milk plant itself or at the sales points. Independent milk peddlers are much more difficult to inspect, because it may be found difficult to trace them on their distribution round and they may be difficult to identify. Moreover, they generally distribute the milk early in the morning, when the inspectors are not yet on duty.

The position of the independent milk peddlers is strong not only because they are able to sell the milk at a low price, but also because:

- They deliver the milk on the doorstep at an hour that suits the consumer. Milk plants may find it difficult to organize such deliveries. Therefore, most plants sell their milk and milk products exclusively through shops, supermarkets and similar sales points.
- The personal relationship built up between the peddler and the consumer is found to be very important.
- Milk peddlers may allow their customers to buy on credit, a system that is hardly workable for milk plants.

Fig. 24. Milk distribution by donkey (Jordan).

Proper propaganda informing the consumer about the advantages of the high-standard products of the milk plant is an important weapon against the sales of low quality raw milk products. It may, however, take several years before the consumer has accepted the products of the milk plant on a large scale.

The position of a milk plant can be strengthened by giving it a monopoly, by introducing a regulation prohibiting the sale of products that have not been properly heat treated. Although such a regulation is also advantageous from a health aspect, it has many consequences, such as:

- The price of the heat treated milk will be higher than that of the raw milk sold by the peddlers, unless the milk plants mix the fresh milk with cheap reconstituted or recombined milk (Section 10.3).
- The total capacity of the milk plant(s) must be large enough to handle all milk, so no stagnation in the supply of milk to the consumers will arise.
- The milk plant must distribute the milk in the same way as the milk peddlers do, which means sales on the doorstep.
- Farmers who are used to selling their milk directly to the consumer must change over to sales to the milk plant, which means that they will make a lower profit, or no profit at all if their production system is aimed at the higher consumer's price.
- All persons involved in the distribution of raw milk are cut out of business. Efforts to introduce these persons into the distribution system of the plant are seldom successful.
- An inspection service must be organized to enforce the regulation.

It is possible to improve the position of the milk plant to a certain extent by the appli-

cation of proper quality standards for all kinds of products. The main standards for raw consumption milk should at least include a minimum fat and solids-non-fat content and certain standards of hygiene. In particular, standards preventing the adulteration of milk (Section 13.3) will protect the milk plant. However, the introduction of a quality regulation will require a properly functioning inspection service.

Urbanization limits the possibilities of the sales of raw milk, because:
- parts of the city will become inaccessible for the milk peddlers;
- the amounts of milk produced in the vicinity of the city will become insufficient.

The consumption of milk and milk products is still low in many countries because only a little milk is available and/or the population is not used consuming milk and milk products or is too poor to pay for them. Nevertheless, especially in the big cities, a group of the population is acquainted with milk products and is prepared and able to pay for these products. This group mainly comprises representatives of the higher income families, who create a certain demand.

A dairy plant introducing milk and milk products may find a ready market, and initially sales will increase rapidly. This could give the misleading impression that there is no limit to the potential for sales. After an initial rapid increase in sales, a saturation point can be reached because the demand of the previously mentioned group is satisfied. Further progress in sales will be slower and will require more effort.

Newly established dairy plants often meet with miscomprehension and even distrust from the side of the consumer. Not seldom, the products are mistrusted, because they come from a factory and are considered to be 'artificial', made from chemicals, etc. The independent milk peddler who comes to the door every day is unlikely to contradict these ideas. Strong campaigns, making propaganda and giving information to the consumer should have top priority. Unfortunately, often very little or nothing is reserved for such activities in the budget. Dairy plants could spend up to 4% of their budget on propaganda, advertising, public relations, etc. And it usually pays!

11.4.4 Distribution

A milk plant can either keep the milk distribution in its own hands or can delegate the distribution to others. There are all sorts of intermediate systems.

All intermediaries, such as wholesale dealers, distributors and shops, will receive a commission for their services, which may contribute to the cost prices considerably. The milk plant may decide to save expenses by executing the whole distribution or at least part of it. Practical experience has shown, however, that it is difficult to make savings in this way. The advantage of an own distribution system will mainly be found in the milk plant's closer concern in the promotion of milk sales in general, and its own sales in particular. Moreover, it may be found difficult to coordinate the interests of the milk plant and those of the intermediaries, especially the wholesale dealers.

There are several sides to the question of whether the milk and the products should be sold through shops or whether these products should be delivered directly to consumers (Figure 25). This matter deserves careful study. Generally speaking, it is difficult to

Fig. 25. Small-capacity milk-delivery van (Zimbabwe). Photo: M.A. Luijkx.

penetrate an existing market where the milk is home delivered, by selling the milk through shops and other sales points only.

Further reading

Arbuckle, W.S., 1986. Ice cream (4th. ed.). The AVI Publishing Co., Westport (Conn.).
Ashton, T.R. et al., 1981. New monograph on UHT milk. International Dairy Federation, Document 133.
Bachmann. M., 1980. The dairy plant in developing countries. In: Die Molkerei der Entwickelungsländer. Deutsche Milchwirtschaft 31:715.
Berg, J.C.T. van den, 1988. Dairy technology in the tropics and subtropics. Pudoc, Wageningen.
Eck, A. (Ed.), 1987. Cheesemaking (Science and Technology). Lavoisier Publishing Inc., New York.
Fenn, M.G., 1975. The economic problems of milk schemes in developing countries. FAO World Animal Review 15:21.
Fox, P.F. (Ed.), 1987. Cheese: chemistry, physics and microbiology. Vol. I. General aspects. Vol. 2: Major cheese groups. Elsevier Applied Science Publishers, Essex.
Gunnis, L.F., 1968. Techniques for the production of anhydrous butter fat. International Dairy Federation, Annual Bulletin VI, Document 43.
Hall, H.S., 1976. Standardized pilot milk plants. FAO Animal Production and Health Series, No. 3. FAO, Rome.
Hall, C.W.& T.I. Hedrick, 1971. Drying of milk and milk products (2nd ed.). The AVI Publishing Co. Westport (Conn).
Harper, W.J.& C.W. Hall, 1976. Dairy Technology and engineering. The AVI Publishing Co.,Westport.
Hunziker, O.F., 1949. Condensed milk and milk powder. O.F. Hunziker, LaGrange (Ill.).
IDF, 1982. Technical guide for the packaging of milk and milk products (2nd ed.). International Dairy Federation, Document 143.

IDF, 1984. Fermented milks. (Seminar) International Dairy Federation, Document 179.
Kosikowski, F.V., 1977. Cheese and fermented foods (2nd. ed.). Edwards Brothers, Ann Arbor, Michigan.
Mair-Waldburg, H., 1974. Handbook of cheese (in German: Handbuch der Käse). Volkswirtschaftlicher Verlag, Kempten (Alg.).
Mann, E.J., 1985. Cottage cheese. Dairy Industries International 50(11)11.
Mann, E.J., 1983. Anhydrous milk fat. Dairy Industries International 48(10)13.
Marque, J., 1973. Dairy equipment and developing dairy countries. FAO World Animal Review 8:34.
Muir, D.D., 1984. UHT-sterilized milk concentrate; a review of practical methods of production. Journal of the Society of Dairy Technology 37:135.
Phelan, J.A., 1977. Milk coagulants; a critical review. Dairy Industries International 42(2)50.
Radema, L.,1974. Investigation into the keeping quality of butterfat exported to tropical countries. Netherlands Milk and Dairy Journal 28:203.
Rajorhia, G.S.& M.R. Srinivasan, 1979. Technology of khoa. Indian Journal of Dairy Science 32:209.
Rañgappa, K.S.& K.T. Achaya, 1974. Indian Dairy Products. Asia Publishing House, Bombay.
Rasić, J.& J.A. Kurmann, 1982. Yogurt: scientific grouds, technology of manufacture and preparations. Mejeriteknisk Bogforlag, Vanlöse (Denmark).
Scott, R., 1981. Cheesemaking practice. Elsevier Applied Science Publishers, London.
Siegenthaler, E.J., 1968. Two procedures for cheesemaking in the tropics and emerging countries. Milchwissenschaft 23:623.
Srinivasan, M.R. & C.P. Anantakrishnan, 1964. Milk products of India. Indian council Agricultural Research, New Delhi.
Steinkraus, K.H. (Ed.), 1983. Handbook of indigenous fermented foods. Marcel Dekker, New York.
Tamine, A.Y. & H.C. Deeth, 1980. Yogurt: technology and biochemistry. Journal of Food Protection 43:939.
Tuszyński, W.B., 1978. Retail packaging, storage and distribution of processed milk. FAO, Rome.
Tuszynski, W.B. et al., 1983. Solar energy in small-scale milk collection and processing. FAO Animal Production and Health Paper, No. 39. FAO, Rome.
Wilcox, G., 1971. Milk, cream and butter technology. Noyes Data, Park Ridge (NY).

11.5 The financial feasibility

Dairy plants usually run at a loss during the first period of operation. However within an acceptable number of years, conditions of operation should have improved to such an extent that the milk plant is running at least at neither a loss nor a profit; in other words, it is at its break-even point. Should this point not be reached, the plant will only be financially feasible if subsidized.

It should be kept in mind that initial losses later weigh heavily on the exploitation results.

The feasibility of a plant depends on many factors, the main ones being the price setting, the processing costs and the throughput of the plant being very important.

11.5.1 Price setting

11.5.1.1 The costs of a dairy plant

Processing costs

The costs of the manufacture and sale of milk products are made up of:

- milk collection and transportation;
- milk processing and storage of products;
- distribution of milk and milk products and sales promotion;
- management, administration, quality control, etc.

The sum of these costs divided by the total amount (kg) of milk received, gives the processing costs per kg of milk.

If only one product is manufactured, the sum of the costs has to be divided by the kg or number of units of the product produced, to find the processing costs of one unit of that product. In most cases, more than one product will be manufactured. Since the costs of processing will differ for the various products, the various cost items must be split up according to the extent they contribute to the various products, and then be allocated to these products.

For price-setting purposes it is practical to split up these costs into fixed costs and variable costs. The costs to the dairy plant that are constant, i.e. that are independent of the amount of milk that is processed, belong to the fixed costs[1]. The costs depending on the throughput (that is the amount of milk that is processed) belong to the variable costs. The latter rise and fall, depending on the amount of milk that is processed.

Fixed costs

The most important fixed costs are those connected with labour and investments. The former group includes salaries, wages and social provisions, such as insurance, benefits, free meals, uniforms, etc. They are only fixed if the number of workers need not be increased if more milk has to be handled or new products are manufactured, and especially if it is not necessary to change from one shift of labour to two or even three shifts. The fixed costs also include amortization and interest on loans and maintenance[2]. Expenditure during the construction of the buildings, the installation of equipment and the starting-up period of the plant, and losses during the first period of operation, like the costs of the initially needed working capital belong to the investments as well.

Fixed costs do not depend on the throughput of the plant, provided no extra investments are required and no extra labour must be employed. Such a necessity will arise as soon as the throughput of the plant surpasses one shift operation, or new products must be manufactured. If the throughput of the plant increases (without new investments or extra labour), the fixed costs per unit of processed milk will decrease. This means that the fixed costs are not fixed (constant) per kg of processed milk, as is shown in Table 13.

Expenditure for the establishment of a dairy plant. The most important expenditure during the establishment of a dairy plant, that is during the period before the plant starts processing milk, is on:

[1] Changes in costs resulting from general increases in salaries and wages, price levels, etc., e.g. due to inflation, have not been taken into consideration here.

[2] For maintenance, often a certain percentage of the investment is brought into account.

Table 13. Interrelationship between fixed costs and throughput.

Throughput (kg/day)	Fixed costs per unit or kg (CU)	Total fixed costs (CU)
10 000	1.00	10 000
15 000	0.67	10 000
20 000	0.50	10 000
25 000	0.40	10 000
30 000	0.33	10 000

- planning, architect, engineering, etc.;
- land, levelling, sewerage, streets, gates, gas, electricity and water connections, water storage tanks, transformer house, etc.;
- buildings and other constructions;
- dairy and auxiliary equipment (cold and steam), pipes, fittings, electrical connections, switch boards, spare parts, etc., and office equipment and furniture;
- shipment of equipment, custom duties and clearance, insurance, installation and erection of equipment, additional materials and implements;
- vehicles;
- certain pre-operational expenditure, which begins even before the milk plant becomes operational, mainly consisting of interest payments on borrowed funds and on labour during a pre-operational phase.

This pre-operational phase lasts, for instance:
- 12 months for land,
- 6-12 months for equipment (a down payment at the moment the order for equipment is placed, is quite common),
- 3-6 months for erection and installation,
- 3 months for transportation,
- 3-6 months for water and electricity,
- 3-6 months for labour; at least some of the employees will be appointed before operation starts, and some may be sent for training, in which case the costs of training must be included,
- 3-6 months for office and administrative expenditure.

Moreover, at the moment the plant becomes operational, a sufficient supply of stationery, detergents, laboratory materials, packaging materials, etc. should already be available.

Working capital. Depending on the period that elapses between the moment the milk plant becomes operational and the moment it receives payment for the products it sells, an amount of working capital has to be available to finance current expenditure. This working capital should for instance cover:
- 2-3 months salaries and wages,

- 2-3 months milk payment to farmers,
- 2-3 months postal expenditure,
- 2-3 months expenditure on water, electricity, fuel, etc.,
- 2-3 months miscellaneous expenditure, like repairs, travel, meetings, public relations, advertising, etc.

The periods mentioned also depend on the moment payments have to be effected, i.e. immediately, in advance, or in arrears. This working capital is actually a necessary minimum starting-up capital, because from the moment the plant receives the first payments for the products it has delivered, the current costs can gradually be paid with this money. The revolving time of the money will be much shorter in the case of products that can be sold for cash immediately after manufacture, than in the case that the products must be stored for some time, e.g. because there is no immediate market, or because the products must undergo a certain ripening, e.g. some cheese varieties. The products in storage represent a certain value, i.e. a certain capital. Interest on this capital should be allocated as a cost item.

Many plants run into difficulties for lack of financial means to pay initial costs.

Depreciation. It is difficult to make suggestions for the costs of depreciation of vehicles, equipment and buildings, because depreciation depends on local conditions and the way the goods are used and maintained, and on the time it takes before it may be necessary to replace them because they have become obsolete e.g. new production techniques may have been introduced. Usually that moment occurs before the moment that the equipment stops being technically usable. But apart from these accelerated replacements, the following depreciation periods may be suggested:

- vehicles: 4 - 5 years
- equipment with movable parts: 8 - 10 years
- equipment without movable parts: 12 - 15 years
- buildings: 25 - 35 years.

Vehicles and equipment will have a certain residual value, e.g. 15 to 25% of their cost; usually, they will not be expected to depreciate beyond that residual value.

Variable costs

The most important variable costs are those of electricity, fuel, water and packaging materials. The more milk is processed, the more electricity is required for cooling, operation of equipment, etc., the more fuel is needed to produce steam for pasteurization, the more water is needed for cooling, the more products have to be packaged, etc., etc.

These costs vary with the amount of milk processed and therefore they are variable for the plant, but theoretically they are constant per kg of milk processed.

Remark. Several variable costs are actually partly fixed and partly variable (such as electricity, water and fuel), whilst many of the fixed costs are not completely independent of the amounts of milk processed. Going further into details would make this explanation too complicated. Therefore, and for practical reasons, it is assumed that there are only

two types of costs: variable ones, fluctuating proportionally to the amount of milk, and the fixed ones, independent of the amount of milk.

Raw material costs

Although certain ingredients, such as sugar, flour, essences, stabilizers, rennet, salt, etc. are used in the manufacture of a number of milk products, milk will be the main raw material for most products.

For most products, the milk is standardized to a certain fat content. The value of the standardized milk can be calculated by summing the values of the pure milk fat component and the skimmed milk component, as will be explained in Section 14.2.

If the demand for milk and milk products in the first years of operation is higher than the initial supply of raw milk, then milk powder and anhydrous milk fat can be used to compensate for the initial milk shortage. In this case the plant can start at a much higher throughput and the break-even point may be reached right from the start of operation. If the demand is higher than the raw milk intake, but still not high enough to reach the break-even point, the use of low-priced skimmed milk powder and anhyrous milk fat may lower the raw material costs and thus the production costs.

The cost price of the raw material, that is the mixture of fresh milk and recombined milk, can be calculated with the formula:

$$RM = \frac{(100 - X) \times M + X \times R}{100}$$

where:

M = the price per kg of fresh milk
R = the price per kg of recombined milk of the same composition as the fresh milk
RM = the price of 1 kg of the mixture
X = the percentage of recombined milk in the mixture.

A gradual replacement of the milk powder and the milk fat by fresh milk will increase the raw-material costs, but this will – or may – be compensated by an overall increase of the throughput of the plant as a result of an increase in demand.

11.5.1.2 The sale price of milk and milk products

The production costs (the cost price) of a product can be calculated by adding up the processing costs and the raw material costs (milk fat value and the skimmed milk value). This cost price is not necessarily the sale price of the product.

As long as the throughput of a newly established plant is low, the plant will have to sell its products below the cost price and to accept a certain loss. This loss will decrease as the throughput increases, until the break-even point at which the plant runs at neither a loss nor a profit is reached. Beyond the break-even point the plant will make a profit.

In Figure 26 a theoretical example is given of the development of the cost price per

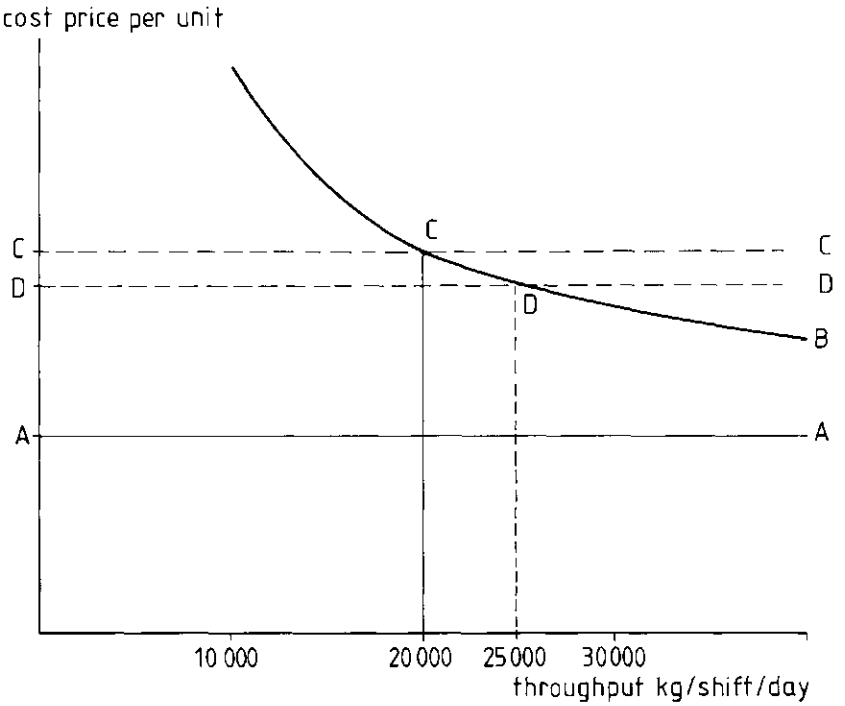

Fig. 26. Break-even point of milk processing. A, B, C, D: see text.

unit with increasing throughput. It is assumed that the milk plant produces one product only and has a daily capacity (one shift) of 30 000 kg. The cost price of one kg of that product at various throughputs is indicated by the points on line B. They consist of the fixed and the variable costs together with the raw material costs. The latter are indicated by the points on line A. These costs (variable plus raw material) have been assumed to be independent of the throughput (Section 11.5.1.1), therefore line A is a straight line. The difference between the points on lines A and B are the fixed costs (interest, labour, etc.). As explained before, they will gradually decrease per unit produced with the increase of the throughput, as is shown in Table 13.

If it is decided that the milk plant must operate at neither a loss nor a profit at the moment its throughput equals 2/3 of its capacity, the break-even point should be reached at 20 000 kg daily. At this moment the sale price of the product is found at point C. To the left of the break-even point the difference between the points on the lines B and C shows the losses per kg. To the right of the break-even point the profits are found in a similar way.

Clearly, that the sale price should be acceptable to the consumer. If no higher price can be obtained than a price D, the diagram shows that the break-even point is found at a throughput of 25 000 kg a day. It should be examined, whether – given the lean/flush ratio of milk intake (Section 8.2.3) and the capacity of 30 000 kg per shift – an average

throughput of 25 000 kg is possible or not. If not, the plant should either work in two shifts, or the capacity should be higher than the planned 30 000 kg. The consequences of this 'enlarged' capacity are discussed in Section 11.5.2. This re-emphasizes the importance of having a well-balanced lean/flush ratio of raw milk availability.

A proper diagnosis of future trends in milk availability will be helpful in determining how much time it will take for the plant to reach the break-even point and how high the initial losses will be.

11.5.2 The break-even point of feasibility

Within a number of years after the establishment of a dairy plant, the throughput should be high enough to reach the financial break-even point of operation. Only if this point can be reached within a reasonable period of time will the plant be financially viable.

Feasibility, and the relation between throughput and sale price can be estimated with a 'break-even point diagram', as the example shows.

Example. Starting from the principle that at least the variable costs with the raw material costs are compensated for by the sale price of the products, the difference between this sale price and the variable costs for one unit is named 'the gross proceeds'. The 'total gross proceeds' are found by multiplying the 'gross proceeds' of one unit by the total number of units manufactured. For a milk plant producing more than one type of product, the 'total gross proceeds' equal the total sale value minus the total of all variable costs, together with the costs of the milk bought from the farmers or the milk powder and butter fat used.

