Neth. Milk Dairy J. 30 (1976): 118-131

Production of milk with a high content of polyunsaturated fatty acids. 2. Fatty acid composition of milk in relation to the quality of pasteurized milk, butter and cheese

H. T. Badings[1], S. Tamminga[2] and J. E. Schaap[1]

[1] Netherlands Institute for Dairy Research (NIZO), Ede, the Netherlands
[2] Institute for Animal Feeding and Nutrition Research 'Hoorn', Lelystad, the Netherlands

Received: 12 April 1976

Summary

Experiments were carried out to produce milk with different levels of polyunsaturated fatty acids, and to evaluate the quality of dairy products made from this milk. Dairy cows were fed rations containing ground sunflower seeds, unprotected or protected against biohydrogenation in the rumen, or they received defatted sunflower seed material in combination with infusion of sunflower oil in the small intestine.

Feeding unprotected sunflower seeds resulted in production of milk with a normal fatty acid composition. By feeding protected sunflower seeds or infusion oil in the small intestine, the linoleic acid content of the milk fat could be raised to 10 - 22 % by weight. After protecting the fresh milk against oxidation, it was used for the production of pasteurized milk, ripened-cream butter and Gouda cheese. These products were evaluated to determine their quality in relation to the linoleic acid content of the milk fat. Pasteurized milk with an increased linoleic acid content was found to be acceptable and of equal quality to the reference milk, even after one week storage at 4 °C.

Ripened-cream butter with an increased linoleic acid content displayed a slightly higher oxidation susceptibility than did normal butter. The butter flavour was more bland, and a slight oilseed flavour was present in some cases. The fresh butter was of acceptable quality, but after one month at —10 °C it was graded as slightly less than acceptable. The spreadability and texture of the butter at 4 °C were good. For use in the household directly from the refrigerator, this is an advantage over butter with a normal linoleic acid content. At higher temperatures the experimental butter became very soft, weak and of general poor quality.

Gouda cheese produced from milk with an increased linoleic acid content was usually of sufficicient quality but more bland in flavour than the control cheese. Sometimes it displayed a slightly oxidized flavour after four months of ripening. The texture of the cheese at 4 °C was slightly mealy but acceptable. At 14 °C, however, the cheese was very soft and mealy.

1 Introduction

One of the factors which may influence the physical and chemical properties of dairy products is the fatty acid composition of the milk fat. From a technological point of view it is therefore desirable to have available techniques to obtain the required fatty acid composition. Obviously this may be possible by fractionation of the milk fat or by the addition of fats or oils of other origin.

In the last few years methods have been developed (1, 2) for the production of ruminant meat and milk with a high content of polyunsaturated fatty acids (PUFA). These methods consist of protecting vegetable oils or crushed oil seeds against hydrogenation by micro-organisms in the rumen, by encapsulation of food constituents with formaldehyde-treated protein. Consequently the polyunsaturated fatty acids pass the rumen and become available in the digestive tract, whence they may be transferred to the depot fat and milk.

The biological efficiency of the transfer of PUFA from the feed to the animal depot fat or milk, has been studied recently by the Institute for Animal Feeding and Nutrition Research 'Hoorn', and the results have been published in an earlier paper (3). In connection with these studies, the Netherlands Institute for Dairy Research at Ede has investigated the relation between the fatty acid composition of milk with a high PUFA content and the quality of dairy products produced from it. The results of these experiments are given in the present paper.

2 Materials and methods

2.1 Experimental animals

The experiments were performed with four lactating cows. Two animals were at the end of the lactation period; they produced 5 to 10 kg milk a day. The other animals were in the initial stage of lactation and produced 24 to 28 kg of milk a day. Of the latter cows, one (animal hb 93) was fitted with a rumen fistula and a re-entrant cannula at the beginning of the small intestine.