The 'total gross proceeds' increase in proportion to the throughput of the plant. These proceeds provide the funds to pay the fixed costs. In the diagram (Figure 27) the fixed costs for a milk plant with a capacity of 30 000 kg of milk per shift per day are represented by line A. The 'total gross proceeds' for various outputs in the event of a 'rather high' level of sale prices are given by line B_1 and in the event of a 'rather low' level by line C_1.

It is assumed that after two years the plant will operate at neither a loss nor a profit, and the break-even point has to be reached. As a result of careful studies and prognosis it is expected that at that moment an average throughput of 20 000 kg daily in one shift will be reached. The 'total gross proceeds' are represented by point B_2. At this point the processing costs of the milk are known, viz. the total of fixed and variable costs, divided by the throughput of the plant. If more than one product is produced, the cost price of a specific product can be calculated by dividing the total of all costs to be allocated to that product by the number of units produced.

If it is calculated that the cost price and consequently the sale price to the consumer is too high and not acceptable to the consumer, there are 3 possibilities, viz.:

- The variable costs, together with raw material costs, must be lowered, either by improving the efficiency of operation or by lowering the raw milk price offered to the farmer. The latter cannot drop below the level paid by the main competitors in the raw milk market.

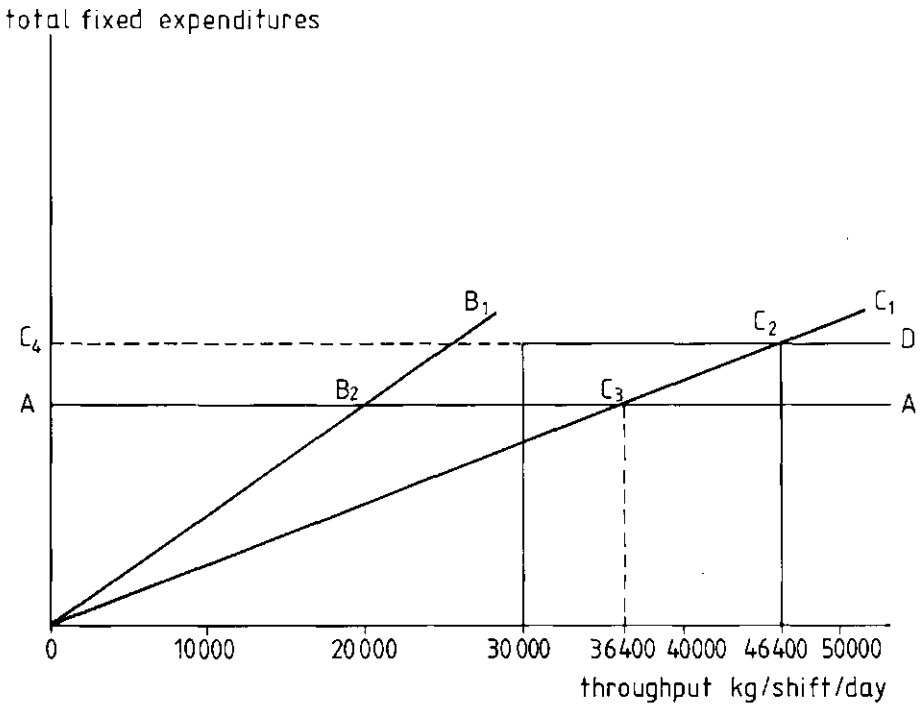

Fig. 27. Break-even point of feasibility. A, B, C, D: see text.

- The product mix should be changed and more profitable products will have to be manufactured, provided there is a market for these products. This may require additional investments.
- The possibilities of a higher milk intake should be considered, provided this extra milk is available or can be made available. There must be a market for the increased production.

If it is decided to set the sale price at a lower level, that is at a level more acceptable to the consumer, the gross proceeds will be lower and more product will have to be manufactured to reach the break-even point (it is assumed that there will be a market for the higher production). This point may be reached at C_3. However, in this case the required average throughput (36 400 kg) is higher than the originally planned capacity of the plant and provisions are necessary for an increased capacity. Such provisions can consist of more collection centres, more vehicles, extra or higher capacity equipment, etc. These 'extra' provisions require higher investments. A two-shift operation could also be a solution, but this requires more labour. In both cases, the fixed costs will be higher, for instance as represented by line D. This means that the break-even point will shift even further to the right. It will be found at point C_2, corresponding with a daily throughput of 46 400 kg of milk. It should be investigated whether this amount of milk can be made available in the future and how the initial losses, will be covered.

Sometimes, loans on soft terms can be made available for the establishment of a dairy plant. The soft terms can include a low interest and/or easy terms of redemption, e.g. granting a 'period of grace' (during the first years only interest has to be paid, and no redemption), or a long amortization e.g. as long as 30 years. In this case, the costs will – at least initially – be lower, and the break-even point can be met at a lower level of 'total gross proceeds'.

Remark. It should be realized that in practice it is not easy to make accurate calculations as shown in Figures 26 and 27, particularly if the calculations must be valid over a long period of time. It is difficult to forecast all cost items in advance. In particular costs of labour and the variable costs may create difficulties. Moreover, the product mix and the prices are subject to changes. Calculations are generally based on prices that will not change, but prices do change and not to the same degree. In spite of all difficulties, it is advisable to use the principles of this method and to make the analysis as accurate as possible, rather than to set up a plant without any feasibility study.

11.5.3 The profitability of dairy plants

The operation of a dairy plant should be remunerative. However, because dairy plants may also have a special function, such as supporting dairy farming or providing the population with safe and high quality products, they are sometimes subsidized. Nevertheless, it is important to analyse whether the investment[1]. for the establishment of a dairy plant is financially justifiable. However, certain effects of the establishment are difficult if not impossible to express in financial terms. Many dairy plants are financially marginal operations, but owe their existence to side effects (see Section 8.1).

There are various techniques for analysing the viability of projects, i.e. the establishment of dairy plants, taking purely financial aspects into consideration only. It is beyond the scope of this book to discuss the various techniques, but brief attention will be paid to two basic techniques: the calculation of the 'internal rate of return (IRR)' and the 'net present value (NPV)', because these are often used to indicate the expected profitability of a project. For more elaborate and detailed information and other methods to indicate the financial results, the relevant textbooks, and manuals should be consulted.

The calculation of the IRR and/or the NPV enables two questions to be answered:
- will a particular investment in a project be profitable or will it make a loss?
- if there is a profit, will this profit be attractive enough to justify implementing the particular project, or can the money (and consequently all other efforts) be better used for the implementation of another project? (again, it should be emphasized that social, environmental and other consequences may play a decisive role).

Since a dairy plant will usually only be fully profitable after a couple of years, and since as a result of various influences the financial results will differ from year to year, the analysis will have to take a number of years into account. When chosing the number

[1] No distinctions will be made in respect of the source of the funds used for the investment.

of years, two points should be considered:
- the longer the period, the more information can be made available, which – at least theoretically – will lead to a higher accuracy;
- the longer the period, the more difficult it will be to make an accurate prognosis for the far-off years.

In practice, the period of analysis can be determined by the estimated technical and/or economic life of the most important equipment (or installation) of the project. In dairy plants a period of about 10 years may be taken in this context. Although for the first set of equipment in a newly established plant, a period shorter than 10 years for the calculation seems justified (Section 11.5.3.6). Labour may still be insufficiently experienced and skilled in the beginning of a project, with the result that the equipment is subjected to heavier wear than normal.

The annual cash flows of an operation form the basic elements for the calculation of its profitability. The cash flow is the amount of cash received as a result of the operation of a dairy plant, and is not needed to effect current payments; in other words, it comprises all earnings before depreciation, but after taxation. In this sense, taxes only mean taxes on profit (which have to be paid), whereas depreciation includes all costs that do not lead to current expenditure,in other words which are not actually *paid* in cash or otherwise, viz. depreciation in the strict sense (on buildings, equipment, vehicles, etc.) and depreciation in the sense of additions to reserves, pensions and similar cost items. In other words, the cash flow of a dairy plant generally consists of all income from sales of products minus all payments for investments (initial and during the period of analysis), labour, raw materials e.g. milk, water and electricity, packaging materials, maintenance and repairs, etc.

The cash flows of the different years do not contribute equally to the profibility of the investment in a project.

If it is assumed that in a given situation the interest rate is 10% per annum, then an investment of 100 CU will yield exactly 110 CU after one year. After two years the yield would be 121 CU, assuming that the interest earned in the first year is reinvested, and so forth. This can be expressed in the following formula:

$$C_n = C_0 \times (1+i)^n$$

in which:
C_0 = the original amount invested
n = the number of years of investment
C_n = the 'future value' of the originally invested amount C_0
i = interest rate

Conversely, it is also possible to calculate the 'present value' of some amount to be obtained in future (called 'discounting'), as is given in the formula:

$$C_0 = \frac{C_n}{(1+i)^n}$$

Given i is positive, the formula shows that the present value of a sum that is to be received in future is always less than if that same amount were available at present. This is because an amount (the cash flow) received in the first year of a project can accrue to a larger sum of money than an equal amount (a cash flow) received in a later year of the project (actually, the cash flow in the first year of the establishment of a dairy plant will always be negative, because this is the year in which – most – of the investments for the establishment are made).

The basic principles explained above can be used to include the cash flows of all the years of the period of analysis, viz. CF_0 for the cash flow of the starting up period, CF_1 for that of the first year, CF_2 for that of the second year, etc., and CF_n for that of the last year. The total of all future cash flows will be:

$$CF_0 + CF_1 + CF_2 + \cdots + CF_n$$

whilst the total present value (C) of all cash flows over the life time (n) of the investment – using an interest rate of i – can be expressed with the formula:

$$C = \frac{CF_0}{(1+i)^0} + \frac{CF_1}{(1+i)^1} + \frac{CF_2}{(1+i)^2} + \cdots + \frac{CF_n}{(1+i)^n} = \sum_{n=0}^{n} = \frac{CF_n}{(1+i)^n}$$

This formula forms the basis for the investment analysis.

CF_0 is the cash flow of the pre-operational year, and since $(1 + i)^0 = 1$, CF_0 will be equal to all expenditures (including the investments) during the pre-operational year; in which year there will be no income.

11.5.3.1 The net present value (NPV)

The NPV is equal to the present value of all cash flows (years 1 to n) after deduction of the original investment, that is the negative cash flow of the pre-operational year = CF_0. In this case a certain interest is assumed, an interest which is considered acceptable. The NPV should not be negative, because this would mean that the yield of the project would be below the chosen interest rate. The NPV should be positive, if one expects the project to yield at least the same or preferably something more than the chosen interest rate.

11.5.3.2 The internal rate of return (IRR)

The IRR expresses the profitability of a project (in this case the establishment of a dairy plant) as a percentage (i) of the investment, if all cash flows over a certain period are taken into consideration. For this calculation the formula for C is used, in which $C = 0$. In this case the investment (represented by the – negative – CF_0 of the pre-operational year) is equal to the total of the present values of the cash flows over the years 1 to n.

In general, the application of the formula given above is relatively simple. The wide-

spread use of personal computers and the availability of 'spreadsheet programs' greatly reduces the effort of calculating an IRR, given various assumptions, in other words, it is easier than by entering various values for i in the formulae until the correct one is found.

The IRR can be calculated with and without inclusion of the costs of financing and the taxes on profit. If these costs are not included in the analysis, they must be deducted from the finally calculated IRR, in other words, in this case the net IRR is equal to the calculated IRR minus the percentage of interest and the taxes on the profit (see example Section 11.5.3.6). Only the resulting net IRR gives an impression of the profitability of the investment.

11.5.3.3 The accuracy of the cash flows

The main problem in the calculation of the IRR and the NPV is the correct estimation of the future cash flows. Mistakes in the estimations can be of decisive influence on the results. Many mistakes can be made in the analysis done to ascertain the feasibility of establishing dairy plants. The most important ones, leading to too favourable results and thus wrong decisions are:

- too low a raw milk price;
- too high a price for the manufactured products;
- the choice of a wrong product mix, e.g. products, which are not appreciated by the consumer;
- too high a throughput;
- too low consumption rates for water, electricity and auxiliary materials (chemicals, laboratory utensils, packaging materials;
- an insufficient working capital and means for advertising and public relations;
- unexpected increases of wages and insufficient funds for welfare expenditure;
- inflation and poor price policy

Sometimes, 'sensitivity analyses' are done, in which the IRR and the NPV are analysed under circumstances in which one or more of the basic data used for the calculation of the cash flows are less favourable than the expected estimates, e.g. analyses in which the throughput remains 10 or 20% lower than the prognosis. Sensitivity analysis may be very misleading if the initial prognoses are very optimistic and the sensitivity corrections are comparatively small.

11.5.3.4 The influence of inflation

Calculations of profitability are generally made under the assumption that prices will not change during the period of analysis, and ignoring possible inflation. But, inflation during the period that is being analysed will of course be reflected in the actual IRR. Since – in general – prices and wages tend to increase as a result of inflation, a few possibilities arise:

- If all costs (including wages and salaries) and prices increase to the same extent, there is no reason to calculate an IRR with inflated data. Theoretically, this IRR would be

higher than the non-inflated IRR by exactly the percentage of inflation.
- If all costs do not increase to the same extent, the IRR will be influenced by these differences. Corrections in the various prognoses used for the estimation of the basic data for the cash flows will be necessary, which complicates the analysis.
- If loans are taken out in other currencies and the inflation rates of the local and foreign currencies differ, relevant corrections for the net IRR will be necessary.

11.5.3.5 Economic analysis

In the previous sections, attention has exclusively been directed towards the financial interests of the dairy plants and their investors, but not to the national economy in its entirity. National economic cost-benefit analysis must give an answer about the economic viability of a project. For this, other yardsticks must be used than for the calculation of the purely financial viability of one particular project.

For the calculation of the economic viability, only those prices of goods and services that are a measure of their real value to the economy as a whole are used.

This means that taxes and subsidies are left out of the reckoning, and that labour costs are expressed in wages that would exist if these costs depended exclusively on the law of supply and demand, i.e. without the supporting activities of trade unions, unemployment benefits, etc. Although this subject is extremely important for the planning of national development programmes and economies, it falls far beyond the scope of this book.

For relevant information, specialized textbooks and manuals should be consulted.

11.5.3.6 Example of the calculation of IRR and NPV

In this simplified example, a dairy plant is established for the manufacture of standardized pasteurized milk, cheese with whey as a by-product, and butter with consumption

Table 14. Milk intake, product mix, payments raw milk and revenues from sale of products (x1000).

	Year							
	1	2	3	4	5	6	7	8
Raw milk received (kg)	8 000	9 900	11 800	13 700	15 500	17 400	19 300	21 100
Raw milk payments (CU)	48 800	60 390	71 980	83 570	94 550	106 140	117 730	128 710
Product mix:								
pasteurized milk (l)	5 000	6 200	7 400	8 600	9 800	11 000	12 200	13 400
cheese (kg)	260	321	381	442	493	553	614	665
butter (kg)	93	116	138	160	181	203	225	246
whey (l)	2 600	3 205	3 810	4 415	4 925	5 530	6 135	6 645
buttermilk (l)	227	280	334	388	439	493	547	598
Total revenues from sale of products (CU)	74 153	91 845	109 469	127 092	143 892	161 515	179 139	195 938

Table 15. Technical data and factory-gate prices of products.

	Fat content (%)
Raw milk	4.00
Pasteurized milk	3.00
Cheese milk	3.00
Cream for butter making	25.00
	Conversion factors (approximate values)
Cheese milk - cheese	0.10
Cheese milk - whey	1.00
Cream - buttermilk	0.70
Milk fat - butter	1.17
	Prices (CU / kg or l)
Raw milk	6.10
Pasteurized milk	9.17
Cheese	75.00
Butter	75.00
Whey	0.20
Buttermilk	5.83

N.B.: All data used in this example are fictitious and not based on any real-world case. Neither are they of any absolute value, nor can they be used for proportional comparison. The purpose of the example is purely illustrative, and no conclusions, whatsoever, as to specific projects can be drawn on this basis.

buttermilk as a by-product. The annual milk intake and the product mix are shown in Table 14, the technical data and the prices of the raw milk and the various products in Table 15.

Most of the project investments were made in the pre-operational year (year 0), together with some pre-operational expenditure, but in later years additional investments were made for equipment, vehicles and office furniture (Table 16).

The calculation of the cash flows required for determining the internal rate of return are given in Tabel 17.

It is assumed that taxes will have to be paid at a level of 35% on the net profits, that is the gross profit minus depreciations. As no consideration has been given to interest payments, which are normally deducted from gross profits, the amount of taxes paid in the example is somewhat high.

The working capital is based on 30 days sales (receivables) and 90 days costs of sales (inventory). The first means that the plant will normally receive payment for its sales after 30 days; the costs incorporated in these sales will have to be financed. The second means that the plant will have to hold and finance an inventory of various materials (butter, cheese, packaging materials, etc.) of 90 days of production. The minimum required working capital is set at 13 300 CU, equal to the working capital required in the first year of production. Thereafter, it is assumed that the plant will be able to finance the increase in working-capital needs out of its own funds generated from its operation.

Table 16. Investments in fixed assets and depreciations (x1000 CU).

Assets	Investment in year	Extra investments in year						
	0	1	2	3	4/5	6	7	8
Land	2 380	–		–		–	–	
Infrastructure	560	–		–		–	–	
Buildings	8 680	–		1 120		–	–	
Equipment	26 110	–		–		5 936	–	
Verhicles	1 820	798		1 365		1 822[1]	1 365[1]	
Utilities	14 700	–		–		–	–	
Office furniture, fittings	420	–		–		70	–	
Total	54 670	798		1 365		7 126	1 365	
Pre-operational expenditure	4 500	–		–		–	–	
Starting-up expenditure	3 590	–		–		–	–	
Total	8 090	–		–		–	–	
Working capital, permanent	13 300	–		–		–	–	

Assets	Percentage depreciation	Depreciations in year						
		1	2	3	4/5	6	7	8
Land	0	–	–	–	–	–	–	–
Infrastructure	10	56	56	56	56	56	56	56
Buildings	5	434	434	434	434	462	490	490
Equipment	12.50	3 264	3 264	3 264	3 264	3 635	4 006	4 006
Vehicles	20	444	524	660	797	797	933	1 070
Utilities	10	1 470	1 470	1 470	1 470	1 470	1 470	1 470
Office furniture, fittings	15	63	63	63	63	68	74	74
Total		5 731	5 810	5 947	6 084	6 488	7 028	7 165
Pre-operational expenditure	20	900	900	900	900	–	–	–
Starting-up expenditure	10	359	359	359	359	359	359	359
Total		1 259	1 259	1 259	1 259	359	359	359

[1] Replacement vehicles.

Table 17. Profit and expenditures statement, and cash flows (x1000 CU).

	Year								
	0[1]	1	2	3	4	5	6	7	8
Revenue	–	74 153	91 845	109 469	127 092	143 892	161 515	179 139	195 938
Expenditure:									
Payment raw milk	–	48 800	60 390	71 980	83 570	94 550	106 140	117 730	128 710
Wages supervisors	360	720	720	720	720	720	720	720	720
Wages labourers [2]	1 500	6 300	6 300	6 300	6 300	6 300	6 300	6 300	6 300
Do. variable [2]	–	–	–	1 134	2 331	3 465	4 662	5 859	6 993
Energy and water [3]	200	1 526	1 798	2 070	2 342	2 600	2 872	3 143	3 401
Laboratory materials [3] and chemicals	80	136	160	84	209	232	256	280	303
Packaging materials	350	2 088	2 587	3 085	3 584	4 070	4 569	5 068	5 554
Maintenance:									
buildings	–	290	290	290	290	290	290	290	290
equipment, etc.	–	1 632	1 632	1 632	1 632	1 632	1 870	1 870	1 870
Overhead (management, sales, administration, outdoor activities, etc.) [4]	1 000	4 413	4 455	4 504	4 546	4 585	4 663	4 711	4 751
Expenditure on vehicles	100	222	276	328	381	432	485	537	588
Unforeseen	–	100	100	100	100	100	100	100	100
Total expenditure	3 590	66 228	78 708	92 328	106 005	118 976	132 961	146 644	159 615
Depreciation	–	6 990	7 069	7 206	7 342	7 342	6 847	7 387	7 524
Expenditure + depreciation		73 218	85 777	99 534	113 347	126 318	139 808	154 031	167 139
Gross profit		935	6 067	9 932	13 744	17 573	21 707	25 107	28 799
Taxes (35%)		326	2 123	3 475	4 810	6 150	7 597	8 788	10 080
Net profit		609	3 944	6 457	8 934	11 423	14 110	16 320	18 720
Cash flow									
Total sources (net profit + depreciation)		7 599	11 013	13 663	16 277	18 765	20 957	23 707	26 243
Total investments		798	–	1 365	–	–	7 126	1 365	–
Working capital		13 300	–	–	–	–	–	–	–
Net cash flow	(67 760)	(6 801)	11 013	12 298	16 277	18 765	13 831	22 342	54 532[5]

[1] It is assumed that all pre-operational and starting-up expenditure is made in one year (year 0).

[2] A minimum amount of labour is required to operate the plant; if the milk intake surpasses 10 000 000 kg annually, an increasing amount of labour must be employed.

[3] The expenditure on energy, water, laboratory materials and chemicals consist of a basic amount for a throughput of 8 000 000 kg and an increase of 0.75 times this amount for every 8 000 000 kg (or proportionally for parts there of) above the basic throughput.

[4] The number of administrative employees and the office supplies depend on the throughput of the plant.

[5] Inclusive working capital and residual values.

For the calculation of the IRR (in 8 years of operation), the total of all discounted cash flows should be 0, or:

$$C = \sum_{n=0}^{n} \frac{CF_n}{(1+i)^n} = \frac{-67\,760}{(1+i)^0} + \frac{-6501}{(1+i)^1} + \frac{11\,013}{(1+i)^2} + \cdots + \frac{54\,532}{(1+i)^8}$$

The IRR (i) can be found using a computer and a spreadsheet program, or by merely trying and incorporating different values for i in the range of formulae. In the example it is 14.63%. This percentage must be interpreted with caution, because it still gives no guarantee that the project is financially feasible. The main cause for this could be that no loans for the investment can be obtained against this rate of interest for a sufficiently long period (in the calculation of the IRR no interest on investments is included).

If a discount rate of 10% is inserted for i in the range of formulae, a value for NPV (C in the range of formulae) will be found to be 15 593 CU. Whether this value (or rather the assumed value for i, i.e. a 10% discount rate) is acceptable, is open to question.

Sensitivity analysis

The sensitivity of the project has been calculated for 5 variations in the basic case:
1. An intake of raw milk at a level of 80% of the base case and a decreased production level of 20% for all products; under conditions of the same investments. All other costs have been adjusted accordingly.
2. A 20% decrease in the sales price of cheese.
3. A 10% decrease in all sales prices.
4. A 20% higher investment in equipment and other installations and vehicles.
5. A general 10% per annum inflation on production costs, whilst sales prices are only adjusted by 0.9 times the inflation level and with a delay of one year.

The results are summarized in Table 18.

Case 1. A drop in throughput leads to a lower IRR and NPV. As the main cost item is the costs of raw milk, the consequences of a drop in sales are offset by a drop in production costs. In projects where the processing costs of a dairy plant amount to a larger or a smaller part of the total costs of the manufacture of the products, the influence of the throughput can be larger or smaller.

Table 18. Sensitivity analysis for the estimation of IRR and NPV.

	Basic case	Case 1	Case 2	Case 3	Case 4	Case 5
IRR (%)	14.63	8.67	8.59	2.36	13.37	2.41
NPV[1] (CU)	15 593	- 4330	- 4519	- 24 099	11 915	- 23 267

[1] In all cases, the NPV has been calculated using a discount rate of 10%.

Case 2. The decline of the sales price of one product only – even if it is not the most important product of the mix – can have a relatively large influence on the profitability of a plant. This especially holds if such a product is a luxury product which is expected to allow for a high profit.

Case 3. A price setting of the manufactured products which is only 10% too optimistic, and consequently necessitates a lowering of the prices by 10%, will considerably lower the profitability of the plant.

Case 4. The fixed costs in general and the magnitude of the investments in equipment in particular are easily underestimated; not only because the prices of the equipment will prove to be higher than assumed, but especially because the expenditure on erection and the costs of erection materials often prove to be much higher than was expected. Similar experiences can be met with the investments in buildings and infrastructure. In this example, the consequences are modest, but their magnitude will depend considerably on the relation between the costs of investments and all other expenditure. In most cases the influence will be dramatically higher.

Case 5. This situation may occur in all cases where governments control consumer prices. It is not uncommon that inflation of costs cannot be passed on consumers immediately, and that governments – after a delay – permit sales prices to be increased by only a fraction of the general inflation. Also, the calculated IRR and NPV should be interpreted in a different way than in other – non-inflatory – cases. The IRR should be corrected for the applied inflation rate (10%) to obtain an impression of the real IRR. In this case, this real rate would be 15.66 - 10 = 5.66%. Also, the discount rate used in the calculation of the NPV would have to be changed. In this case the change is equal to the inflation rate. At a discount rate of, say, inflation plus 6%, NPV would be negative. Both figures clearly illustrate that the project will probably not be feasible under those circumstances.

This hypothetical example and the sensitivity analysis clearly show that the ratio between the raw milk costs on the one side and the other cost items on the other side have considerable consequences for the IRR and the NPV in general and for the sensitivity of the analysis in particular.

An accurate estimation of all costs and a correct setting of the prices of raw milk and manufactured products, as well as proper prognosis of future developments decisively influence the reliability of the outcome of calculations of the IRR and NPV of dairy projects. The answer to the question of whether the raw milk price will be attractive for the farmer and the price of the products acceptable for the consumer will be of particular importance.

As a general remark, it is stressed that in the example the cash flow does not reflect the effects of a possible use of borrowed funds. The cash flow should be at least sufficient to cover the debt service (interest + redemption) on borrowed funds. Another rough

approximation is to compare the IRR with the going interest rates. If the IRR is above those rates, the project would be feasible, although this does not take repayments of borrowed funds into account. The profitability of the dairy plant in this example is extremely marginal (Section 11.5.3).

Further reading

Baum, W.C., 1988. The project cycle (3rd. ed.). World Bank, Washington.

Commission of the European Community, 1976. Appraisal of productive projects in agriculture; economic analysis and rate of return; VIII/701/76, Rev. 4. EC, Brussels.

Helmers, F.L.C.H., 1977. Project planning and income distribution. Thesis. Veenman, Wageningen.

Irvin, G., 1978. Modern cost-benefit methods. An introduction to financial, economic and social appraisal of development projects. McMillan, London.

Meier, G.M., 1983. Pricing policy for development management. EDI Series of economic development (World Bank). The John Hopkins University Press, Baltimore.

Mishan, E.J., 1976. Elements of cost-benefit analysis. George Allen & Urwin, London.

Powers, T.A. (Ed.), 1981. Estimation accounting prices for project appraisal. Inter-American Development Bank, Washington DC.

Sasson P. & W. Schaffer, 1972. Cost-benefit analysis; a handbook. Academic Press, New York.

Squire, L. & H.G. van der Tak, 1975. Economic analysis of projects (World Bank). The John Hopkins University Press, Baltimore.

12 Organizational structure of collection centres and dairy plants

Collection centres either belong to dairy plants, or operate as independent enterprises, collecting milk and selling it to other parties, usually dairy plants. Independent collection centres are usually cooperatives, less often governmental or private enterprises.

Dairy plants may operate as:
- a private enterprise,
- a cooperative,
- a governmental enterprise.

12.1 Private enterprises

Private enterprises are primarily established to make profit. Therefore, they are usually located where their successful operation will be more or less guaranteed. The stimulation of dairy husbandry or the provision of the population with cheap products is not necessarily their main objective. On the other hand, it is not correct simply to assume that private enterprises are out to exploit farmers or consumers. Private enterprises may be in dependent or be part of a large – sometimes international – company. These enterprises often have the advantage of having sufficient specialists, capital, know-how and technical and technological backstopping at their disposal for a successful operation, whereas branches of international companies may be able to use well established and popular trade marks. The difficulty of introducing otherwise excellent products under a new name or trade mark in an area where the same products are already available under a well known trade mark is often underestimated.

It is sometimes claimed that private companies have quicker-reacting management than cooperatives and – at any rate – than government agencies.

Governments sometimes try to attract foreign firms by giving them special facilities, such as tax facilities, consents for transfer of profit, etc. Foreign firms may establish industries together with local firms, thus forming joint ventures and/or provide technical assistance and permit their brand names to be used, for which royalties are received. Governments may make specific provisions for the apportionment of the shares in joint ventures, e.g. prescribing that the majority of the shares should be held by the local firm, either immediately or after a number of years.

12.2 Cooperatives

The cooperative form of milk industry is often propagated on the strength of successes in dairy-developed countries. Although agricultural cooperatives have many advantages, this is not necessarily correct, not even in societies where the population has developed a strong community spirit. A number of reasons may be mentioned, such as:

- The farmers are individualists and have no understanding or comprehension of a co-operative movement, let alone that they are inclined to participate in a cooperative.
- Traditional marketing channels (often based on systems of credit or other obligations) are strong.
- Farmers only join cooperatives because they expect to receive loans on easy terms, or other services.
- Potential participants – especially small farmers – have no strong leaders for the management of the cooperatives, whereas large farmers may not be fully aware of the needs of the small farmers. Sometimes, cooperatives are run by outsiders. This may have the result that the farmers do not consider the cooperative as their own instrument.
- No trained and skilled staff and labour can be found to operate the cooperative; or, the members – being poor themselves – are not prepared to pay sufficiently attractive salaries and wages.
- The actual situation in the field does not change as a result of the establishment of the cooperative, because middlemen can also become members, or the cooperative even makes use of the services of the middlemen for the collection of milk.
- Supervision of the administration (managerial and financial) may be insufficient or even completely lacking. Abuse of confidence will seriously impair the cooperative feeling of the members.
- The members are not obliged to supply the cooperative with all the milk they produce, with the result that the cooperative only receives the milk surpluses (Section 8.2.3).

Cooperatives can generally only be introduced along gradual lines. And this way may prove to be a very long one. Governments and extension services can play an important role here. Sometimes, governments establish cooperatives to coerce farmers to subject themselves to an outlined policy, by giving cooperatives monopolies for supplying credits on easy terms, or for the sale of agricultural inputs, such as seeds, feed, fertilizers, etc., and the purchase and resale of agricultural products, such as milk. Although such a policy can be seen as an incentive to serve the interests of the farmers, it seldom imposes the cooperative sense.

12.3 Governmental enterprises

In an affort to avoid the possible disadvantages of private or cooperative industries, dairy plants are often established and run by governments. In such cases, governments may give loans or channel unilateral or bilateral foreign aid. Unfortunately, governmental plants are often organized like government administrations, and more emphasis is laid on administrative than on technological matters. A complete administrative staff will have

been appointed before one litre of milk can be processed. Moreover, there is sometimes a tendency to appoint too many administrative staff and labourers under the excuse that 'otherwise they will be unemployed'. If this is government policy, no objection can be made, provided that:

- The extra costs of labour are not passed on to the price of the product for the consumer.
- If the plant is taken over by a non-governmental institution, e.g. a cooperative, it will not be necessary to take over the excess staff and labour. It should, however, be realized that it will prove very difficult to decrease the number of employees, if a certain method of working has been created and consequently a certain division of labour has taken place.
- The employees do not hinder each other by the execution of their tasks.

In many countries employees may not be dismissed once appointed. In this case, a very careful policy of contracting people should be followed.

It is easily assumed that labour is cheap in most developing countries, but the sometimes high social expenditures and the low work output must be taken into consideration as well. Work output is often low because of the low level of mechanization and automation, which is low because labour is cheap; and since labour is cheap, it is not necessary to mechanize and to automate, with the result that the work output is low, etc. In other words, labour is considered cheap and – consequently – many labourers are employed, which makes labour comparatively expensive.

The investment required to replace one labourer can be roughly calculated (Table 19).

Table 19. Financial feasibility of costs of replacing one labourer.

The financially justified investment for the replacement of one labourer, earning 10 CU per hour, can be calculated with the formula:

$$I = \frac{W \times R \times D}{E} = \frac{8 \times 10 \times 312}{0.25} = 99\,840 \text{ CU}$$

in which:

I = feasible investment
W = man hours per day (8)
R = hourly wage (10 CU)
D = working days per year (312)
E = factor investment costs

Costs arising from investment (%) are:

Annual amortization of equipment	10	
Interest rate 10% of 50%	5	
Maintenance, repairs	3	
Insurance	2	
Various	5	
Total	25	$E = 0.25$

It must be borne in mind, that the purchase, the maintenance and repairs of equipment may require foreign currency

Further reading

Dülfer, E., 1974. Operational efficiency of agricultural cooperatives in developing countries. FAO Agricultural Development Paper, No. 96. FAO, Rome.

FAO, 1978. FAO/Netherlands expert consultation on national coordinating organizations and institutions for dairy development. FAO, Rome.

IDF, 1984. Dairy cooperatives. International Dairy Federation, Document 98.

IDF, 1985. International study of dairy cooperatives. International Dairy Federation, Bulletin 188.

NDDB, 1984. Milk procurement and technical inputs manual. National Dairy Development Board. Anand, India.

UNRISD, 1975. Rural cooperatives as agents of change; a research report and a debate. Geneva.

13 Payment for milk

Systems for payment of milk may be very simple or very complicated: they should be based on the amount and the composition of the milk and its hygienic quality.

Many factors have an influence which system is chosen, and the conditions under which it must be practised vary enormously. They depend amongst others on:

- The stage of development of the dairy industry. In the early stages, the system should be simple. More complicated systems can be introduced gradually.
- The educational level of the milk suppliers. It is very important that the suppliers understand the system of payment. If not, they may easily become discontented, because they will feel themselves too much at the mercy of the buyer, i.e. the dairy plant.
- The dairy legislation that is in force in the country or in the particular area.
- The readiness of the farmers to submit themselves to the system of payment. If they do not accept a system of payment for quality, or, for one reason or the other, do not agree with the quality assesment of their milk, they may decide to sell the milk to less critical or less quality-conscious buyers, even if the price paid by these buyers is lower than the price paid by the dairy plant.
- The importance of milk as part of the total income of the supplier. If this part is very substantial, the supplier may be more interested in supplying high quality milk than when his income from milk is just of minor importance.
- The requirements of the dairy plant. Different products may require different standards of quality, and specific tests may be introduced if this is important for the manfacture of specific products.

Every system of payment should satisfy two conditions, e.g.:

- The price to be paid must correspond with the value of the milk, which in turn depends on amount and composition, and on hygienic quality.
- The farmer must not merely receive a fair price, but should also believe that the price is fair. Therefore, all farmers should receive the same basic price, despite the fact that the collection of large amounts of milk (large suppliers) is cheaper than the collection of small amounts (small suppliers). It is often difficult to uphold this principle, e.g. if third parties start buying milk exclusively from large farmers for high prices.

Finally, it is extremely poor policy to accept milk in the lean season and to refuse milk in the flush season.

To encourage milk suppliers, it is not only important to pay an attractive and a fair price (Section 7.3.1), but also to pay at regular intervals. Although expensive, under certain circumstances it may be advisable to pay every day, at least in the starting-up period of milk collection. Unlike cash crops, milk procures the cattle owner or his wife (!) a

regular income, which is often used for 'every-day expenditures'.

No system for a quality programme (compositional and hygienic) can be established overnight; on the contrary, a gradual introduction of an understandable system is to be preferred. Systems practised in countries with an advanced dairy industry are often too sophisticated and consequently will not apply in dairy-developing countries. Programmes and experiences gained in the advanced countries should be critically evaluated to avoid the implementation of systems and tests that are impracticable in many areas of the world.

13.1 Payment on composition and amount

13.1.1 Payment for amount

Payment exclusively on the amount of milk is what the farmer generally expects and what is easily understood. If the milk is paid for exclusively on amount, no laboratory testing is required, but the system does not comply with the condition that payment should depend on composition. Moreover, the system encourages adulteration of the milk by fat (cream) extraction and water addition.

13.1.2 Payment for fat

If the milk is paid for fat content only, the farmer will be rewarded for his efforts to increase the fat content of the milk by proper breeding, whereas adulteration with water apparently does not pay, because it does not increase the amount of fat and there is no payment for the larger volume of 'milk'. However, adulteration does pay, if the farmer partly skims the milk and sells the part with the high fat content to the plant and the part with the low fat content to another buyer – for instance a private consumer – who does not pay for fat.

13.1.3 Payment for amount and fat

Payment for amount and fat is usually well understood by the farmer and it rewards him for his efforts to increase the fat content of the milk, whereas creaming the milk and selling low fat milk to the plant does not pay. A proper setting of the price to be paid for fat and for amount may meet some difficulties (Section 14.2). Adulteration of milk with water will still be profitable.

13.1.4 Payment for amount, fat and protein

Many countries have already introduced payment on protein. Protein is not only an important nutritive component of the milk, but it largely contributes to the yield in the manufacture of cheese and concentrated products, such as condensed milk and milk powder. If a system for payment on amount and fat content and protein content is intro-

duced, the part of the milk price that goes to the fat must precisely correspond with the value of the fat, i.e. the value of the fat in butter or ghee. If not, adulteration by creaming will be attractive. The remainder of the milk money (that is the total price to be paid minus the part that goes to the fat) must - in some way or other - be divided over protein and amount. Apart from being complicated, this system still makes adulteration with water profitable.

13.1.5 Payment for fat and protein

If farmers are exclusively paid for the fat and the protein content of their milk, the amount of milk they supply is only indirectly important, because more milk merely means more fat and more protein, and there is no payment for the amount of milk as such. With this system the adulteration of milk by removing fat (cream) or adding water does not pay. A proper price setting of fat and protein is, however, necessary (Section 14.2).

13.1.6 Payment for fat and protein with a deduction for amount of milk

Dairy plants producing concentrated products such as cheese, milk powder and condensed milk are more interested in large amounts of milk fat and protein (or solids-non-fat) than in large amounts of milk, actually water. The latter must be handled and processed, without directly contributing to the yield in dairy product, but bearing the full costs of processing. In this case an appropriate system of payment could be one in which the milk price consists of two elements, a gross price for fat and protein and a deduction per 100 kg of milk or part thereof to cover certain expenditures of the dairy plant, such as the costs of milk collection and processing, and various levies. The gross prices are equivalent to the values of fat and protein in a certain milk product; they include the processing costs of that particular product (Section 14.3). Sometimes, allowances are given for large amounts, lean-season supplies, etc., but the total of the allowances is always lower than the total of the deductions. A hypothetical example is given in Table 20.

This system has a large number of advantages:
- The farmer indirectly receives the full benefit of his efforts to increase the amount of milk, and is directly rewarded for increasing the fat and the protein content of the milk.
- Extraction of fat by creaming does not pay.
- Since it does not change the amount of fat and protein, the addition of water (deliberately or unintentionally) does not pay. On the contrary, it results in a larger volume of 'milk' and consequently a higher deduction for amount and, ultimately, lower proceeds

The total income of three farmers is compared in Table 21, with Farmer A supplying milk with a high fat and protein content; Farmer B supplying the same milk as farmer B, but with addition of 6% water; and Farmer C supplying the same amount of fat and protein but in a larger volume of milk.

Analyses for the protein content may be found to be too complicated for simple dairy plants. Therefore, a system similar to the payment for fat and protein can be followed, in

Table 20. Calculation of milk price based on fat and protein content with deduction for amount of milk.

Gross price per kg of fat		105	CU
Gross price per kg of protein		120	CU
Amount deduction per 100 kg of milk		170	CU
Fat content milk		4.10	%
Protein content milk		3.25	%
Calculation of payment per kg of milk			
Gross price fat	4.10 x 1.05	4.31	CU
Gross price protein	3.25 x 1.20	3.90	CU
		+	
Total gross price		8.21	CU
Deduction for amount		1.70	CU
		-	
Milk price to farmer		6.51	CU

which system milk is paid for according to its fat and solids-non-fat contents. A deduction for amount of milk may or may not be applied. Estimation of the fat content is generally accepted and not too complicated. The solids-non-fat content can be calculated if the density is known. The test for density is a simple one.

Table 21. Comparison of prices paid for milk supplied bij three farmers (A, B and C; see text).

Gross price per kg of fat	105 CU
Gross price per kg of protein	120 CU
Deduction for amount per 100 kg of milk	170 CU

	Farmer A	Farmer B	Farmer C
Milk supply (kg)	500	500	530
Added water(kg)	-	30	-
Fat content milk (%)	4.50	4.50	4.25
Protein content milk (%)	3.30	3.30	3.15
Total amount supplied:			
Fat (kg)	5.00 x 4.50 = 22.5	5.00 x 4.50 = 22.5	5.30 x 4.15 = 22.5
Protein (kg)	5.00 x 3.30 = 16.5	5.00 x 3.30 = 16.5	5.30 x 3.15 = 16.7
Gross price fat (CU)	22.5 x 105 = 2 362.50	22.5 x 105 = 2 362.50	22.5 x 105 = 2 362.50
Gross price protein (CU)	16.5 x 120 = 1 980.00	16.5 x 120 = 1 980.00	16.7 x 120 = 2 004.00
	+	+	+
Total gross price (CU)	4 342.50	4 342.50	4 366.50
Deduction for amount (CU)	5.00 x 170 = 850.00	5.30 x 170 = 901.00	5.30 x 170 = 901.00
	-	-	-
Payment to farmer (CU)	3 492.50	3 441.50	3 465.50

13.2 The adulteration of milk

One of the most lucrative ways for a farmer to make money is the adulteration of milk. This can be done in several ways:
- the addition of water;
- the extraction of cream;
- the addition of reconstituted (skimmed) milk;
- the neutralization of sour milk;
- the conservation of milk by the addition of preservatives.

13.2.1 Addition of water

Processing milk with an increased water content is disadvantageous to the dairy plant. Moreover, the water content of the milk can be so high that the legal standard for composition cannot be met.

Measuring the density of the milk is only a rough standard for the detection of addition of water. Addition of water will lower the density of milk, but the latter also depends on the fat and the solids-non-fat content, because, compared with water, milk fat has a lower density and skimmed milk has a higher density. This means that water added to low-fat milk will give the same density as high fat milk, as is shown in Table 22. This reduces the reliability of the density test for the detection of adulteration. Only large amounts of water can be detected with certainty.

The most reliable method for the detection of water addition is the determination of the freezing point. The freezing point is fairly constant, but it varies between species of milking animal (Table 23). Special difficulties in the interpretation of the test can be expected if milk of various species is received, or mixtures are supplied.

Table 22. Influence of composition and water addition on the density of cow's milk.

Assumed density:	skimmed milk	1.033
	milk fat (liquid)	0.92
Density of cow's milk with 4.20% fat (H):	$\frac{4.20}{0.92} + \frac{95.8}{1.033} = \frac{100}{H}$	
$H = 1.0277$		
Density of cow's milk with 3.00% fat (L):	$\frac{3.00}{0.92} + \frac{97.0}{1.033} = \frac{100}{L}$	
$L = 1.0292$		

Milk with a density of 1.0277 can be obtained from milk with a fat content of 3.00% (density 1.0292), by adding an amount of water equivalent to 5% of its volume.

Table 23. Density of milk from various species.