2.2 Feeding experiments

After a period of normal feeding (period 0) the experiments were started. In the experimental period I the cannulated animal was fed with a food ration containing unprotected sunflower seeds. In the experimental period II all animals were fed with the same constituents but the ground sunflower seeds were coated with formaldehyde-treated casein.

In the experimental period III the cannulated animal was fed with the same constituents as in experiment I. However, the sunflower seed supplement

was defatted and the lipids were supplied by continuous infusion of sunflower oil into the small intestine.

Concentrates containing sunflower seeds (Exp. I and II) and the sunflower oil (Exp. III) were stabilized against oxidation by the addition of 30 and 150 mg ethoxyquin per kg respectively. Further details on the feed rations and the experimental designs are given in the previous paper (3).

2.3 Sampling of milk

Each of the three feeding experiments consisted of an adaptation period of three weeks, and an experimental period of at least one week. For each experiment usually 10 to 30 litres of milk from two consecutive milkings was used. The milk was cooled to <4 °C immediately after collection and protected against autoxidation by addition of 10 mg butylated hydroxyanisole (BHA) per litre.

During experimental period II four samples of milk were investigated. Two samples were obtained from all experimental animals together. One sample consisted of milk from the two cows which were in the beginning of lactation and the fourth sample was collected from the two cows which were in the last lactation period. During experimental period III, two samples of milk were taken from the cannulated animal.

2.4 Production of milk and milk products

Within four hours after collecting the last milking, the preparation of pasteurized milk, ripened-cream butter and Gouda cheese was started. These preparations were made in the usual way, but in pilot plant equipment, suitable for handling 10 to 30 litres of milk.

2.5 Analysis

Determination of thiobarbituric acid (TBA) values was made by the method of Koops (4). Peroxide value determinations were made according to Loftus Hills & Thiel (5).

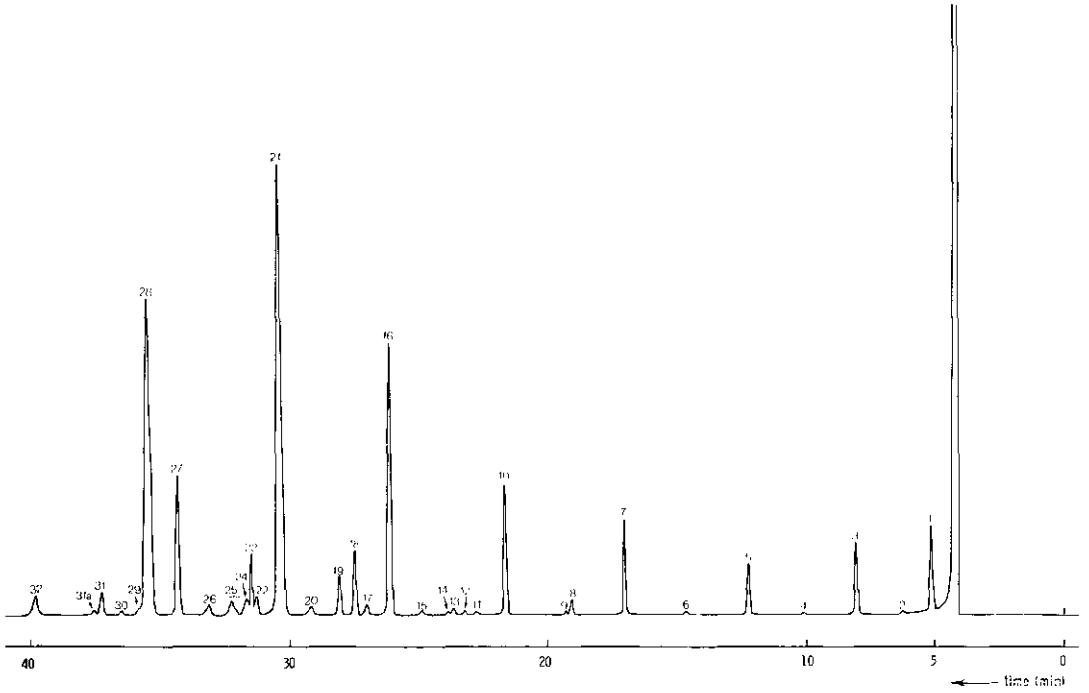
Fatty acid composition of milk fat samples was determined by gas chromatography. The fatty acids were converted into methyl esters according to De Man (6), and these were analysed in a wide-bore glass capillary column (l = 32 m, i.d. 0.7 mm) coated with diethylene glycol succinate (DEGS). This technique (7) offers a significant improvement in resolution compared to packed columns and can be carried out in conventional instruments without any modifications of them.