Animal	Density
Cow	1.029
Buffalo	1.031
Goat	1.033
Sheep	1.036

Table 24. The relation between the freezing point and the acidity of cow's milk.

Kind of milk	Freezing point
Fresh	- 0.533
Alcohol positive	- 0.541
Ditto, but neutralized	- 0.565
Clot-on-boiling positive	- 0.553
Ditto, but neutralized	- 0.611

Source: CMMB, Wageningen.

The breakdown of milk components in 'old' milk with an increased acidity will lower the freezing point (Table 24), as does the addition of preservatives, e.g. bichromate, to milk samples.

13.2.2 Extraction of cream

The extraction of cream (fat), by partly skimming milk can be disadvantageous to the dairy plant, especially if products with a high fat content are manufactured. It is practically impossible to detect fat extraction, because the fat content between species and individual animals shows a wide variation. Moreover, variations from day to day can be considerable. Only cases of extremely low fat content give an indication of adulteration. Therefore, this kind of adulteration must be made unattractive by proper payment on composition.

13.2.3 Addition of reconstituted skimmed milk

Cheap imported skimmed milk powder is often available on local markets. Reconstituting this powder to 'skimmed milk' and adding this product to fresh full-cream milk will increase the volume of milk and consequently is profitable to the farmer. Since the total amount of milk fat supplied with the milk will not change, although the fat content decreases, this type of adulteration will not affect the payment the farmer receives for supplied milk fat.

Adulteration of milk with reconstituted skimmed milk powder is extremely difficult to verify. Farmers may let the calf suckle before milking starts. Since the first milk has a

lower fat content than the last milk, the milk obtained will have a comparatively high fat content and will be very suitable for adulteration with reconstituted skimmed milk.

13.2.4 Neutralization of sour milk

Milk neutralized with sodium bicarbonate, sodium carbonate, calcium carbonate or similar products should be considered low-quality milk, less fit or unfit for the production of high-quality products.

Detection of neutralization involves complicated tests. Fortunately, milk suppliers find it difficult to determine the exact amount of the neutralizing agent required to bring the acidity back to normal; in other words, milk is often 'over-neutralized'. Regular testing of milk for acidity will detect milk, that has too low an acidity as a result of over-neutralization.

13.3 Payment for milk on hygienic quality

Payment for milk on hygienic quality is highly recommended, because:
- the processing of high-quality milk is one of the conditions for the production of high quality products;
- a farmer who pays much attention to the quality of the milk should be rewarded.

Milk which passes the platform tests is not necessarily milk of high hygienic quality. To test the milk for hygienic quality more elaborately, time-consuming tests must be performed. Actually, for the purpose of complete quality control, all milk should be tested every day, because it is not possible to preserve samples to be used for bacteriological examination. Since daily testing is uneconomic, random samples can be taken at irregular intervals, e.g. once every two weeks.

In view of the cost, not only the number of samples, but also the number and the choice of the methods is subject to limitations. Large-scale examination calls for routine methods which must be neither time-consuming nor costly. Payment for farm milk on exact determination of its hygienic quality is therefore not feasible.

The results obtained from analysing random samples give only a rough idea about the care paid to milk production and the quality of the milk but can be used to stimulate the farmers to follow an adequate daily routine. Major tests that can be introduced for the evaluation of the hygienic quality of the milk refer to:
- purity (filter test),
- bacteriological quality (reduction test or germination number),
- milk cell count (admixing mastitis milk),
- smell,
- residues (antibiotics, disinfectants, pesticides, etc.).

The tests can – of course – be combined.[1]

[1] Tests on composition and hygienic quality and their interpretation are discussed in the companion volume 'Dairy technology in the tropics and subtropics'.

13.3.1 The introduction of a system for payment on hygienic quality

The introduction of an adequate system, and even the introduction of new tests, often causes difficulties, because the farmers may not understand the purpose of the tests, let alone the interpretation of the results. Therefore, the system of payment for hygienic quality and the tests to be performed, with their financial consequences, should be cautiously and gradually introduced. Farmers' milk should be quality tested for a long period (e.g. 6 months) before any financial consequences are imposed. During this period, the farmers will become acquainted with the system and the test, and can be taught how better results can be obtained.

The interpretation of the tests on which the milk is graded and the financial consequences should be lenient at first, but can be tightened gradually as required.

For psychological reasons it may be found advisable to avoid designations like 'bad' and 'poor' in the system of classification, and deductions for poor quality milk should be avoided as well. In most cases it is better to distinguish a few classes only, for instance 'standard' (never 'normal') for the lowest quality and 'good' and 'excellent' for the better qualities. Standard quality receives the basic price, whereas good quality receives a small premium and excellent quality a substantial premium. It is not good practice only to tell the farmer what classification his milk has. He should also know the grading of all tests separately, so that he can trace and remedy the cause of low classification.

To ensure a correct system of payment, it may be necessary to adjust tests – and their interpretation – to new developments in milk handling and milk processing.

13.3.2 Purity tests (filter or sediment test)

Milk should not contain dirt or filth. To check the cleanliness, a sample of milk is filtered through a pressed cotton-wad filter in order to grade the wad on collected dirt, or it is centrifuged in a test tube of special shape and the amount and appearance of the sediment is judged.

The value of this test is not uniformly accepted. Farmers may be careless in milking and milk handling and may remove dirt by filtering the milk, believing that their negligence will be compensated for in this way. Since bacteria can pass through the farm filter, the bacteriological quality of the milk will not improve. It may even become worse, because dirt collected on the filter from a previous amount of milk will be 'washed out' by a subsequent amount, thus dispersing the bacteria in the milk. This can be avoided by changing the filter regularly; unfortunately, this seldom happens.

13.3.3 Tests for bacteriological quality

High bacterial counts in milk badly affect the keeping quality of the milk and the quality of the products manufactured from such milk. Therefore, milk supplied to a dairy plant should have a low bacterial (actually microbiological) count, and the milk should be tested accordingly. A number of laboratory tests can be performed.

13.3.3.1 Reduction test

This test is based on the ability of certain micro-organisms, e.g. lactic acid bacteria, to reduce certain dyes added to milk, thus changing their colour.

The methylene-blue reduction test (MBR test) is performed by adding a small quantity of methylene blue to the milk; micro-organisms change the colour of the mixture from blue to white during incubation.

The resazurin test (RES test) is performed by adding a small quantity of resazurin to the milk; micro-organisms will change the colour from blue through pink to white during incubation.

The time it takes to change the colour is an indication of the hygienic quality of the milk, which is classified accordingly. Both tests have a number of disadvantages:

- Not all micro-organisms have the same reducing capacity. Under tropical conditions, a flora of non-acid producing bacteria may develop in milk and ultimately spoil it by sweet-coagulation. These bacteria have only a very limited reducing capacity, if any.
- Bacteria in milk that has been stored over long periods at low temperatures (e.g. 4°C) are in a 'dormant' state and will not develop in the period that is normally set for this test.
- Milk with a high somatic cell count will show a short reduction time, even if the bacteriological quality is excellent .If the somatic cell count is also included in a system for scoring milk for payment on hygienic quality, the farmer may be punished twice for the same defect. Moreover, it raises the question of whether it is correct to punish a farmer who milks in a hygienic way, and who handles the milk with much care, for a high mastitis count in the milk, which is in most cases due to a disease (i.e. mastitis) of his animals. A farmer thus punished may become confused and may no longer believe in the necessity of proper milking and milk handling.

For these reasons, determination of the germination number is occasionally preferred.

13.3.3.2 Germination number

The intention of this test is to count the number of bacteria in milk after making them visible to the naked eye. In this test, a small amount of milk is mixed with a warm, liquid agar nutrient in a flat dish (Petri dish). Thereafter, the dish and its contents is cooled, whereby the contents solidify into a thin disc or plate. Then the dish and its contents is incubated a few days at a certain temperature. During this time the micro-organisms develop into colonies, which can be counted, thus giving the original number of bacteria in the milk, the so-called germination number or plate count. This is used to classify the milk in a number – usually three – of categories. The test is an empirical method, which has a number of disadvantages, such as:

- Some micro-organisms will be unable to develop under the conditions of the test, because of an unfavourable incubation temperature, the presence of oxygen, lack of essential nutrients in the agar, etc.
- Micro-organisms in groups will only form one colony. The number of colonies counted

will always be smaller than the number of bacteria present in the milk.

13.3.3.3 Other bacteriological tests

The value of the reduction test and the germination number is limited for more reasons than already mentioned. They merely give an idea about the extent of contamination, not about the kind of bacteria. The latter may be important in the manufacture of certain products, such as thermoresistant bacteria in the production of pasteurized milk and butyric acid bacteria in the manufacture of a number of cheese varieties. For this reason tests to count the number of specific bacteria have been introduced.

13.3.4 Milk cell count

Milk from cows suffering from mastitis usually shows an increased somatic cell count. Several tests can be used to estimate the number of these cells. Milk can be classified into various categories in accordance with the number of cells.

13.3.5 Smell

Although milk with a poor smell can be rejected at the point of collection, the smell can also be part of the system for payment, after classification into two or three categories.

13.3.6 Residues

Several residues may be present in milk, such as:
- Antibiotics, if the animal has been treated with an antibiotic.
- Oxydizing agents, to which certain detergents that are used for the sanitization of milking utensils belong. They are sometimes deliberately added to the milk in an effort to improve the keeping quality.
- Pesticides, which are used against plant diseases, insects, etc.

Milk may be tested for the presence of residues and the result of the test may be included in the system of payment.

13.4 Systems for payment on hygienic quality

All the tests mentioned above – and some additional ones – can be introduced in a system for payment on hygienic quality. Many of the tests require a well-equipped laboratory, which may not be available under field conditions. Moreover, if a system for payment on quality is started, it should not be too complicated in the beginning. Therefore, it seems advisible to start with a limited number of basic tests, namely:
- the MBR test or the germination number;
- the purity test and/or;
- the smell test.

Testing the somatic cell count of the milk should be introduced for extension purposes (veterinary services) rather than for payment on quality. Other tests, such as tests on residues, could be performed in well-equipped centralized laboratories, but whether the outcome of these tests can be included in the system of payment, or whether they will only be used for extension activities, will depend totally on local conditions.

Many variations in rating and scoring with the three basic tests are possible, but a generally accepted system is given in Table 25.

The lowest obtainable score is 0, the highest 18. Several systems for payment can be followed, e.g.:

- score 0 receives the basic price (e.g. 5.0 CU) and for every subsequent point, a certain amount of money is added (e.g. 0.1 CU),
- score 0 - 8 receives the basic price (e.g. 5.0 CU); score 8 - 12 receives a small (e.g. 0.6 CU) and 13 - 18 a substantial (e.g. 1.8 CU) bonus in money.

In both systems the maximum price will be 6.8 CU. The first system seems more acceptable for psychological reasons.

The scoring of a testing is used for all payments between that testing and the subsequent testing.

It is also possible to pay a basic price and to give penalty marks. In this case the maximum price is paid for the highest quality milk and deductions are made, instead of additions. However, deductions in a system of payment may not be advisable, as explained before (Section 13.3.1).

If more tests are included in the basic system shown in table 25, the number of scores could be extended, or deductions could also be included, particularly for the presence of antibiotics and oxydizing agents.

Table 25. Ratings and corresponding scores for a simple system for payment for milk on hygienic quality.

Test	Frequency	Rating		Score
1. Bacteriological quality				
a. methylene-blue reduction test	once every 2 weeks	I	(good)	4
		II	(moderate)	2
		III	(poor)	0
b. germinating number (colony-forming number/ml)	once every 2 weeks	I	(below 100 000)	4
		II	(100 000 - 250 000)	2
		III	(above 250 000)	0
2. Sediment test	once every 2 weeks	I	(good)	6
		II	(moderate)	2
		III	(poor) - very dirty swab	0
3. Smell	once every 2 weeks	I	(good)	4
		II	(poor)	0

13.5 Penalties for the adulteration of milk

All adulterations of milk (Section 13.2) should be severely punished, by giving penalties and removing the profit to be gained from adulteration, as will be explained in Section 17. Only if a milk supplier has already been punished for the addition of water, when a system of payment on composition with a deduction for amount of milk is practised as explained in Section 13.1.6, should no extra penalty be given. In this case it is nevertheless advisable to issue warnings to the suppliers, because they may not be aware that their milk contains unintentionally added water.

13.6 Sampling of milk

Samples can be taken from every delivery and be tested immediately thereafter. This method will give the most accurate insight into the composition and the hygienic quality of every milk delivery. It is labour-intensive and very expensive (Section 13.3).

Samples for testing the composition can be taken once a week or fortnight. They are tested immediately and the results of the tests can be used for the payment of all milk supplied between two samplings. This method is not very costly, but the results of the tests will hardly give a reasonable insight into the composition of the milk, because daily fluctuations in composition, especially fat content, can be considerable.

A good system of sampling of milk for composition is to make a composite sample. The milk is sampled every day during one or two weeks and all daily samples are pooled in one bottle. After the sampling period, the mixture in the bottle is tested. Composite samples should be stored under refrigeration, and a preservative (e.g. sodium bichromate or sublimate) should be added to prevent spoilage.

The hygienic quality of milk should be satisfactory every day, and the farmer carries the full responsibility for this. Therefore, samples for ascertaining the hygienic quality of milk can be taken at intervals of about one, or generally about two weeks. The intervals should be irregular, i.e. the period between two testings should never be the same number of days, and the farmer should not know on what day the milk will be sampled.

Testing for hygienic quality should take place as quickly after sampling as possible, preferably within 24 hours. The samples must be cooled even during this short period of storage. Preservatives may not be added! The sample bottles (and the stoppers) for milk which will be used for bacteriological tests, inclusive the MRB test and the RES test (Section 13.3.3), must be sterilized.

Samples for testing milk on composition or hygienic quality can be taken at several places:

- from the farm tank on the farm;
- from the containers (usually milk cans) in which the milk is supplied;
- from the bowl of the scale in which the milk from every supplier is weighed.

In the case of bulk-milk collection, where the milk is pumped from the bulk or farm tank into the road tanker, sampling takes place from the bulk or farm tank after the milk has been thoroughly mixed. The sampling spoon should be clean. If milk is delivered in

the original farmer's containers or milk cans, the sample can be taken from the container after its contents are mixed or from the bowl of the scale in which the milk of one farmer is poured out for weighing. If a farmer supplies more than one container, the milk will be sampled after all containers have been poured out into the weighing bowl, but it is also possible to sample the containers directly. In this case, a sample must be taken from every container after its contents have been thoroughly mixed. These samples must be mixed in the sample bottle. Stirrers and sampling spoons for the inspection of the bacterilogical quality should be rinsed and disinfected after sampling each farmer's delivery.

13.7 Dairy farm inspection

Some countries impose minimum standards of design, maintenance and hygienic condition for dairy farms, milking sheds and milk-storage rooms. The condition can be of influence on the price paid for the raw milk. Such an inspection system may promote, but will not guarantee hygienic milk production. A proper system for testing the quality of the milk will be indispensable and more valuable than any form of farm inspection.

Parts of this chapter (i.e. in the Introduction and Sections 13.1 and 13.3) are based on a lecture by the author that was published in: Milk - The vital force (1987). Proc. XXII Int. Dairy Congr. (The Hague). D. Reidel Publishing Company, Dordrecht, p. 233-238. ISBN 90-277-2331-1.

Further reading

AOAC, 1980. Official methods of analysis (13th ed.). Association of Official Analytical Chemists, Washington DC.

APHA. Standard methods for the examination of dairy products. American Public Health Association, Washington DC.

Bachmann, M., 1978. Quality control of milk in developing countries. In: Proceedings of the XX International Dairy Congress. Congrilait, Paris.

Berg, J.C.T. van den, 1986. Composition and quality of milk as a basis for payment of farmers. In: Proceedings of the XXII International Dairy Congress (The Hague). D. Reidel Publishing Co., Dordrecht, p. 233.

Berg, J.C.T. van den, 1988. Dairy technology in the tropics and subtropics. Pudoc, Wageningen.

Bernard, S.E., 1979. Sampling and collecting milk. Circ. 565. Pensylvania State University.

Davis, J.G., 1956. Laboratory control of dairy plant. Dairy Industries, London.

FAO 1972. Payment for milk on quality. FAO Agricultural Studies, No. 89. FAO, Rome.

FAO/WHO, 1973. Code of pricipies concerning milk and milk products (7th ed.). International standards and standard methods of sampling and analysis for milk products. FAO/WHO, Rome.

Foley, F. et al., 1974. Commercial testing and product control in the dairy industry. Department of Dairy and Food Technology, University College, Cork.

Harding, F., 1974. Design of a dairy laboratory. Dairy Industries 39:159.

IDF, 1984. Inventory of IDF/ISO/AOAC adopted methods of analysis for milk and milk products. International Dairy Federation, Document 180.

IDF, 1986. Payment for milk as a basis of quality. International Dairy Federation.

IDF, 1987. Integrated quality control and assurance. In: Proceedings XXII International Dairy Congress (The Hague). D. Reidel Publishing Co., Dordrecht, p. 815.

Lück, H.B., 1972. Bacteriological tests for bulk-cooled milk. Dairy Science Abstracts 34(2)101.

Rook, J.A.F., 1979. Somatic cells in milk, their significance and recommended methods for counting. International Dairy Federation, Document 114.

Tolle, A. et al., 1981. Laboratory methods for use in mastitis work. International Dairy Federation, Document 132.

Veisseyre, R., 1975. Milk technology, composition, collection, handling and processing of milk (3rd. ed.) (In French: Technologie du lait, constitution, récolte, traitement et transformation du lait). La Maison Rustique, Paris.

White, C.H. et al., 1978. Evaluation of raw milk quality tests. Journal of Food Protection 41:356.

14 Price setting and price structure

14.1 The basic price of raw milk

Apart from additions and deductions, which depend on the composition and the hygienic quality of milk, an average basic price has to be paid to all farmers.

It is often stated that the farmer should receive a fair price. This statement is based on social considerations rather than on reality, because it merely means that the farmer should not be cheated or exploited, which – of course – is self evident.

It must be realized that the requirement of a fair price raises many questions, such as:
- Should the price be fair in such a way that the farmer obtains a reasonable (if this can be defined) living from his dairy husbandry? And, if this is the case, how many animals should the farmer have as a minimum to make his dairy farming profitable? Or does a fair price mean that a certain (how much ?) income can be regenerated per animal?
- Should the income from other activities (e.g. in the case of mixed farming) be taken into account?
- What type of animal is the farmer supposed to have; specialized dairy animals or all-purpose animals, which are poorly productive?

These and many other questions should be answered, but most probably cannot be. Moreover, should only the price to be paid to the farmer be taken into consideration, and not the price the consumer has to pay? Or should a compromise be found, and if so, at what level?

Actually, three factors determine the basic price set:
- the existing raw milk price;
- the production costs of the milk;
- the 'break-even price' of the milk.

14.1.1 The existing milk price

Unless there is a milk surplus, a dairy plant will only be able to collect a sufficient amount of milk if a price that is generally received in the market is paid; and preferably, the price should be somewhat higher. An encouraging price should be paid, especially if a plant wishes to promote milk production and milk delivery. However, there are a number of reasons why it may be found difficult to pay the generally accepted price (Section 8.3.1). The main reason is that the ultimate price of the products will become too high for most consumers.

14.1.2 The production costs of milk

It seems fair to pay the farmer a price that corresponds with the production costs under conditions of proper management, augmented by a certain profit. However, it may not be found easy to calculate these costs. And if the costs are calculated for a number of farms, large differences will be found. Such differences may depend on the quality of farming, e.g. management and efficiency, or on circumstances that are beyond the farmer's control, e.g. quality of land, climate, etc. If the price is set too low, farmers may not be interested in milk production, or they may sell the milk to other parties; if the price is set too high, it may promote inefficiency in production and too many marginal farms will start production, whilst the products of the plant may become too expensive to the consumer. For a correct price setting, based on the production costs, three systems can be followed.

In the first system, a number of farms where conditions of milk production meet certain acceptable standards of efficiency and management must be identified. The price is then based on the average cost price on these farms. It is evident that this system will have many drawbacks resulting from the difficulty of setting standards of efficiency and management, and from the impossibility of ascertaining and assessing these standards on farms.

In the second system, a completely theoretical calculation is made 'from behind the desk'. This requires a profound knowledge of all farming conditions as well as the necessity of agreeing on standards, as described before.

For the third system, cost price analyses are made on a large number of farms, and it is decided that from the large range of different cost prices found, only a certain percentage – for instance 90% – must be covered by the milk price. In this case the remaining (in this example, 10%) production costs are considered to be too high for one reason or other. This means that some of the farmers will receive a milk price that is lower than their production costs. These farmers will not be fully compensated for their inputs in labour and capital, and many of them may stop milk production. This system raises a barrier against inefficiency and mismanagement, but many may raise objections from social motives. It should also be borne in mind that if farms stop production as a result of this system and the same percentage of acceptable cost prices is maintained, then every time the milk price is adjusted again it will be at a comparatively lower level, because a number of farms that used to receive a price that covered their costs will not be able to continue production for the newly adjusted price.

An example of the calculation of the production costs of milk is given in Table 26.

The farmer must have an income from his activities. This income should consist of:
- his labour on the farm;
- interest from his investments;
- a profit or his reward as an entrepeneur.

The income from labour and investments is included in the calculation. The income from labour should be equal to the money the farmer would have to pay if hired labour were to do the work presently done by the farmer himself and by unpaid members of his family. Two points should be taken into account:

Table 26. Hypothetical example of the calculation of the production costs of milk per cow per year.

Assumptions				
Number of cows on farm			5	
Value of pregnant heifer			19 800	CU
Productive years milking cow			5	
Meat value of cow			9 900	CU
Number of calves in 5 years			3	
Average value of calf (inclusive deduction for mortality) per cow			2 400	CU
Farmer's labour per year			1 500	CU
Amount of milk per lactation			2 600	l
Interest rate			10	%
Investment in cowshed (depreciation in 10 years)			880	CU
Investment in milking equipment (depreciation in 5 years)			200	CU
Expenditures				
Roughage (grass, bran)	3 660	CU		
Concentrates	2 370	CU		
Cow replacement CU 19 800/5	3 960	CU		
Interest for animal capital				
10% of (19 800 + 9 900)/2	1 485	CU		
Farmer's labour	1 500	CU		
Veterinarian/medicines/AI	330	CU		
Mortality risk cows	600	CU		
Miscellaneous	270	CU		
Amortization and interest on cowshed	136	CU		
Amortization and interest on milking equipment	20	CU		
Total expenditures	14 331	CU		
Revenues				
Calf 0.6 x 2400 CU	1 440	CU		
Manure	1 500	CU		
Meat 9900/5 CU	1 980	CU		
Total	4 920	CU		
Expenditures for 3/5 x 2600 litres of milk	14 331 - 4 920 =		9 411	CU
Production costs of milk per litre			6.03	CU

N.B.: There are enormous differences between the cost items and the revenues in different parts of the world. In this hypothetical example, all cost prices and revenues are fictitious.Neither are they of any absolute value, nor can they be used as a measure for proportional comparison of the various cost items and the returns.

- Only work directly connected with milk production may be considered. e.g. it is not correct to include the time required for feed production or raising calves in these wages, if the value of the feed produced on the farm or the value of these calves are already included in the cost price calculation.
- If the farmer or members of his family do not find a full-time job in milk production,

only the time actually spent can be included, and not the idle time or the time spent on other activities. His income as entrepreneur could be assessed at 10 or 20% of the total cost price (in the example 10% of 9411 CU), but usually the total income from dairying is lower than the total of the three sources mentioned above, even in countries with a developed dairy industry. A small farmer often hardly earns more than a labourer's income and his own property does not yield more than an assurance of employment.

The calculation in the example can be used for farms where the animals are kept mainly for the production of milk and possibly calves, with manure as a byproduct. If the animals are kept mainly as draught animals or rather for the production of bull calves, with a comparatively small volume of milk as byproduct, the calculation will not be accurate enough for the determination of the cost price of milk, because the income from milk will be disproportionately small in comparison with the revenues from the other purposes for which the animal is kept. The revenue from draught is difficult to assess.

14.1.3 The break-even price of the plant

If it is known what price the consumer is prepared to pay for the milk and the milk products, the price that can be paid for the raw milk can be calculated by using the break-even diagram (Section 11.5.1.2, Figure 26). It may be found that the resulting price is too low, i.e. not attractive to the farmers. In this case, a dairy plant will not be viable, unless subsidies are given. Other possibilities are the use of cheap milk powder, which can be mixed with the local expensive milk, or the production of other more profitable products, provided that these products are acceptable to the consumer.

14.2 The value of milk fat and skimmed milk

Once the basic raw-milk price is known, the part of this price that goes to the milk fat, and the part that goes to the skimmed milk must be estimated. This differentiation may be used for the payment of milk and for calculating the raw material costs in the manufacture of several milk products. An accurate calculation is very difficult, but an indication of a correct price for the two components can be obtained with the formulae used in the following example (all values in CU):

$$3.5 \times V + (100 - 3.5) \times S = 100 \times M$$

$$84 \times V + (100 - 84) = 100 \times B - C$$

where:

V = the value of 1 kg of milk fat

S = the value of 1 kg of skimmed milk

M = the price paid to the farmer for 1 kg of milk with 3.50% fat. The fat content in the formula (3.50%) should be equal to the average fat content of the raw market milk. If necessary, '3.50' should be adjusted in the formula

B = the cost price of 1 kg of butter with a fat content of 84%

C = production costs of 100 kg of butter. If the farm-gate price of 1 kg of butter is taken, C can be ignored. If the ex-factory price is taken, then C (= the costs of manufacture, that is the production costs exclusive the raw-material price) should be deducted.

If farmers produce and sell ghee, the price of the milk fat can approximately be set at the level of the farm-gate price of the ghee. The production costs of butter and ghee at the farm are ignored.

14.2.1 Calculation of the raw milk price

If the milk is paid according to amount and fat content, the raw milk price can be calculated as follows (all prices in CU):

$$M = \frac{(100 - F_f) \times S + F_f \times V}{100}$$

where:
M = price of 1 kg of raw milk
F_f = fat content of the milk in per cent
S = price of 1 kg of skimmed milk
V = price of 1 kg of milk fat.

14.2.2 Calculation of the raw material costs of various products

The raw material costs of various milk products depends on the composition of the milk used. A few examples will be given below (all prices in CU).

Consumption milk. The raw material costs of 100 kg pasteurized milk with a fat content of 3.50% can be calculated with the formula:

$$100 \times L = 3.5 \times V + (100 - 3.5) \times S$$

where:
L = raw material costs of 1 kg consumption milk.

Butter. The raw material costs of 100 kg butter, with a fat content of 84% can be calculated with the formula:

$$100 \times O = 84 \times V + (100 - 84) \times S$$

where:
O = raw material costs of 1 kg of butter.

It is assumed that the non-fat part of the butter consists of buttermilk and that there is no difference in price between buttermilk and skimmed milk.

Cheese. If it is assumed that 10 kg of milk are required to produce 1 kg of cheese, the raw material costs for the production of 10 kg of cheese, can be calculated with the formula:

$$10 \times K = 3.2 \times V + (100 - 3.2) \times S - 90 \times W$$

where:
K = raw material costs of 1 kg of cheese
W = the value of 1 kg of undiluted whey.

It is assumed that full-cream cheese is manufactured for which the milk must be standardized at 3.20% fat.

14.3 The gross price of fat and protein

The gross price for fat and protein (Section 13.1.6) can be calculated from the prices of cheese, butter and whey, as will be shown in the next simplified example (all prices in CU).

If the fat content of butter is 84%, the gross price per kg of milk fat is:

$$V_g = \frac{100}{84} \times B$$

where:
B = factory price of butter per kg.
The value of the non-fat part of the butter is ignored.

It is assumed that 10 kg of cheese can be made and 90 kg of whey will be obtained from 100 kg of standardized cheese milk with a fat content of 3.20% and a protein content of 3.25%.

If the factory price of 1 kg of cheese is K and of 1 kg of whey is W, the gross value of 100 kg of the standardized cheese milk (that is inclusive processing costs) will be:

$$10 \times K + 90 \times W$$

The gross value of the fat in 100 kg of cheese milk is:

$$3.20 \times V_g$$

The gross value of 100 kg of fat-free cheese milk in 100 kg of cheese milk is:

$$10 \times K + 90 \times W - 3.20 \times V_g$$

The gross price of 1 kg of protein is:

$$\frac{10 \times K + 90 \times W - 3.20 \times V_g}{3.25}$$

The gross price of protein, as it is calculated in this example is – as a matter of fact – not the price of the protein, but the price of the skimmed milk divided by the protein content of the milk. Nevertheless, the system is perfectly suitable for assessing the gross price of protein for the payment for milk on fat and protein with a deduction for amount of milk, as explained in Section 13.1.6.

By taking the prices of butter and cheese as 'starting prices' for the calculation, the processing costs of the milk are included in the gross price for fat and protein. Dairy plants not producing butter and cheese may object to this system. They can use similar systems adjusted to the products they manufacture. For instance, a milk plant mainly producing standardized liquid milk and butter can calculate the cost prices as follows.

The gross price of milk fat is:

$$V_g = \frac{100}{84} \times B \text{ per kg}$$

It is assumed that the fat content of the standardized liquid milk is 3.00% and the protein content is 3.25%.

The gross skimmed-milk value of 100 kg of fat-free liquid milk (inclusive processing costs) will be:

$$100 \times L - 3.00 \times V_g$$

where:
L = factory price of liquid milk per litre (actually kg).

The gross price of protein is:

$$\frac{100 \times L - 3.00 \times V_g}{3.25}$$

As explained before, payment for protein content is of little importance for milk plants only producing liquid milk products and butter.

14.4 The price policy

Governments are often inclined to control the raw milk price on the one side and the consumer prices of liquid milk and sometimes of milk products on the other side. This is done to guarantee a minimum price to the farmer, but in most cases the aim is to protect the consumer against high prices. A low raw milk price will not stimulate milk production, whereas a high consumer price will put milk out of the reach of many consumers, especially the vulnerable and poor groups. As a matter of fact, the interests of both parties are controversional. Since the processing costs and other expenditures of the dairy plants must be defrayed from the margin between the farmer's and the consumer's price, a critical situation may arise if in their efforts to satisfy the interests of both parties

governments leave a margin that is too narrow for an adequate operation of the plants (Section 11.5). This may result in:
- the dairy plant being financially unable to maintain its position;
- the dairy plant adding cheap milk powder and milk fat to the raw milk to lower the raw material costs;
- the dairy plant producing products that do not meet the legal standards, e.g. liquid milk with too low a fat content.
- the plant economizing on maintenance, repairs and replacement of buildings and equipment, thus becoming dilapidated;
- the dairy plant having to be subsidized.

Costs of milk production and milk processing generally show an upward trend, especially in countries with an inflationary tendency. This necessitates a regular adjustment of the raw milk price and the consumer's prices. If the price of raw milk is not increased in accordance with the increase in production costs, the farmers may lose their interest in dairying and milk availability will decrease. The sales prices of dairy plants must be regularly increased by amounts that compensate for the higher price of raw milk and the higher expenditures of processing.

Government milk plants sometimes do not change their sales prices sufficiently, even if the raw milk price is increased. Losses are compensated for by contributions from the exchequer. If this kind of subsidy is withdrawn for economic reasons, or because the government changes its priorities, sudden and drastic price increases are inevitable, otherwise the dairy plants will run into serious difficulties.

Further reading

Abbott, J.C. & J.P. Makeham, 1979. Agricultural economics and marketing. Intermediate Tropical Agricultural Series, Longman Group Ltd., London.

Fagard, P., 1980. Guidelines for dairy accounting. FAO Animal Production and Health Paper, No. 21. FAO, Rome.

Belloin, J.C., 1988. Milk and dairy products: production and processing costs. FAO Animal Production and Health Paper, No. 62. FAO, Rome.

15 The position of women in dairy husbandry

One should be careful not to generalize about the position of women in dairy husbandry in developing countries, because circumstances may differ from region to region and even from tribe to tribe. The actual position of women is in most cases determined by religion and tradition. Enormous differences exist. In some cases women hardly venture outside the home, even though dairying is one of their tasks. In other cases women are even responsible for the marketing of milk and milk products (Figure 28).

A number of aspects will be discussed in this chapter, but this does not mean that they are generally valid, because to assume as much would be to imply that men fulfil little if any agricultural role in third world countries. This contention is not correct, although it has been put forward in many - often emotional - publications. Probably one of the major causes why the position and role of women is still underestimated is because this topic does not receive the attention it deserves and hence is not accorded the necessary seriousness.

15.1 The position of women in the family

The position of the woman in Third World countries is to a considerable degree determined by her gender. Because families are generally large and the period during which a woman will have children is generally long, women will be more vulnerable than men and will enjoy less freedom of movement. As a result the woman becomes 'tied to the house' and responsible for specific tasks, such as:

- collecting fuel wood and fetching water;
- producing and cooking food (vegetable garden and kitchen);
- looking after small and large livestock;
- milking and processing of milk;
- selling agricultural products, in the market or on the doorstep, or to middlemen;
- looking after the members of the family;
- cooking for others;
- seasonal agricultural work (e.g. picking coffee);
- assisting in the cultivation of cash crops;
- home crafts;
- domestic employment.

Since men are less vulnerable and enjoy more freedom of movement, and are often

Fig. 28. Fulani girl selling nono (fermented milk) in a Nigerian village. Photo: Mrs. A. Waters-Bayer.

physically stronger, they have taken over other activities, such as:
- protecting family, relatives and tribe;
- hunting and fishing;
- tending large livestock (often herding domestic animals);
- cultivating land;
- producing cash crops;
- marketing crops;
- seasonal agricultural work for others;
- domestic or industrial labour;
- home crafts;
- attending meetings and taking decisions.

In the division of labour, the production of food crops (especially in subsistence agriculture) is generally assigned to women, whereas the production of cash crops is largely a male pursuit, although women often assist. There are, of course, many intermediate forms, especially in cases where there is a switch over from subsistence farming to farming for the market.

15.2 Historical background

The historical background of the division of labour as described above is not difficult to understand. In nomadic tribes, it was the task of men to protect women and children against attack and to herd the livestock. Women were given the tending tasks. For settled farmers, the situation was little different. Here, the men had to protect their families or tribe and to perform the arduous work, like cultivation of new land if the old fields were exhausted and infertile. Moreover, hunting and fishing to supplement the daily diet was their duty. As the need for men to protect their family and possesions became obsolete, an important part of their duties disappeared, whilst – seemingly – in most cases they did not take over a substantial part of the women's activities. This explains how 'attending meetings and taking decisions' became part of their duties.

15.3 Statistics

There are two ways of lying; the ordinary lie and the statistics

The activities of women in agriculture in the Third World are often underestimated, for which the statistics are to blame. A study done by the United Nations Development Programme showed that in many parts of the world, most of the labour for agricultural activities was female:
- Africa (sub-Sahara) 75 - 80 %
- Asia 60 - 80 %
- Latin America 20 - 40 %

There is no consensus about the reason for the disparity between Africa and Asia on the one side and Latin America on the other side. Some doubts have been expressed about

the accuracy of the UNDP data; the contribution of women – especially in Asia – seems to be very high. Nevertheless, it may be assumed that their contribution will be very important. A number of explanations can be given as to why the contribution of women is often underestimated:
- in surveys, men will be questioned. The man is the head of the family and will (intentionally or not) play down the part of women, to his benefit;
- the women (and their children) are ignored because they 'only' perform family labour;
- women's labour is counted, but it is given a lower rating e.g. one woman is 2/3 man;
- in subsistence farming, women are not considered to be economically active, and their labour is consequently not counted;
- surveys are done in periods of little labour activity, especially for women.

On the other hand, care must be taken not to include activities that are actually the manifestation of hidden unemployment.

Incorrect statistical estimates may have consequences for the forecasts of the creation of labour in projects.

15.4 The income of women

In cases where women in the subsistence sphere produce the food for their family themselves, the provision of the nourishment of the family will generally be guaranteed, except in the event of calamities, such as extreme drought. If the woman produces a little more than her family requires, she can sell the surplus to others, which brings in a small daily or weekly income. This income accrues directly to her family, specially if her produce is sold in the market or on the doorstep, because in this case she generally receives a higher price and is directly paid in cash. If the services of a middleman are necessary, extra income will be smaller, and may only become available once a week or every fortnight.

Intensification of the agricultural activities, e.g. as a result of a project to intensify dairy husbandry, either in number of animals or in the productivity of the animals, may have a number of consequences, such as:
- making the task of the women more arduous;
- the man taking over production.

In the former case there is a risk that the woman's task will become so arduous that she can no longer do it. Unless she gives up other tasks, the project for the intensification or improvement of dairy husbandry will fail. In the second case, there is a chance that the income from dairying will no longer go to the woman, but to the man instead, and it is not unlikely that he will use the money differently. A similar situation will occur if there is a change over from the production of food crops to cash crops, whether it be caused by a development project or not.

Finally, it should be realized that in most cases there is no guarantee at all that women receive any income directly from the sale of food-crop surpluses sold to cooperatives or other institutions. This may have repercussions on how these revenues will be spent.

15.5 Ownership of land

In many parts of the Third World there used to be no registered private ownership of land. Land belonged to the community and individuals only possessed a right of use. This right could be 'permanent', or it could be granted annually. In most cases, the right to land for arable farming was an individual right, but the right to pastures and other grazing land (e.g. on fallow arable land) was communal. The right to use land often belonged to women and was passed on from mother to daughter.

In cases of land reform, where the proprietary right of land is changed or officially registered, a few things may occur:

- the land will be collectivized. In this case the government may give concessions to companies, projects, state farms, etc. In all these cases the land is lost to individuals for the production of food crops or for animal husbandry; however, sometimes individuals have the right to graze animals on fallow land, or to grow food crops or keep animals on a restricted area.
- the land which originally belonged to big farmers or to state enterprises, is parcelled out to individual farmers. In this case it will be allotted to the head of the family, that is the man. In this case, the position of the small farmer can be improved, but it should not be taken for granted that the food situation of the individual families will improve considerably. Sometimes full ownership of land that was not officially owned by the families that used it (in subsistence agriculture, often the women, who used the land for the cultivation of food crops) is given to the individuals families. In this case it is generally recorded in the name of the man. This can result in:
- the situation not changing de facto, or
- in the man taking over the production of food, or
- in the man starting to produce cash crops (possibly encouraged by projects, government policy, etc.), or
- in the man selling the land to financially strong farmers.

In the latter case the land reform stimulates large holdings. The result is that the food position of the family will not be improved or even maintained.

15.6 Cooperatives

The establishment of cooperatives may worsen the position of the woman if this decreases her control over products that she originally sold on behalf of her family. In many countries women are not accepted as members of cooperatives.

15.7 Capital

In general, but fortunately not always, it will be more difficult for women to apply to the money market for capital to improve their agricultural activities.

15.8 Mechanization

Mechanization in agriculture is generally a matter for men. It may facilitate the farm-activities of women, but on the other hand, it may also deprive them of the opportunity of work, and consequently of income from labour.

15.9 Training and extension

Training and exension in agriculture are usually directed to men. Moreover, their domestic duties make it difficult for women to attend courses. Extension and courses organized for women are usually restricted to topics such as child care, nutrition, sewing and other household activities, and very rarely cover training and extension in agricultural subjects. If agriculture in general and dairy husbandry in particular is a specific task of women, it cannot be expected that they will be in a position to follow the development of techniques and that the results of new developments will be beneficial to their agricultural activities, unless the men attend courses and training and exercise an important supporting task.

When preparing educational projects and programmes it is necessary to consider whether the trainee or the person who attends a course or who is the target for the advice is indeed the person who is in charge of the particular activity on the farm. It is of little use to train men, if women are in charge of dairy husbandry.

The possibilities of training and advising women are often restricted, for traditional, religious and other reasons; moreover, women are often illiterate. On the other hand, it may be difficult to find qualified experts for extension and training, especially if they have to be women.

15.10 The planning of projects

Women often perform the greater part of the dairy-farming activities, especially in the smallholder farming areas, by completely undertaking, or at least participating actively in all phases of production, which may include the production of feed, grazing, feeding, health care, milking, and processing and marketing of milk. Therefore, it is extremely important that women are involved in the planning and development of projects for the improvement of dairy husbandry, and that their interests are guaranteed. If this does not happen, the ultimate results of the projects could be disappointing for the farmer's family.

Further reading

Anonymous, 1980. The right to work: for nothing. Ceres 13(3):15.

Chavangi, N.A. & A. Hanssen (Ed.), 1983. Women in livestock production with particular reference to dairying. Compilation of papers. FAO, Rome.

Chen, M. et al., 1986. Indian woman, a study of their role in the dairy movement. Shakti Books, New Delhi.

Dixon, R.B., 1982. Women in agriculture; counting labour force in developing countries. Population and development review (USA) 8(3)539.

Doorenbos, J. et al., 1988. Women and rationalization of smallholder agriculture. Agricultural administration and extension 28(2):101.

ILO, 1977. Labour force estimates, 1950-1970; labour force projections 1975-2000. ILO, Geneva.

Rogers, B., 1980. The domestication of women. Kogan Page Ltd., London.

Rojan-Aleta, I., 1979. A review and comparative analysis of roles and status and programs for Asian rural women. FAO, Rome.

Saeger, J. & A. Olson, 1986. *Women in the world. An International Atlas.* Pluto Press Ltd., London.

UNDP, 1980. Rural women's participation in development. Evaluation study No. 3. UNDP, New York.

WCARRD, 1976. The participation of women in the development of Latin America. World Conference on Agrarian Reform and Rural Development. FAO, Rome.

16 Training and extension

Illiteracy in general and lack of sufficient basic agricultural knowledge in particular are the most important impediments in the execution of projects for the improvement of dairy husbandry in developing countries. The consequences of agricultural knowledge that runs no further than the level of the traditional form of dairy husbandry are generally underestimated. Therefore, the introduction of improved dairy animals and production methods requires a drastic adaptation of the quality of management. This often proves to be extremely difficult. It requires intensive training and extension, and for this highly qualified teachers and extension workers must be available. These should possess certain qualifications, e.g.:

- they must be fully aware of the local situation, the traditions and the methods of farming that prevail in the area their trainees come from;
- they should not only have sufficient scientific experience, but should also have a technological and practical background;
- they must be able to communicate with the trainees on the trainees' level of education and practical knowledge;
- they should be master of all skills that they teach the trainees.

Before training and extension can start, it is often necessary to give teachers and extension staff additional training first.

Not seldom, farmers successfully follow an excellent training programme and acquire all proper skills, but once back on their own farm they relapse into their old traditional methods of farming. There are many causes for this, the principal one being that there is too great a difference between the level of the educational programme and the lessons on the one side, and the level of farming and the possibilities of putting the skills into practice on the other. Training must be pitched to the educational level of the participants and it should be carried out stepwise. Extension facilities should be available to assist the farmers to apply their newly acquired knowledge on their own farms. Not only must the level of training be attuned to the trainee's level of development, but the evironmental conditions must also be of the correct level. Training on a farm or institution that is far more sophisticated than the trainee's farm – in other words on a farm where he finds nothing familiar to him – seldom produces the desired results.

Too often, training programmes tell how things should be done, but do not show them how, let alone give them the opportunity to try for themselves.