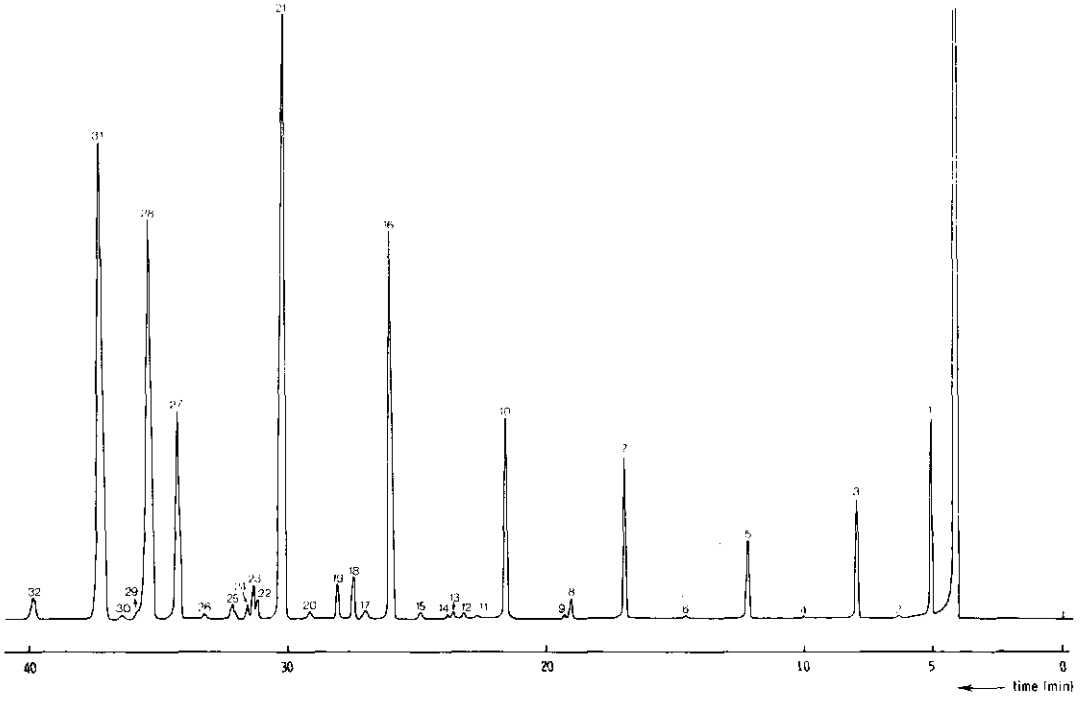
The melting thermograms were recorded by a Du Pont 900 differential thermal analyzer with a Du Pont DSC cell. For the thermogram the fat was

Table 1. Fatty acid composition of milk fat obtained during the various feeding experiments[1].

Fatty acid	Low-producing cows		High-producing cows					
	control	after feeding protected supplement	control	after feeding unprotected supplement	after feeding protected supplement			after infusing sunflower oil
	0* (30 + 37)**	II (30 + 37)	0 (53)	I (93)	IIA (53 + 93)	IIB (53 + 93)	IIC (53 + 93)	III (93)
4:0	3.2	3.2	4.4	4.1	4.5	4.6	4.4	3.3
6:0	2.4	2.1	2.6	2.6	3.0	2.9	3.1	2.5
8:0	1.4	1.3	1.4	1.6	1.7	1.7	1.9	1.7
10:0	3.2	2.5	2.3	2.9	3.2	3.0	3.1	3.1
10:1 + 11:0	0.5	0.3	0.2	0.3	0.3	0.3	0.3	0.4
12:0	4.4	3.8	2.9	4.0	4.4	4.1	4.2	3.9
13 br	0.2	0.1		0.1	0.1	0.1	0.1	0.1
12:1	0.2							
13:0								
14 br	0.2	0.2					0.1	0.1
14:0	12.4	10.4	8.7	10.9	10.6	10.1	9.3	10.2
15 br	0.4	0.3	0.2	0.3	0.2	0.2	0.2	0.2
14:1 + 15 br	2.3	1.2	1.1	1.4	1.1	1.1	0.9	1.1
15:0	1.6	1.0	0.6	1.0	0.8	0.8	0.7	0.7
16 br + 15:1 + 16 br αMe	0.6		0.4	0.3				0.1
16:0	30.6	21.4	25.6	20.8	18.4	18.4	17.2	23.4
16:1	0.7	0.6	0.7	0.7	0.5	0.6	0.4	0.5
17 br	2.4	1.0	1.9	0.8	0.6	0.7	0.6	0.7
17 br	0.8	0.6	0.9	0.7	0.8	0.7	0.5	0.3
16:1 + 17:0	1.0	0.8	1.0	0.7	0.3	0.7	0.5	0.7
17:1 + 18 br	0.8	0.4	1.0	0.3	0.4	0.2	0.2	0.2
18:0	6.8	12.1	10.3	12.3	13.7	13.1	14.8	6.8
18:1	20.2	25.5	29.6	26.9	22.6	23.5	24.0	16.9
un	0.5		0.5					
19:0	0.2	0.6	0.3	1.0	0.6	0.7	0.5	0.4
un				0.4	0.1	0.2		
18:2	1.3	9.0	1.7	3.8	10.7	10.4	11.7	21.4
20:0	0.5		0.4			0.2		
18:3 + 18:2 iso	1.1	1.4	1.3	1.9	1.0	1.1	1.0	0.9
un		0.1		0.1	0.3	0.4	0.2	0.2
22:0	0.1	0.1		0.1	0.1	0.2	0.1	0.2

[1] Figures < 0.1 % are not listed.
* The figures on this line refer to the experimental periods.
** The figures on this line refer to the cows' numbers.


40
30
20
10
5
0
time (min)


40
30
20
10
5
0
time (min)

heated to 60 °C, stabilized at that temperature for one hour and cooled to —50 °C with a linear cooling programme of 5 °C/min. The fat was stabilized for half an hour at —50 °C and then heated at a rate of 5 °C/min. The heating curve was recorded (8).

2.6 Sensory evaluations

Samples of milk, butter and cheese were tested by a team of six experienced graders from our Institute. Marks were given for the flavour of the products, the intensity of certain defects and the texture of the butter and cheese. The scoring scales are given in the related tables.

3 Results

3.1 The influence of the diet on the fatty acid composition of the milk fat

In order to determine the influence of the diet on the fatty acid composition of the milk fat, analyses were carried out of milk samples obtained during the different experimental periods. The results are summarized in Table 1.

The fatty acid composition of the milk fat from the control period (period 0) was normal. The linoleic acid contents were 1.3 to 1.7 %. After feeding the unprotected supplement (period I), the level of palmitic acid ($C_{16:0}$) and oleic acid ($C_{18:1}$) decreased, whilst the level of stearic acid ($C_{18:0}$) and linoleic acid ($C_{18:2}$) increased slightly from 1.7 to 3.8 %. However, the fatty acid composition was not unusual for milk, if compared with data from the literature.