Residential courses in institutes, may encounter difficulties, because farmers may be unable to leave their farm. This especially holds in all cases of training for women, if women are responsible for the dairy husbandry and associated activities. Children may

not be sent for education or training, because they must work on the farm. In this situation, preference should be given to an on-farm intensive training programme given by extension workers.

It must be borne in mind, that even if teaching and training is free of charge, attending such teaching and courses will always entail expenditures, such as clothing, books, pencils, travel, etc., which may form an insurmountable obstacle for the poor.

Fortunately, the importance of training dairy farmers to function in cooperatives and other institutions is increasingly being recognized. Overseas training in dairy-developed countries may be very useful to teach staff how to operate collection centres and dairy plants. However, they should be trained in centres and plants that can be compared with those in their own country, and not in highly computerized and automated plants. Training of maintenance staff and mechanics for dairy equipment and transport vehicles is highly recommended; too often, too little or no attention is paid to this.

Training teachers and extension workers abroad is wasted if there is no guarantee that the trained persons will occupy the posts for which they are trained. Measures should be taken to prevent trainees from feeling that they are an élite and consequently 'too superior' to perform their original job.

Dairy husbandry projects will only succeed if underpinned by an intensive extension service. This is as important as a properly organized and qualified veterinary service. The extension service must be in existence before a project is initiated. Although the services often do exist on paper, in practice they do not always function adequately, for a number of reasons, such as:

- Qualified staff with the appropriate motivation and mentality are not available. In many cases, it is not actually a matter of mentality or motivation, but that the responsible members of the staff are veterinarians who are experts in the field of veterinarian matters, i.e. diseases, rather than in the field of animal husbandry or dairy technology. Graduates from agricultural universities who are specialized in animal husbandry and all related fields of agriculture, are sometimes – in accordance to governmental regulations – automatically ranked below veterinarians, which is no incentive for joining the extension service or for the performance of their specialized task.
- Extension workers may be too theoretically orientated and be short of practical knowledge and an understanding of the needs of farmers (especially of small farmers).
- There is a lack of staff, and the available staff are hamstrung by administrative matters. Sometimes this can be used to shield them from problems that are beyond their expertise.
- The extension suffers from serious lack of means. Lack of transport is specially notorious.
- There is poor communication between extension worker and farmer, because of differences in level of education, which makes it impossible to communicate on the same wavelength. Moreover, the extension worker may be specialized in a different field of expertise (see previous points).
- The preference of the extension worker is directed to those who easily absorb his

knowledge, that is to the farmers of higher educational level, in most cases the larger farmers. These are also in a position to give the extension worker some kind of a remuneration for his service.

- It may be difficult to reach those members of the family who really need the extension worker's advice and information, especially if these are women.

Demonstration farms are often a very helpful means of showing farmers the profitability of new farming methods. Seeing the advantages of new practices is far more convincing to farmers than lessons on theory or abstract recommendations.

Further reading

FAO, 1979. Establishment of dairy training centres. FAO Animal Production and Health Paper, No. 15. FAO, Rome.

IDF, 1982. Education, training. In: Proceedings of the XXI International Dairy Congress (Moscow), Vol.2, p. 330; Brief communication, Vol.1, p. 659.

17 Legislation

For the dairy industry to develop soundly, adequate legislation must be enacted, because on the one side, the consumer must be protected against inferior products, whilst on the other side the dairy industry must be protected against unfair competition. Although it is beyond the scope of this book to discuss legislation in detail, a few remarks will be made:

- Rules and standards must be laid down to control the quality as well as the marketing of milk and milk products.
- Legislation must be adjusted to the conditions and the possibilities that prevail in the country or area concerned. Drastic and detailed standards and regulations that the industry cannot yet satisfy, should be avoided. It is better to provide general (not too specific) legislation, so that standards can gradually be raised by interpreting the regulations.
- Slavishly copying the dairy legislation of countries with an advanced dairy industry (the United States of America and Switzerland are favourite examples) is unjustifiable.
- No regulations should be stipulated if no proper means of inspection exist and an effective system for inspection and punishment of offences should exist.
- Legislation should be applied to local as well as imported products.

It is not possible to inspect everything and to take samples of everything. Inspection should take place at irregular intervals, so that it comes as a surprise. Only in this way will it have a preventive character. Whenever offences are observed, a penalty should be imposed and the profit of the farmer or dairy plant should be taken away, as is shown in the next example.

Example. A milk plant produces liquid milk with a fat content of 2.95%, whereas it should be 3.00% according to legal standards. If the plant produces 30 000 litres per day and the previous visit of the inspection service took place 12 days ago, the profit of the plant that has to be taken away amounts to (in CU):

$$12 \times 30\,000 \times \frac{3.00 - 2.95}{100} \times F$$

where F is the milk fat value in CU per kg.

If after 10 days the same offence is observed, the penalty should be doubled, and the amount that is taken away as profit could be multiplied by 1.5. Then it will be (in CU):

$$10 \times 30\,000 \times 1.5 \times \frac{3.00 - 2.95}{100} \times F$$

This system can be continued if the plant commits a number of consecutive offences during a certain period of time. The penalties can be increased every time, but there should also be a relapse if after a number of consecutive inspections no offence is committed.

The option of closing a plant that repeatedly commits offences against the legislation sometimes arises. However, it is better to look for other measures, because closing a plant may severely penalize milk producers (i.e. farmers) and consumers.

Although it can be asked to what extent governments must control or participate in the development of dairy husbandry and the milk-processing industry, the necessity of a – be it modest – government role in these developments cannot be denied. Unfortunately, a clear policy is often lacking and regulations are made and projects are implemented along lines of improvisation, without taking the milk chain (Section 1.3) and other developments into consideration. It is best to set up a specialized section for dairying in the Ministry of Agriculture. A dairy board can be very helpful in planning and enforcement, either in an advisory capacity, or in a regulating and controlling capacity, which may or may not need government sanction. Such a board should contain representatives of milk producers and the milk-processing industry, as well as government officials and consumers.

The development of a dairy industry is a long-lasting affair and it requires a very consistent government policy, especially in respect of legislative matters, the availability of development funds, the import policy, the price policy and the granting of subsidies.

18 Food aid

In the United Nation's Declaration of Human Rights, one of man's basic rights has been described as freedom from hunger. This can only be achieved if sufficient food is available for everybody.

It is extremely difficult to estimate the food availability per capita. FAO publishes national food balance sheets for most countries, giving the average energy and protein availability per person. When preparing the sheets, account is taken of estimates of national production, export and import figures, and stock changes for all food products, with deductions for seed and animal feed, manufactured non-food products and losses during transport and storage. These estimates cannot be very accurate; production in the subsistence sphere and local market sales are especially difficult to assess. By dividing the national availability by the number of the total population, the average availability per capita is calculated.

However, the distribution of the available food among the various socio-economic groups and also within the family, and restrictions resulting from a poor infrastructure, make the situation for many individuals in countries with a low level of food availability even worse than the average data imply.

Various estimates have been made about the numbers of undernourished persons in the world, but all estimates suffer from unreliability, because on the one hand the exact food availability is – as explained before – not known, whereas on the other, the exact minimum requirements in energy, protein and other nutrients that comply with good health and psycho-social well-being of various population groups are not exactly known (Section 19.3). Depending on the criteria applied, the number of undernourished people must lie between 200 and 500 million.

Many areas in the world which used to export cereals, (this includes rice and maize) are currently short of these products. The reasons for this include:

- The explosive growth in population, partly resulting from a higher life expectancy, made possible by improved medical care.
- Government policies that pay insufficient attention to the increase in the food production, which may not have a high priority, or which remains low because agriculture is lagging behind.
- Production costs of locally produced food products, such as cereals and milk, may be higher than the prices of those products available on the world market, which are produced very efficiently or whose export is subsidized. This may result in comparably low food prices, a disincentive to local farmers and even in a rural exodus.
- Acts of war and civil disturbances.

- Calamities, which are often caused by the explosive growth of the population, e.g. erosion, desertification, overgrazing of pastures, etc.

Food shortages and even famine are a frequent occurrence in Third World countries. This has led to large quantities of different kinds of food being supplied by donor countries.

Originally, the food was exclusively meant to improve the nutritional status of the suffering groups, but gradually food aid aimed at other objectives as well. At present the principal objectives are:

- The supply of food in acute emergencies, e.g. resulting from catastrophes in nature.
- The improvement of the nutritional status of vulnerable groups, like young children, pregnant and lactating women, and others.
- The performance of development programmes. In this case, the countervalue of the commodities is – in one way or another – used for the execution of the programmes, e.g.:

• the government receives the commodities and sells them to industries, institutions or private persons; the countervalue is used for pre-agreed development projects;
• the commodities are used directly, often on contract between donor and receiver for development projects, either as raw material (e.g. milk powder for milk plants, Section 8.2.7) or for the payment of labourers;
• the reinforcement of the treasury of governments receiving the commodities, without any particular application of the counterpart funds being stipulated by the donor.

The food aid may be supplied entirely free of charge or at a price which is below (often considerably so) world market prices.

Although food aid may solve problems of malnutrition and can stimulate development programmes, it should never be considered as a fundamental solution for any particular problem. Food aid can only be a temporary measure until the receiving country is able to solve its own nutritional problem or has finalized its sponsored development programme. This also means that to fulfil these conditions, the aid should be given for a period that is long enough to allow for the conditions to be implemented.

Further reading

Anonymous, 1986. Operation Flood; the intelligent use of food. The Courier No. 100, p.121.

Blau, G. et al., 1985. Food for development. FAO Economic and Social Development Paper, No. 34. FAO, Rome.

Briel-van Ingen, T. van den & A.P. den Hartog, 1985. Guidelines for dairy food aid. The Netherlands Nutrition Foundation, Wageningen.

FAO/UNFPA/IIASA, 1984. Land, food and people. FAO, Rome.

FAO, 1988. Food aid in figures No. 6 (annual publication). FAO, Rome.

Gittinger, J.P. (Ed.), 1987. Food policy: integrated supply, distribution and consumption. EDI series in economic development (World Bank). The John Hopkins University Press, Baltimore.

IDF, 1989. The world dairy situation (annual report). International Dairy Federation.

NDDB, 1984. Milk procurement and technical inputs manual, National Dairy Development Board, Anand, India.

Pronk, F., 1987. Dairy food aid. In: Proceedings of the XXII International Dairy Congress (The Hague). D. Reidel Publishing Co., Dordrecht, p. 317.

Rindell, R.C., (1987). Foreign aid reconsidered. Overseas Development Institute, London.
Singer, H., 1987. Food aid, a challenge and the opportunity. Oxford University Press, Oxford.
UNICEF/WFP, 1986. Food aid en well-being of children in the developing world. UNICEF, New York.
UN/FAO/WFP, 1981. Milk marketing and dairy development; operation flood I. FAO, Rome.

19 Milk in human nutrition

For the newly born infant or mammal, milk is a well balanced and almost complete food. Its main constituents, protein, fat and lactose or milk sugar, which supply building materials for the young animal, and energy are accompanied by a large variety of other nutrients: minerals, vitamins and other organic compounds. However, milk is comparatively short of iron and vitamin D, for which the young animal must depend on the reserves it received from its mother at birth.

19.1 Milk components

19.1.1 Proteins

The main proteins in milk either belong to the casein complex or to the whey or serum proteins. Casein can be coagulated by the addition of an acid or an animal or vegetable rennet. Whey proteins can be coagulated by intensive heat treatment. In both cases, the nutritive value is hardly affected.

Proteins, which can be considered as the organic carriers of nitrogen, are the main building material of most tissues and are part of many other substances in the human body. Their basic components are amino acids. The proteins are characterized by the number and type of their amino acids and the way these are arranged. Milk proteins are built up of 20 different amino acids and contain all amino acids the human body requires.

The proteins in the human tissues are in a constant process of synthesis and breakdown, whereby amino acids and smaller fragments can be reutilized for the synthesis of new amino acids and proteins. However, some of the amino acid is lost in this process, and after being broken down is secreted by the kidneys as urea. This part needs to be replaced by ingested proteins. Extra intake is also necessary for the production of new tissues in the case of growth of the individual or for the production of milk by lactating women or animals or for tissue repair after trauma or illness. Not all amino acids required by man can be synthesized in the human body, or rather, can be synthesized at a rate that meets the body's requirements. Adults need eight of these essential amino acids, which must be ingested with the food (Table 27). Growing children need one more (histidine).

There is an enormous variation in the composition of proteins of different origin, and not all proteins are of the same value to man. The proteins consumed by man must satisfy two conditions:

- they must meet the need for total organic nitrogen, ingested as protein;

Table 27. The essential amino acids.

Isoleucine	Threomine
Leucine	Tryptophan
Lysine	Valine
Methionine + cystine	
Phenylalanine + tyrosine	Histidine

Methionine and cystine, and phenylalanine and tyrosine can – at least partly – replace each other. Histidine is one of the essential amino acids for infants, but opinion is divided about whether it is essential for adults.

- they must meet the need for essential amino acids.

Proteins in which one or more essential amino acids are available at a proportionally lower level than required by the human body, will be of lower overall value than a protein in which all essential amino acids are available at the level that meets the needs of the human body. The essential amino acid that is relatively most lacking in a protein is called 'the limiting amino acid'. The greater the deficit of the limiting amino acid, the lower the 'biological value' of the protein will be.

The egg and milk proteins have a pattern of animo acids, that comes closest to the human requirements for growth. They have been given a grading of 100 for their biological value and were originally taken as the reference against which other proteins could be compared (with the exception of young infants, for whom the proteins were compared with the protein in human milk). Recently, on the basis of studies with humans, international WHO/FAO/UNU expert committees have proposed reference patterns of amino acids that are considered to be better adapted to different age groups (young children having higher needs for essential amino acids than adults (see Section 19.5.3).

The overall value of a protein for human beings, or actually for building human protein, also depends on the digestibility of the protein. Egg and milk proteins are almost completely digested, but many vegetable proteins are less completely digested. A measure that combines both these quality aspects is called 'net utilizable protein' (or NPU, which stands for 'net protein utilization'). It can be calculated by multiplying the digestibility by the biological value. If, for instance, 70 % of the protein is digestible and its biological value is 62, the NPU (in g per 100 g of that protein) is:

$$\text{NPU} = 70 \times \frac{62}{100} = 43$$

The lower the quality of a protein, the more of that protein must be ingested to meet the required amount of essential amino acids. If the quality of the protein is low and the protein content of the food is low too, then the situation may arise that more of the food than the body can physically ingest, or that can be made available to the consumer must be consumed to meet the requirements. Such a situation occurs – especially in children – in the event of protein malnutrition.

Table 28. The quality of various proteins.

Source of protein	Net utilizable protein (%)
Egg	100
Milk (cow)	90
Beef	80
Soya	68
Cereals	50 - 55
Pulses	45
Potato	55

It is of course possible to combine various proteins with different limiting amino acids in such a way that the proteins complement each other in the food, thus allowing for a higher net protein utilization than that of the individual proteins.

Animal proteins are more valuable man than vegetable proteins (Table 28).

Comparatively small amounts of cow's milk can satisfy the human requirements for essential amino acids. Moreover, cow's milk complements proteins in many foods which are deficient in certain amino acids. Milk protein contains a considerable amount of lysine, which is lacking in most vegetable proteins; notably cereals. Therefore, milk will be a very valuable component in most diets.

If young children consume 350 ml of milk daily, the proteins in this amount of milk will satisfy their total demand for essential amino acids.

There is no relation between the amounts (or rather the ratio of the amounts) of amino acids required by a growing child and those required by an adult.

It is sometimes claimed that the proteins in goat's milk have a lower biological value than those of cow's milk. It is doubtful whether this opinion is correct. On the other hand, the curd of goat's milk is soft and easily digestible. It is also claimed that children who do not tolerate cow's milk, because they are sensitive to certain compounds (specific antigens) may – in a number of cases – tolerate goat's milk.

19.1.2 Fat

The term 'milk fat' should only refer to the pure fat, but since the fat is associated with other fat-like substances, such as lecithine, cholesterol and vitamins, the term 'lipids' is often used for all fat and similar components that can be extracted from milk by ether. Pure milk fat consists of glycerol (12.5%) and fatty acids (87.5%). Fatty acids consist of a chain of carbon atoms linked to hydrogen atoms. At the end of the chain one carbonyl group is found. In most cases, a fatty acid is bound to each of the three alcoholic groups of the glycerol (triglyceride) (Figure 29), but sometimes there are only two fatty acids (diglyceride) or one fatty acid (monoglyceride). Fatty acids are characterized by the number of carbon atoms responsible for the chain length of the acid, i.e. short-chain (4-8 carbon atoms), medium-chain (10-14 carbon atoms) and long-chain (16 and more carbon

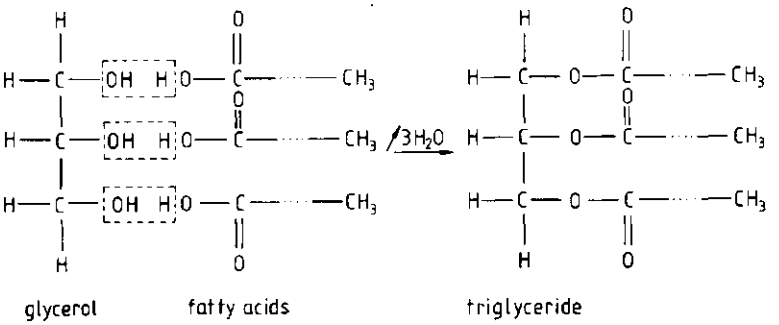

Fig. 29. Structure of milk fat.

atoms) fatty acids. Fatty acids with more than 10 carbon atoms may be saturated or unsaturated. In the saturated fatty acids, all adjacent carbon atoms are linked with a single bond. In the unsaturated fatty acids two (mono unsaturated) or more (poly unsaturated) adjacent carbon atoms are linked with a double bond (Figure 30).

Like the milk fat of all ruminants, cow's milk fat is rich in short-chain and medium-chain fatty acids, to which beneficial effects are credited. They are more easily absorbed than the long-chain fatty acids, but they are also more susceptible to oxidation. The fat of sheep's and goat's milk is characterized by a still higher content of short- and medium-chain fatty acids than the fat in cow's and buffalo's milk. The last mentioned is particularly rich in long-chain fatty acids.

Human milk is comparatively poor in short- and medium-chain fatty acids. Unlike butter, most other fatty products contain few short-chain fatty acids.

The content of saturated fatty acids in cow's milk is comparatively high and, the content of poly-unsaturated fatty acids is low. Human milk contains more mono- and poly-unsaturated fatty acids than cow's milk. The levels of unsaturated and poly-unsaturated

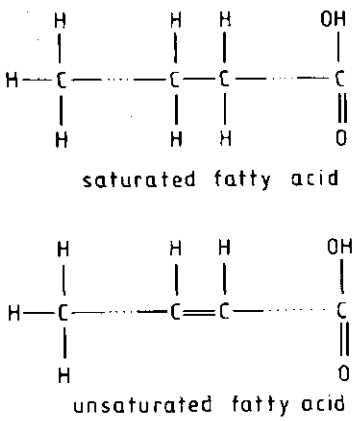

Fig. 30. Diagrammatic representation of fatty acids.

fatty acids in milk largely depend on the feed and food consumed by the lactating mammal.

Poly-unsaturated fatty acids (especially found in the phospholipids) seem to be important for the functioning of the human body. These so-called 'essential fatty acids' are very unstable, because they are easily oxidized.

Milk fat serves as the principal energy supplier in the milk and the carrier of a number of other substances. Lactose and proteins supply less energy.

19.1.3 Lactose

Lactose, or milk sugar, is the carbohydrate of milk. It is a disaccharide, consisting of one glucose molecule and one galactose molecule. Lactose supplies energy and plays a role in the absorption and utilization of calcium. Moreover – together with the milk salts – it is responsible for the isotonic balance between milk and blood. Milk sugar may, because of its sweetness, make milk tasty to the baby or young animal and consequently stimulate suckling. There are also disadvantages attributed to lactose, such as the acidification of milk by the action of lactic acid bacteria. This disadvantage, however, is fully compensated for by the preservative activity of the acid in suppressing the growth and action of pathogenic and putrefying bacteria (Section 20).

Unfortunately, many people are intolerant or poorly tolerant of lactose. Under normal conditions the lactose is hydrolysed in the gut by the enzyme lactase into glucose and galactose. These monosaccharides can be absorbed from the intestine by the blood, although rare cases of galactose intolerance are known. Moreover, these monosaccharides can be converted into lactic acid creating an acid environment in the gut, in which pathogenic and putrefying bacteria cannot develop.

Large groups of the world population – especially non-Caucasians – loose the ability to hydrolyse lactose, because the production of lactase diminishes and sometimes even stops after weaning at an age of two to three years. As a result, lactose will not be hydrolysed, or only in a diminished degree. This will decrease the capacity of sugar (hydrolysed lactose) absorption by the blood and may lead to abdominal pressure, stomach ache, flatulence and diarrhoea. This phenomenon primarily occurs in populations that have no tradition of continuing milk consumption after weaning. The phenomenon is hardly found in 'milk-drinking populations'. Representatives of populations that do not drink milk cannot prevent loss of lactase production by continuing to consume milk after weaning.

The total or partial loss of lactase production (low lactase activity) is generally termed as lactose intolerance, but some investigators distinguish lactose malabsorbtion (an indication that it is only the sugar that is not absorbed) and lactose intolerance (an indication of the non-absorption of the sugar accompanied by clinical symptoms).

The lactase activity is measured by administering 2 g lactose per kg body weight – up to a maximum of 50 g – and checking thereafter whether the sugar content of the blood is sufficiently increased.