After feeding the protected supplement to the low-producing cows there was an increase in the stearic acid content and particularly the linoleic acid content of the milk. The latter value increased from 1.3 % to 9.0 %. These increases were mainly at the expense of palmitic acid. Similar results were obtained after feeding the protected supplement to the high-producing cows.

Fig. 1. Analysis of the fatty acid composition of two samples of milk fat. Separation of fatty acid methyl esters by means of programmed temperature gas chromatography on a wall-coated glass capillary column (32 m × 0.7 mm).

Stationary phase DEGS. Temperature programme: start 50 °C, heating rate 4 °C/min, maximum temperature 185 °C.

Sample 1a (top): milk fat from experimental period 0 (normal feeding).

Sample 1b (bottom): milk fat from experimental period III (infusing sunflower oil).

Identity of peaks: 1 = 4:0; 2 = 5:0; 3 = 6:0; 4 = 7:0; 5 = 8:0; 6 = 9:0; 7 = 10:0; 8 = 10:1; 9 = 11:0; 10 = 12:0; 11 = 13 br; 12 = 12:1; 13 = 13:0; 14 = un; 15 = 14 br; 16 = 14:0; 17 = 15 br; 18 = 15 br + 14:1; 19 = 15:0; 20 = 15:1 + 16 br + 16 br αMe; 21 = 16:0; 22 = 16:1; 23 = 17 br; 24 = 17 br; 25 = 16:1 + 17:0; 26 = 17:1 + 18 br; 27 = 18:0; 28 = 18:1; 29 = 19 br + 18:2 iso; 30 = 19:0; 31 = 18:2; 31a = 20:0; 32 = 18.3 + 18:2 iso.

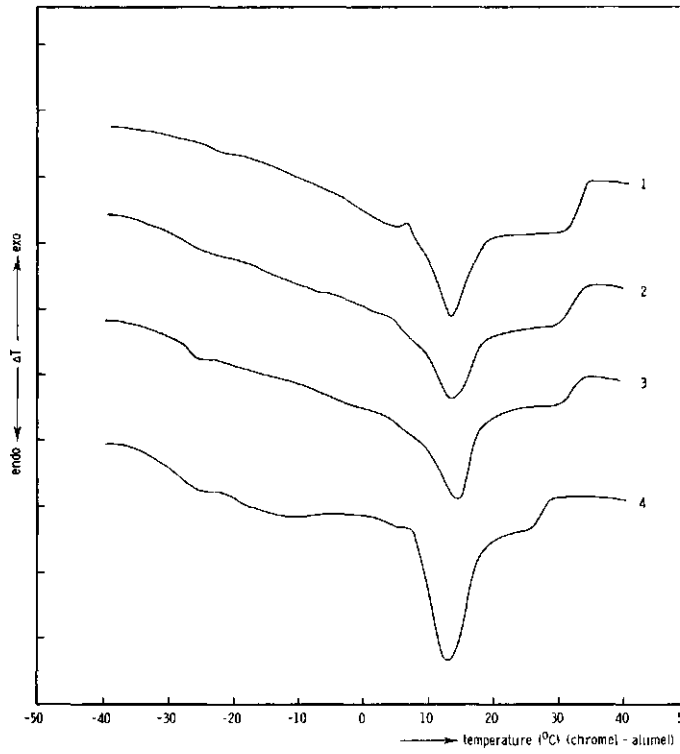


Fig. 2. Melting thermograms. Heating programme: start —50 °C, rate: 5 °C/min, reference: empty pan.
Curve: 1: experimental period I (unprotected supplement);
curve 2: experimental period II (protected supplement);
curve 3: experimental period II_C (protected supplement);
curve 4: experimental period III (infusing oil).

Three successive analyses were carried out in this period. The linoleic acid content of the milk fat increased to values between 10.4 and 11.7 %.