Lactose intolerance does not necessarily mean that milk will not be tolerated, because

the intolerance is seldom absolute and small amounts of milk (250 to 500 ml) spread over a day will usually be accepted without disturbances. In most cases, sour milk products are tolerated absolutely or better. It is not fully understood why, because only a maximum of 40% of the lactose in these products will be converted into lactic acid, leaving 60% still available. The lactic acid bacteria of the sour-milk products generally do not survive passage through the stomach, but their enzymes may do, and they may continue their fermentation in the intestine.

There are three different types of lactose intolerance:
- lactase deficiency from birth; this seldom occurs;
- primary lactose intolerance; the ability to hydrolyse lactose is lost after weaning;
- secondary lactose intolerance; the ability to produce lactase is reduced or lost as a result of undernourishment or gastroenteritis. In this case the lactase production is usually regained after recovery.

19.1.4 Minerals

19.1.4.1 Calcium and phosphorus

Calcium in the food is important for building up and maintening the skeleton and the teeth, which contain about 99% of the calcium in the human body. Vitamin D is of major importance for the regulation of the calcium metabolism, and lactose plays a role in the intestinal absorption of this element.

Calcium is especially important for growing children, expectant and lactating mothers and the elderly, especially women. Deficiences of vitamin D (if the skin of the body is insufficiently exposed to the sun) and of calcium generally lead to rickets in children. The consumption of milk and milk products is extremely important for providing the body with the required supply of calcium; especially for the groups mentioned above.

Like calcium, phosphorus is an important element for the skeleton and the teeth.

19.1.4.2 Iron

Milk is poor in iron, which is an important element for the formation of red blood cells.

19.1.4.3 Trace elements

Milk contains a large number of trace elements, which are all believed to be essential for the young creature. However, it is difficult to assess their importance, because various elements may enter the milk by contamination, either directly through the body, or indirectly after production (milk is easily contaminated by copper and iron from the milking utensils).

Some elements, like iodine, which are ingested with the food in increased quantities are excreted with the milk. Heavy metals in the food are largely retained in the body.

19.1.5 Vitamins

Milk contains fat-soluble and water-soluble vitamins. Vitamins A, D, E and K belong to the former, and the B complex and vitamin C belong to the latter.

The vitamin content of milk varies between species. The content of some vitamins in milk depends entirely on their intake with the food. Other vitamins can be synthesized by the body. Ruminants are able to synthesize more types of vitamin than non-ruminants.

19.1.5.1 Vitamin A or retinol

Deficiency of vitamin A in the human diet results in a cessation of growth, defects in teeth and keratinization in the epithelium in various parts of the body. It causes diseases of the eye, which may lead to complete blindness. Moreover, it may cause a diminished immune response, i.e. greater susceptibility to infectious diseases. Milk fat forms an important source of this vitamin. Apart from the vitamin itself, provitamin A or carotenoids contribute to the vitamin A activity of milk. Ruminants, and non-ruminants depend totally on their intake of feed for their supply of vitamin A and provitamin A. The carotenoids of the feed are converted into vitamin A in the intestinal wall. The efficiency of conversion by goats, sheep and buffaloes is very high and, contrary to cows, no carotenoids are found in their milk fat. Carotenoids are responsible for the yellow colour of the fat of cows. The milk fat of goats, sheep and buffaloes is white. Vitamin A is mainly stored in the liver.

19.1.5.2 Vitamin D or calciferol

Deficiency of vitamin D leads to a decreased growth and a reduced deposit of calcium and phosphorus in the skeleton and the teeth, leading to rickets in children (Section 19.1.4.1). Elderly people suffering from low calcium deposits are susceptible to fractures of bones, which are difficult to cure. A low calcium intake in youth may manifest itself at an older age.

The vitamin D activity resides in a number of structurally similar compounds, of which vitamin D_2 and vitamin D_3 are the principal forms. Vitamin D_2 or ergocalciferol is the vegetable form, produced in plants by solar irradiation acting on its provitamin ergosterol. Vitamin D_3 or cholecalciferol is produced by solar irradiation acting on its provitamin 7-dehydrocholesterol in the skin of man and animals. Both vitamins are equally active in man. Vitamin D is stored in the liver.

The natural vitamin D content of milk largely depends on the food and the amount of sunlight to which man and animals are exposed. The vitamin D content of domestic milk may be too low to meet the requirements of children who still mainly depend on milk as their major food and are poorly exposed to sunshine. For this reason, milk is sometimes enriched with vitamin D.

Non-Caucasian children from tropical and subtropical countries, may show a lower efficiency in the transformation of the provitamin in the skin if they are transferred to the

temperate zones, than the Caucasian children indigenious to these zones. Consequently, the former group of children is more susceptible to rickets in countries where sunshine does not abound.

19.1.5.3 Vitamin E or tocopherol

Milk does not seem to be a very important source of vitamin E for man. The content in milk depends on the quality of the feed. It acts in the body as biological anti-oxidant.

19.1.5.4 Vitamin K

Milk is a poor source of vitamin K to man. Deficiency of this vitamin causes haemorrhages (retardation of the clotting time of blood, leading to bleeding).

19.1.5.5 The vitamin B complex

The vitamin B group consists of a group of different water-soluble vitamins that have little relation in function and structure. The vitamins of this group are of vegetable origin, but are also synthesized by micro-organisms in the rumen of ruminants, which do not need a supply in their feed. The levels of these vitamins in the milk of ruminants is fairly constant. Non-ruminants depend on the intake with their feed.

With the exception of children still depending on milk as their only or most important food, milk cannot be considered as an important source of the vitamin B group, although it may form an important source of riboflavin in the human diet.

Vitamin B_2 or riboflavin. Riboflavin is a pigment which gives whey its greenish-yellow colour. It is involved in the enzymatic oxidation of various organic compounds in metabolic processes. The major symptoms of deficiency are lesions of the skin and mucous membranes.

19.1.5.6 Vitamin C or ascorbic acid

Vitamin C plays an important role in metabolic processes in general and the maintenance of intercellular material in the body of man and animals in particular. Ruminants are able to synthesize the vitamin themselves, but non-ruminants depend on the amount of this vitamin contained in their diet. Regular supplies are required, because it is poorly stored in the body.

The typical symptoms of the deficiency of this vitamin are lassitude and decreased resistance to infections. More serious symptoms are haemorrhages in various tissues, leading to the disease scurvy.

Vitamin C is easily oxidized, especially in the presence of light.

19.1.6 Other compounds

Apart from the vitamins mentioned already, milk contains a number of other factors important for the functioning of the human body. Milk contains a number of bacteriostatic compounds that protect the baby or young animal against infectious diseases. They include lactoferrin, the immunoglobulins and the bifidus factor (Sections 19.5.6, 19.5.7).

19.1.7 Enzymes and hormones

It is doubtful whether the enzymes in milk are important from a nutritional point of view, although lactoperoxidase has bacteriostatic properties. The importance of hormones in milk is still not fully understood.

19.2 Losses of nutritional value during processing

19.2.1 Heat treatment

Various systems of heat treatment are applied in the dairy processing industry, the main ones being:
- high temperature - short time pasteurization (HTST) during 15-20 seconds at 72-74°C;
- ultra-high-temperature sterilization (UHT) during 3-10 seconds at 135-150°C;
- in-package sterilization during 10-25 minutes at 110-125°C.

Both normal pasteurization and UHT treatment preserve the nutritive value of the various compounds in milk in a similar way. With increasing intensity of heat treatment, more damage is done to various compounds, but only in-package sterilization seriously affects certain compounds, as will be discussed below. Excessive heat treatments will not be dealt with.

19.2.1.1 Proteins

Coagulation of proteins. The casein in milk will only show minor changes in the physical properties as a result of heat treatment. Whey proteins, however, do coagulate, depending on the intensity of heat treatment: varying from 10% during HTST pasteurization to 80% during intensive UHT treatment and 100% during sterilization. However, these changes are not or are hardly detrimental to the biological value of the proteins.

Cooked flavour. Intensive heat treatment results in the liberation of volatile sulphur-containing compounds, like hydrogen sulphide from sulphur-containing amino acids (cystine, methionine). So, the content of these acids in milk will be slightly reduced in sterilized products, but this hardly affects the nutritional value.

Maillard reaction. During heat treatment of milk, a reaction takes place between the

animo acids and reducing sugars (and their breakdown products). This Maillard reaction results in a loss of lysine, varying from 1% in pasteurized milk to 20% in intensively sterilized milk. Since there is sufficient lysine available in milk, this will hardly affect the biological value of the proteins.

Most other essential animo acids are stable or show small losses during moderate heat treatment. In sterilized products, there are slight losses of leucine, isoleucine, valine, cystine and histidine.

19.2.1.2 Vitamins

Most vitamins, like the fat-soluble vitamins and some vitamins of the vitamin B complex (vitamin B_2, pantothenic acid, biotin and nicotinic acid), show good resistance against heat treatment. Other vitamins of the B complex (B_1, vitamin B_{12}, folic acid) and vitamin C are more sensitive. The more intensive the heat treatment, the more they are affected. Their losses are small (up to 20%) in pasteurized milk, but are much higher (up to 100%) in sterilized products, i.e. in-package sterilized milk and evaporated milks. UHT products ensure that more vitamins are retained.

19.2.2 Homogenization

Homogenization decreases the size of the fat globules, making the fat more easily digestible and facilitating absorption. Homogenized milk gives a softer coagulum in the stomach.

19.2.3 Light and oxygen

Contrary to most other vitamins, vitamin C and vitamin B_2 are very vulnerable to light.

Vitamin C is easily oxidized, as is folic acid (vitamin B complex) and, to a lesser extent, vitamins A, E, K and the vitamin B_{12} and choline of the B complex. The other vitamins are only slightly vulnerable, if at all. The preservation of milk with hydrogen peroxide may be harmful to the oxygen-sensitive vitamins.

19.2.4 Fermentation

Some vitamins (e.g. vitamin B_{12}) are consumed by the fermenting bacteria, but other vitamins may be synthesized during fermentation.

19.2.5 Standardization

The content of fat-soluble vitamins in milk and milk products depends on the fat content of these products. Skimmed-milk products will not contain these vitamins unless they are artificially vitaminized.

19.2.6 Concentration and drying

Concentration of milk in evaporators and spray drying of milk does not or will hardly affect the nutritional value of milk proteins, but losses up to 25% of the oxidation-sensitive vitamins may take place during drying. Losses in biological value of evaporated and condensed milk and spray-dried milk powder are the result of the treatment of the milk before or after concentration and drying. The milk for these products is usually intensively heat treated before concentration and drying, whereas evaporated milk may undergo an intensive in-package sterilization.

19.3 Protein and energy requirement

Originally, it was believed that malnutrition was a typical matter of protein deficiency, with clinical symptoms, like oedema, but also emaciation and cessation of physical and mental development ('kwashiorkor'), especially in children. To cope with this kind of malnutrition, large amounts of skimmed milk powder were sometimes provided. This often turned out to have disastrous consequences, because:

- The surplus amounts that are not used by the body for the synthesis of protein in tissues are broken down, being used for energy supply. The final product, urea, is excreted by the kidneys, making a heavy demand on the functioning of the kidneys and disturbing the body's water regulation.
- The comparatively large amounts of lactose in the skimmed milk powder caused symptoms of lactose intolerance.
- Vitamin A deficiency can occur as a result of the absence of the fat-soluble vitamins, whereas extra ingestion of skimmed milk increases the vitamin A requirement and consequently results in a higher deficiency of this vitamin.
- Malnutrition is not cured by giving a diet that consisted wholly or mainly of skimmed milk powder.

It is now realized that in most cases the symptoms that were originally attributed to protein deficiency were actually caused by a serious energy deficiency, generally in combination with protein deficiency.

A joint FAO/WHO/UNU Expert Committee has laid down standards for human requirements of energy and protein.

There is a difference in the way the needs for energy and protein (the energy 'requirement' and 'safe level' of protein intake) are expressed:

- The energy requirement is the energy consumption that is believed to cover the needs of an average healthy person, belonging to a certain category of individuals. The average requirement is thus too high for some, too low for others, but it is expected to be regulated by satiety mechanisms.
- The safe level of protein intake is the amount of protein necessary to cover the physiological needs and to maintain the health of practically all representatives belonging to a certain category of individuals.

The difference between the two definitions is clear. The recommendations for protein

Table 29. Rough indication of requirements for protein and energy for adults.

Group	Protein[1] (g/day)	Energy [2] (kcal/day)
Male	40 - 60	2000 - 4000
Female	30 - 50	1600 - 3000

[1] Based on a requirement of 0.75 g of high-quality protein per kg of body weight per day. If no high-quality protein is available, a correction should be made for net utilizable protein (Section 19.1.1).
[2] Depending on level of activity.

include a distinct safety margin and consequently the standard is higher than the average needs. The recommendations for energy are exactly put at the average requirements. This is necessary because too high a standard for energy would lead to a gain in weight, which would – ultimately – be detrimental to health. A surplus of protein is not accumulated in the body, but broken down and excreted as urea, as already mentioned.

In this book it is not possible to give all the recommendations concerning protein and energy requirements for various groups of the population (Section 19.4). But as a rough indication, the requirements for adults are mentioned in Table 29.

The requirements of infants and growing children are much higher per kg of body weight.

19.4 Protein-energy ratio

In cases when energy is marginal or sub-marginal, some of the protein will be used for energy supply directly and a higher protein intake is needed to meet requirements. This means that there is a relationship between energy and protein (actually the NPU, Section 19.1.1) requirements. Therefore, the 'net protein-energy ratio (NPE)' has been introduced, which expresses the part of the total energy in a diet that comes from the dietary protein. It can be calculated as follows: the grams of dietary protein (NPU in g per 100 g of that protein) in a certain amount of food (A in g), multiplied by the specific energy of that protein, usually a factor of 4, divided by the total energy (E) in the same amount of the food, so:

$$\text{NPE} = \frac{4 \times A \times \text{NPU}}{100 \times E}$$

The concept of net protein-energy ratio can be used to express the recommended amounts of intake for individuals, and also to express the nutritional value of products and diets. It should be appreciated that this value, like the safe level of protein intake and the energy requirement, depends on many factors. The recommended values are given for groups of individuals. For example:

- infants, growing children and adults;
- males and females;
- pregnant and lactating women.

They mainly depend on age, body weight, physical activity, basal metabolism, health and climate.

Because of differences between individuals, all standards should be taken as guidelines, rather than as exact norms. See also the way the needs for protein and energy are expressed in Section 19.3.

It is increasingly believed that the value of milk in the diet must not be attached to one or more separate components only, such as protein or fat, but to the whole combination of the available nutrients, which can improve poor diets. Milk as such should be seen as having a complementary value in human diets.

19.5 Comparison between human milk and milk of dairy animals

19.5.1 Composition

Apart from differences in composition of milk between species, there are also wide variations within species, within breeds and also between individuals. Such differences mainly result from genetic characteristics, but the content of many constituents in milk also depends on the feed that is consumed. Some of the main differences between human and cow's milk will now be discussed.

In Table 7 the difference between the main constituents of both milks is shown. The lower casein and the higher lactose content of human milk is most striking. The difference in energy content is comparatively small.

19.5.2 Proteins

Differences in protein are especially attributed to the difference in casein and whey proteins of human and cow's milk (Table 30) and to differences in the content of essential amino acids.

Children are more exacting in respect of the composition of the proteins and they need a far greater amount than adults. With increasing age, the requirements of essential

Table 30. Comparison of proteins in human and in cow's milk.

Type of protein	Human milk (%)	Cow's milk (%)	Essential amino acids (%)
Casein	0.8	0.7	25
Whey proteins	2.6	0.6	75

amino acids become relatively less demanding. For adults, the protein quality is largely determined by the digestibility only, as their essential amino acid requirements are relatively low, and rarely become limiting.

19.5.3 Milk fat

The milk fat in human milk contains fewer long-chain fatty acids and more short-chain and medium-chain fatty acids, and unsaturated and poly-unsaturated fatty acids.

19.5.4 Vitamins

Differences in vitamin content are particularly interesting, but information in literature is not always consistent. Human milk is richer in the vitamins A, C, E and nicotinic acid (vitamin B complex), whilst cow's milk is richer in vitamin K and some vitamins of the B complex (B_1, B_2, B_6, B_{12}, pantothenic acid, biotin and choline). The differences in vitamins B_2, B_6, B_{12} and biotin are especially great.

19.5.5 Minerals

The mineral content of human milk is considerably lower than that of cow's milk. The calcium content and phosphorus content in cow's milk are 2.5 and 6.5 times higher, respectively.

19.5.6 Lactoferrin

Of special importance are the lower content of iron in human milk and the much higher content of lactoferrin, a proteinic compound, that binds iron and makes it unavailable for the growth of bacteria, especially coli bacteria. However, some believe that it has a direct bacteriostatic function in the intestine.

19.5.7 Bifidus factor

An important bacteriostatic compound that is found more in human milk than in cow's milk, is the bifidus factor, a nitrogen-containing carbohydrate. One of its functions is believed to be stimulating the production of an acid environment in the intestine, thus suppressing pathogenic bacteria, such as coli and salmonella bacteria.

It should be realized that when the milk of domestic mammals is used as a substitute for human milk it is almost always heat treated and that lactoferrin and the bifidus factor will be inactivated during heating.

19.6 The necessity of milk consumption

'Milk is the most perfect food to man' is often considered a slogan, and nothing more

than that. Unfortunately, it is often believed that the consumption of milk and milk products in most developing countries is merely an imitation of the 'Western way of life' and a matter of prestige. Reference is made to the many countries and populations where – apart from breast feeding – milk consumption was and still is practically non-existent. However, a few points are easily forgotten, like the explosive growth in population in general and urbanization in particular; the decreasing natural food resources, such as game; the desire to combat malnutrition in general and infant and child mortality in particular and the desire of those who can pay for it, for more luxury food, to which milk and milk products belong. Compliance with the desire of the latter may – in cases where there is a growing demand for milk – result in increasing prices, making milk less available to the lower income groups.

It should be appreciated that malnutrition and shortages of food must be combated by producing (or importing) more food and producing food of higher nutritional value. It has already been explained that milk is an excellent product to improve and complement the nutritive value of the diet of man, especially of vulnerable groups, i.e. infants, children and pregnant and lactating women.

19.6.1 Babies

Human milk is best for newly born human beings, because:
- it is the biologically appropriate food, which has the composition the baby requires;
- it has a psychologically beneficial function;
- breast feeding is the most hygienic way of feeding;
- it is cheap;
- it contains protective compounds.

Colostrum is of particular interest, because it contains a high percentage of easily digestible whey proteins and antibodies (immunoglobulins) to protect the young child against infectious diseases.

Breast feeding should be given as long as the infant cannot have the full benefit of milk from domestic animals as a replacement, or – if such milk is not available – as long as it is unable to be adequately nourished on other food products. Unfortunately, for various reasons not all children receive sufficient breast feeding for a sufficiently long period.

In all cases where none or not sufficient mother's milk can be made available, or the mother cannot be persuaded to breast-feed, an alternative must be found, such as:
- A wet nurse. This is generally the best solution.
- Milk from domestic animals. To make this milk more comparable with human milk, some water and sugar may be added. But although many babies may – generally after some adaptation – accept such a product, it differs considerably from human milk in composition and characteristics. For many other babies – especially the very young and premature babies – restrictions in acceptability can be expected.
- Milk preserves can be used instead of fresh milk. The main milk preserves used for this purpose are concentrated milk and milk powder. Apart from having the same drawbacks

as fresh milk from domestic animals, these products have a few additional disadvantages.

Evaporated milk (the unsweetened product) may be considered a satisfactory substitute for fresh milk. However, as a result of the intensive heat treatment during the in-package sterilization, some nutrients may be lost (Section 19.2.6). In this respect, the UHT-sterilized product may be preferred. The product can be enriched with the vitamins A and D. Skimmed-evaporated milk is less suitable.

Condensed milk (the sweetened and less intensively heat-treated product) has the advantage over evaporated milk that it has an excellent keeping quality after the tin has been opened. Many consider it to be less fit for babies. The enzymatic system of babies is not sufficiently developed to hydrolyse large quantities of saccharose in the intestine which may result in disturbances similar to lactose intolerance. As a result of this phenomenon, in some countries it is obligatory to print 'unfit for babies' on the labels of the tins. However, it should be realized that many babies do tolerate condensed milk, and that there is hardly any objection to feeding the product if the baby is under regular medical supervision which enables immediate action if difficulties arise. Moreover, the question can be raised what should be given if no other alternative exists? Special problems may arise in diluting the sweetened product, because too much water may be added in a misguided attempt to economize and because the product is diluted 'to taste'. In this case the sweetness of the milk may lead to the addition of too much water. The sensitivity to saccharose normally disappears at an age between 1 and 5 years. Skimmed condensed milk must be regarded as unfit for babies. Vitamins A and D may be added to condensed milk.

Milk powder is a good substitute for fresh milk, but has the disadvantage of caking if it is exposed to the air. If full-cream milk powder is used, only the gas-packed product in tins should be bought, otherwise the product may have a tallowy flavour. Skimmed milk powder has the disadvantages mentioned in Section 19.2.6.

Artificial human milk. As explained above, all substitutes for mother's milk have one inadequacy or another. Many recipes of varying degrees of complexity are available for the manufactures of substitutes for human milk in the home; most of them are based on fresh milk or milk preserves. But even the simplest recipes may already cause unsurmountable difficulties, because:

- the components are not available and/or cannot be properly stored in the home;
- there are no facilities for weighing out the correct quantities;
- the skill for preparing the substitute milk is lacking.

Products prepared in the home will only resemble human milk in terms of the macro composition. To meet the particular characteristics of the components of the substitutes for human milk, preference should be given to commercially prepared breast-milk substitutes (milk, usually cow's milk, that has been modified in such a way that it resembles human milk as closely as possible) or 'ready-to-use baby-milk formulas'. But this should only happen when human milk is not available, or in cases that the baby needs special nourishment, for instance in incidences of disease or intestinal disturbances.

All substitutes that must be dissolved or diluted before use have the disadvantage that

they are dependent on the quality of the water. Poor-quality water and unhygienic conditions of preparation and handling of the substitutes pose a serious risk to the health of the baby. The water should always be boiled and the substitute should – if possible – be fed with a spoon, rather than with a bottle or teat, because the latter are difficult to sanitize.

Another risk is that a drink with an incorrect composition will be prepared. If it is too concentrated, the osmotic pressure may be higher than agrees with the digestion of the baby; if it is too dilute, the intake of nutrients may be too low.

In an effort to promote breast feeding and to overcome problems that might discourage it, the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) have drawn up the International Code of Marketing of Breast-milk Substitutes and recommended their member countries to incorporate this code in their national legislation. The code states that when mothers do not breast-feed, or only do so partially, there is a legitimate market for infant formula and for suitable ingredients from which to prepare it and that all these products should accordingly be made accessible to those who need them. However, they should not be marketed or distributed in ways that may interfere with the protection and promotion of breast feeding. In other words, the proper use of breast-milk substitutes, when these are necessary, should be ensured on the basis of adequate information and through appropriate marketing and distribution.

Filled milk products. In these products the milk fat is replaced by vegetable fat, often coconut fat. This fat is deficient is short-chain and unsaturated fatty acids, and fat-soluble vitamins. To improve the quality of these products, some of the coconut fat is generally replaced by vegetable oils, such as palm-kernel oil, and the products may be artificially vitaminized.

19.6.3 Other vulnerable groups

At an age of 3 to 5 months, infants may be introduced to food additional to breast milk. Care should be taken that this food is not too bulky and too unbalanced. Thin porridge of local staple crops, like cassava and cereals and water is generally poor in energy and protein. Milk or skimmed milk powder will be a useful component for the diet of such infants. This also holds for all other growing children, particularly during the period they are too young to take part in and have the full benefit of the normal daily meals of the family.

An adequate diet consisting of more food of greater variety, is required for pregnant and lactating women. Unfortunately, the importance of proper nourishment during pregnancy is often underestimated. Milk may play an important contribution, especially because of its protein, mineral (calcium) and vitamin content.

Elderly people may particularly benefit from the easily digestible calcium in milk and milk products.

N.B. It is beyond the scope of this book to discuss the food requirements of the various groups of the population in various parts of the world in greater detail. Neither is it inten-

ded to make suggestions for the diets. For this information, relevant textbooks and manuals should be consulted.

Further reading

Bender, A.E., 1983. Protein evaluation. In: Role of proteins in human nutrition. Kieler Milchwirtschaftliche Forschungsberichte 35:267.

Bond, T.J. et al., 1981. Infant and child feeding. Academic Press, New York.

Briel-van Ingen, T. van den & A.P. den Hartog, 1985. Guidelines for dairy food aid. The Netherlands Nutrition Foundation, Wageningen.

Cameron, M. & Y. van der Hof, 1983. Manual for feeding infants and young children (3rd. ed.). Oxford University Press, Oxford.

FAO/WHO, 1979. Protein and energy requirements; a joint FAO/WHO memorandum. Bulletin World Health Organization 57(1)65.

FAO/WHO/UNU, 1985. Energy and protein requirements. Technical Report Series No. 724. World Health Organization, Geneva.

Galesloot, T.E. & B.J. Tinbergen (Ed.), 1985. Milk proteins 1984. Pudoc, Wageningen.

Hartman, A.M. & L.P. Dryden, 1965. Vitamins in milk and milk products. US Dept. of Agriculture, Beltsville.

Golden, M.H.N., 1982. Protein deficiency and oedema of malnutrition. Lancet 1:1262.

Hambraeus, L., 1981. Comperative nutritive value of vegetable and milk proteins. International Dairy Federation, Document 139, p. 10.

Henderson, J.L., 1971. The fluid milk industry (3rd ed.). The AVI Publishing Co., Westport (Conn.).

Hiel, A.M.M. et al., 1986. A field guide for the use of local foods and DSM in Africa. The Netherlands Nutrition Foundation, Wageningen.

IDF, 1983. Cultured foods in human nutrition. International Dairy Federation, Document 159.

Jelliffe, D.B., 1968. Infant nutrition in the subtropics and tropics (2nd ed.). World Health Organization, Geneva.

Jelliffe, D.B. & E.E.P. Jelliffe, 1978. Human milk in the modern world. Oxford University Press, Oxford.

Kaplan, M.M. et al., 1962. Diseases transmitted through milk. In: Milk Hygiene. World Health Organization, Geneva.

Kisza, J. & K. Borawski, 1983. Influence of heat treatment on the essential amino acids. Kieler Milchwirtschaftliche Forschungsberichte 25:323.

Kusin, J.A., 1987. Infant feeding. In: Infant growth and nutrition. Proceedings of a workshop. Foundation for the Advancement of the Knowledge of the Nutrition of Mother and Child in Developing Countries, Ede.

Kon, S.K., 1972. Milk and milk products in human nutrition (2nd ed.). FAO Nutritional Studies, No. 27. FAO, Rome.

Mann, E.J., 1981. Lactose-hydrolysed milk and milk products. Dairy Industries International 46(9):17.

Meer, R. van der, 1988. Species-dependent effects of dietary casein and calcium cholesterol metabolism. In: Milk products and health. International Dairy Federation, Bulletin 222.

Northolt, M.D., 1984. Growth and inactivation of pathogenic micro-organisms during manufacture and storage of fermented dairy products. Netherlands Milk and Dairy Journal 38:135.

Packard, V.S., 1982. Human milk and infant formula. Academic Press, New York.

Porter, J.W.G., 1975. Milk and dairy foods. Oxford University Press, Oxford.

Räihä, N., 1983. Milk proteins and the new born. International Dairy Federation, Document 166.

Reiter, B., 1985. The biological significance and exploitation of non-immunoglobuline protective proteins in milk, lysozyme, lactoferrine, lactoperoxidase, xanthineoxidase. International Dairy Federation, Bulletin 191.

Renner, E., 1983. Milk and dairy products in human nutrition (4th ed.). Volkswirtschaftlicher Verlag, München.

Schaafsma, G., 1983. The significance of milk as a source of dietery calcium. International Dairy Federation, Document 166.

Schaafsma, G. et al., 1988. Nutritional aspects of yogurt. Microbial lactase activity and digestion of lactose. Netherlands Milk and Dairy Journal 42:121.

Theuer, R.C., 1983. Milk proteins in infant nutrition. In: Role of milk protein on human nutrition. Kieler Milchwirtschaftliche Berichte 35:433.

WHO, 1981. International code of marketing of breast-milk substitutes. World Health Organization, Geneva.

Young, V.R., 1983. Human studies for evaluation of protein quality with particular reference to milk protein. In: Role of proteins in human nutrition. Kieler Milchwirtschaftliche Forschungsberichte 35:247.

20 Milk products and human health

Nutritionally, milk can contribute considerably to human health. On the other hand, it can be a dangerous vehicle for a great variety of milk-borne diseases. Milk may be contaminated with:
- pathogenic micro-organisms or viruses (called pathogens, for short);
- inorganic or organic chemical contaminants that are hazardous to health.

Pathogens are considered to be especially dangerous to man, because via milk they can easily spread over large groups of the population, assuming an epidemic character if no proper precautions are taken.

In most cases, persons contaminated with pathogens become diseased immediately or within a relatively short time after infection. Contaminations with chemical compounds usually produce a different picture, because the contaminants accumulate in the body and diseases may only appear after a long period, when a certain level of contamination has been reached, whereas in other cases the general health of the individual deteriorates without signs of any particular disease.

20.1 Pathogens

Pathogens can be pathogenic to man, because they are able to affect human health either directly by their activities in the human body, or indirectly, by producing toxins or other harmful substances in milk and milk products, before these are consumed. Several diseases can be spread if milk or milk products have been contaminated, either directly by human beings or indirectly via infected utensils, equipment, water, etc. A number of animal diseases may be transmitted to man if milk produced by diseased animals is consumed. Milk and milk products can become contaminated at any stage along the marketing chain between animal and consumer. The principal pathogens found in milk are shown in Table 31 and are briefly discussed.

20.1.1 Tuberculosis

Tuberculosis is caused by *Mycobacterium bovis*, *M. avium* or *M. tuberculosis*, which are responsible for the diseases in bovines, fowl and man respectively. Human beings are susceptible to all three varieties.

Cows, and other mammals suffering from the disease may contaminate their milk by the udder, but also by manure and in exceptional cases by the respiratory organs. Although there is little or no proof that human tuberculosis is spread via milk, persons

Table 31. Diseases in man caused by micro-organisms and viruses.

Direct		Indirect
animal source	human source	
Bovine tuberculosis	Human tuberculosis	*Staphylococcus aureus*
Brucellosis	Diphtheria	*Bacillus cereus*
Foot and mouth disease	Scarlet fever	*Clostridium perfrigens*
Anthrax	Dysentry	*Listeria monocytogenes*
Escherichia coli	*Salmonella* diseases	
Campylobacter jejuni		
Q fever		
Salmonella diseases		

suffering from the disease should not be directly involved in the handling and processing of milk.

Tuberculosis is very rare in goat's milk. This does not mean that goat's milk is safe to drink without proper heat treatment, because in many tropical and subtropical countries goat's milk may be contaminated with other pathogens, particularly brucellosis.

20.1.2 Brucellosis

Brucellosis, also known as 'contagious abortion' or 'Bang's disease', is considered a typical animal disease, to which mammals like cattle, buffaloes, sheep and goats are susceptible. Man is infected by the consumption of raw milk from diseased animals, and the products manufactured from such milk. In exceptional cases, infection may take place by direct contact. Several species of brucellis are known, such as *Brucella abortus* and *B. melitensis* ; the latter (the most virulent for man) is generally associated with goats. When man is infected, the disease is generally known as 'undulant', 'Malta' or 'Mediterranean' fever. The most common symptoms are: intermittent fever accompanied by headache, pain in the back, the joints and the abdomen.

20.1.3 Foot and mouth disease

Foot and mouth disease is caused by a virus to which cattle and other cloven-hooved animals are highly susceptible. It is characterized by the formation of vesicles on feet and in the mouth, and on the udder of the animal. When the vesicles on the udder break, the milk is likely to be contaminated during milking. Man can also be infected: the symptoms are mild, and are similar to those observed in cattle, namely fever, difficulties in swallowing, blisters in the mouth and rarely on the hands.

20.1.4 Anthrax

All warm-blooded animals, including man, are susceptible to anthrax, which is caused by *Bacillus anthracis*. Infected animals usually die in 2 to 4 days. Shortly before death, the bacilli are found in the milk, which is usually blood-stained. Therefore, consumption of contaminated milk is not very likely, and infection of man through milk is very rare, although the spores of the bacilli survive pasteurization. Nevertheless, proper quarantine measures must be taken to ensure that milk produced by herds in which the disease has broken out is not offered for consumption. Anthrax spores may remain virulent in the soil for periods of 20 years, and perhaps even longer.

20.1.5 Campylobacter jejuni

Campylobacter jejuni is found in water and in many food products, like poultry. It causes symptoms, that are rather similar to cholera. Its importance for the dairy industry is not completely understood. After contamination of milk, the viable numbers of this bacterium rapidly decrease.

20.1.6 Escherichia coli

Certain groups of *Escherichia coli* in milk may cause acute gastroenteritis, especially in infants and children, but also in adults. The disease is very similar to diseases caused by salmonella infections. Since the bacteria are prevalent in the intestinal tract of dairy animals, milk is easily contaminated. The bacterium can grow in milk, especially at temperatures prevalent in the tropics.

20.1.7 Q fever

Q fever, caused by *Coxiella burnetti* (*Rickettsia burnetti*), is found in a number of tropical countries. Cattle and other cloven-hooved animals, and man are susceptible to the disease, which causes high fever, accompanied by backache and chills in man. Infection is possible by inhalation and through the consumption of contaminated milk.

20.1.8 Salmonella diseases

This is the name for a group of diseases found in almost all animal species. It is widespread in tropical and subtropical countries. The bacteria are very pathogenic to man, causing intestinal disorders and high fever. Since the bacterium is found in the intestinal tract, it will easily contaminate milk during milking. Water - especially surface water - is also often contaminated. If this water is used for an after-rinse of milking utensils, milk can easily be contaminated. Animals and man can carry the disease without showing clinical symptoms.

20.1.9 Diphtheria

Diphtheria is caused by *Corynebacterium diphtheria*. It may give rise to a sore throat, especially among young children. The disease is not commonly spread via milk. It may cause ulcers on the teats of the udder of mammals.

20.1.10 Scarlet fever

Scarlet fever and a number of other virulent infections, like septic sore throat are caused by pathogenic streptococci. Persons who are carriers of the streptococci without showing clinical symptoms, may contaminate milk, and may infect milking animals.

20.1.11 Dysentry

Two varieties of dysentry are known, an amoebic form which does not seem important as a milk-borne disease, and a bacillary form caused by *Shigella dysenteriae*. Infections of the latter may occur via the hands of the milker and during milk handling and processing, but the bacterium may also enter milk through infected water and flies. The symptoms are characterized by blood in the stools of diseased persons. After recovery, former patients may still be carriers of the germs.

20.1.12 Mastitis

Mastitis is the general term used for inflammation of the udder of mammals. Various bacteria may be responsible for the disease. Most common are pathognic streptococci, like *Streptococcus agalactiae*, but other species like staphylococci and tuberculosis bacteria, and pathogenic moulds are also found; the latter especially in tropical countries.

Milk from cows suffering from mastitis may show abnormalities and consequently is not fit for consumption.

Although lactating women may suffer from mastitis, the most common infecting micro-organisms are considered non-pathogenic to man. However, some mastitis streptococci are believed to be able to cause a sore throat, and certain streptococci may be responsible for the occurrence of ulcers in man.

Penicillin seems less effective against staphylococcal mastitis than against streptococcal mastitis. In some tropical countries, the former variety is most common.

20.1.13 Staphylococcus aureus

Staphylococcus aureus is a pathogenic bacterium that is able to produce a toxin in milk, which causes acute and serious gastroenteritis (food poisoning) in man. The bacterium is able to grow under conditions of increased osmotic pressure, as in some cheese varieties with very high salt content and in balance tanks for condensed milk.

20.1.14 Bacillus cereus

Bacillus cereus belongs to the 'putrefying bacteria' which grow rapidly in milk, forming breakdown products from the proteins, which give the milk a bitter taste. Consumption of such milk may cause intestinal disorder. Other putrefying bacteria are *Bacillus subtilus* and *B. circulans*.

20.1.15 Other infectious diseases

Although intestinal disorders caused by enterococci belong to the most common infectious diseases, milk and milk products can be contaminated with many other infectious pathogens, such as *Clostridium perfrigens* and *Listeria monocytogenes*, which are widespread in nature. The spores of *C. perfrigens* survive pasteurization, but – if present in milk – are quickly outnumbered by other bacteria. The spores are destroyed during proper sterilization but may survive if the heat treatment is not sufficiently intensive, after which they may grow profusely if the milk is not cooled. This clostridium may produce toxins in the human body. It causes gastroenteritis in persons consuming contaminated milk. *L. monocytogenes* is killed during normal pasteurization, but it may grow in insufficiently heat-treated products and on the surface of contaminated surface-ripened cheeses, even at low temperatures (5°C). In its mildest form, it causes influenza-like symptoms, but it may cause abortion in pregnant women and meningitis, especially in vulnerable groups with a low resistance.

20.2 The control of pathogens

It can be extremely difficult to prevent the contamination of raw milk with pathogens. Therefore, the safest way of controlling pathogens in milk and milk products is proper heat treatment and the prevention of contamination of the milk (and the milk products) thereafter. Contamination can take place at any moment during the processing of milk, and in the marketing line of milk and milk products. But with modern production and processing techniques, and an adequate health inspection and quality control, it is possible to provide consumers with safe and healthy products. However, whenever proper control is missing, there will always be a risk of an outbreak of milk-borne diseases.

In normal HTST pasteurization and comparable pasteurization techniques, all pathogens will be killed or destroyed, with the exception of the spores of anthrax bacteria. However, it is not very likely that anthrax-contaminated milk will be marketed (Section 20.1.4.7). Spores from putrefying bacteria and from *Clostridium perfrigens* will survive pasteurization; they will only be destroyed by intensive sterilization.

Rickettsia burnetti , the bacterium that causes Q fever, is very heat-resistant, and in the event of outbreaks of this disease, it may be recommended to increase the pasteurization temperature, e.g. by 5°C.

Heat treatment does not destroy toxins produced by staphylococci and the protein breakdown products of putrefying bacteria.

Raw milk and raw-milk products may be contaminated, either by the animal or by man. These products, such as unpackaged pasteurized milk and pasteurized milk of doubtful quality, must, as far as possible, always be boiled. Products like khoa, which are heated during processing, are not necessarily safe for consumption, because they may be contaminated after processing.

The increased acidity of fermented milks kills or at least inhibits the development of most pathogenic organism. Some investigators believe that a bacteriostatic activity may be attributed to the lastic acid as such. Although fermented milks are rarely responsible for the outbreak of infectious diseases and acidification of milk diminishes the risk of being a carrier of diseases, souring of milk is no absolute guarantee of a safe product. Especially tuberculosis and brucellosis bacteria are very acid-resistant; they can survive for weeks in fermented milks

Since most pathogens survive in milk, and a number, like salmonella, staphylococcus, coli and streptococcus, even grow in milk, fresh milk with a so-called prolonged keeping quality (no development of lactic acid bacteria) is extremely dangerous to drink without proper heat treatment.

Raw-milk cheese will contain all pathogens present in the raw-milk. Maturing of cheese does reduce the number of pathogens, but tuberculosis and brucellosis are very resistant as are spore-formers. Heavy salting may suppress pathogens, but staphylococci may even grow in pickled cheeses and produce toxins.

White fresh cheese manufactured from raw milk is particularly dangerous to health. So-called 'cheese poisoning' by eating fresh cheese in tropical countries is believed to be caused by toxins produced by staphylococci.

Edible ices form a dangerous source of pathogenic bacteria. Improper sanitization of the equipment between production batches, during which period all kinds of bacteria will develop profusely, may be the cause of outbreaks of infectious diseases. Salmonella contaminations are notorious. It is too often believed that the low temperature of the ice will ensure absolute protection.

20.3 Chemical contaminants

A large number of organic and anorganic chemical contaminants may be found in milk. They can get into the milk directly or indirectly.

20.3.1 Antibiotics

Antibiotics may be excreted in the milk after an animal has been treated with an antibiotic or after it has eaten feed containing antibiotics.

Antibiotics may be responible for certain allergic reactions in man. Moreover, repeated administration of even small amounts may lead to the development of resistant strains of bacteria, and thereby threaten people's health.

20.3.2 Pesticides

To control insects on crops and livestock in agriculture, use may be made of pesticides or insecticides. Milk can be contamined directly through the air, e.g. by spraying the animal that eats contaminated feed. In particular, chlorinated hydrocarbons may be found in the milk. Some of these chemicals are broken down in the digestive tract of the animal, but others are excreted with the milk.

Some of these products are very injurious to health. They may accumulate in the fatty tissues of the human body, and are liberated during emaciation or slimming, and during lactation if the fat reserves of the body are used.

20.3.3 Mycotoxins

Mycotoxins are produced by moulds which grow on feed. They can be injurious to health, especially the aflatoxins, which are believed to be carcinogenic.

20.3.4 Heavy metals and radionuclides

The dairy animal acts as a filter for heavy metals, and milk cannot be regarded as an important source of heavy metals which are injurious to health, unless the milk is directly contaminated.

If a dairy animal is contaminated by radionuclides, e.g. by consuming feed or water containing radio-active isotopes, some of the contaminants will be filtered out by its body, but some will be excreted with the milk. Nuclear fall-out may form a serious threat of contamination.

Further reading

Boer, E. de et al., 1984. Milk as a source of *Campylobacter jejuni*. Netherlands Milk and Dairy Journal 38:183.

Defigueiredo, M.P. & D.F. Splittstoesser, 1976. Food microbiology. Public health and spoilage aspects. The AVI Publishing Co., Westport (Conn.).

Hall, H.T.B., 1985. Diseases and parasites of livestock in the tropics. (2nd. ed.). Intermediate Tropical Agricultural Series, Longman Group Ltd., London.

Kaplan, N.M. et al., 1962. Diseases transmitted through milk. In: Milk Hygiene. World Health Organization, Geneva.

Khalid, A.S. & W.F. Harrigan, 1984. Investigation into the effect of salt level on growth of, and toxin production by *Staphylococcus* in Sudanese cheese. Lebensmittel-Wissenschaft und -Technologie 17(2):99.

Mossel, D.A.A. Microbiology of foods. Faculty of Veterinary Medicine of the University of Utrecht.

Northolt, M.D., 1984. Growth and inactivation of pathogenic micro-organisms during manufacture and storage of fermented dairy products. A review. Netherlands Milk and Dairy Journal 38:135.

Northolt, M.D. et al., 1988. *Listeria monocytogenes:* heat resistance and behaviour during storage of milk and whey, and making of Dutch type of cheese. Netherlands Milk and Dairy Journal 43:207.

Index *

* In composite terms, the word 'milk' is often deleted, e.g. 'milk fat' and 'milk collection' are indexed under the terms 'fat' and 'collection', respectively; to avoid confusion, the terms may be followed by the word 'milk'. In many other cases, terms are followed by second terms to allow for further specification. Specifications may – whenever applicable – also be given in brackets.