Infusing sunflower oil resulted in a strong increase of the linoleic acid content of the milk fat to 21.4 % and a decrease of stearic acid and oleic acid.

The radical changes in the fatty acid composition of milk fat after avoiding biohydrogenation of the polyunsaturated fatty acids in the feed are shown in Fig. 1.

The melting thermograms of milk fat produced in the experimental periods Nos I, II, II_C and III are given in Fig. 2. From these thermograms the following conclusions can be drawn.

Curve 1 (fat from experimental period I) shows the melting behaviour of a normal milk fat in the winter period.

Compared with Curve 1, Curve 2 (fat from experimental period II) shows that the latter sample contains more triglycerides melting in the traject between 0 and +10 °C. At extremely low temperatures (—20 to —30 °C), the melting behaviour is very little changed. In the extremely low temperature range of curve 3 (melting curve of fat from experimental period No II_C), a change in melting behaviour is visible. The temperature difference ΔT of the sample at —30 °C with the reference lags more than in curve 2. This is a normal phenomenon for polyunsaturated fats. The same effect, but even more pronounced, is seen in curve 4, made with fat from experimental period III. In the traject of —20 °C to 0 °C the temperature difference ΔT between the sample and the reference is greater than that in normal fat. This demonstrates the more unsaturated character of the fat. It is also confirmed by the shoulder in the curve between 0 °C and +10 °C. This shoulder increases in the curves, going from 1 to 4. The temperature where the greatest ΔT is recorded also shifts to a lower temperature. The same holds for the temperature where the total fat is liquid. In curve 1 this temperature was 37 °C. In curve 4 this temperature decreased to 28 °C.

3.2 The influence of the fatty acid composition of the milk obtained in the different feeding experiments on the quality of pasteurized milk, butter and cheese

Table 2 represents the results of the organoleptic evaluations of milk obtained in the various experimental periods. The milk was pasteurized, and stored at 3 °C. The milk was graded fresh and after one week storage. It can be concluded that all the samples were of acceptable quality. There were no significant differences between the reference sample I and the other samples. Specific flavour defects were not found.

In Table 3 the results are given of the organoleptic evaluations and analyses of ripened-cream butter produced from milk which was obtained in the various experimental periods.

After one week of storage at 7 °C all samples were found to be of acceptable quality.

After one month of storage at —10 °C the reference butter I was found to be of acceptable quality (6.1) although oxidized. Feeding the protected supply resulted in butter which was equal or 0.3 points lower in score. Although this difference is small, three of the four samples were graded just below 6. One sample (II) had a moderate oxidation flavour, the others where slightly oxidized. Two samples (II_A and II_C) possessed a slight oilseed flavour.

Butter obtained from the period (III) in which sunflower oil was infused was graded 5.7 mainly because of an oilseed flavour.

Table 2. Results of the sesory evaluations of milk obtained during the various feeding experiments.

Evaluation	Low-producing cows	High-producing cows				
	protected supplement	unprotected supplement	protected supplement			infusing sunflower oil
	II* (30 + 37)**	I (93)	II_A (53 + 93)	II_B (53 + 93)	II_C (53 + 93)	III (93)
Fresh	6.4	6.6	6.7	6.3	6.3	6.4
After one week at 4 °C	6.3	6.0	6.4	6.2	6.1	6.3

Scoring scale: 8 = very good; 7 = good; 6 = acceptable; 5 = unacceptable; 4 = bad; 3 = very bad.
* The figures on this line refer to the experimental periods.
** The figures on this line refer to the cows' numbers.

Table 3. Results of sensory evaluation and analysis of ripened-cream butter produced from milk from the various feeding experiments. The butter samples were kept at 4 °C during sensory evaluation.

Evaluation after	Low-producing cows			High-producing cows														
	protected supplement			unprotected supplement			protected supplement									infusing sunflower oil		
	II* (30 + 37)**			I (93)			II_A (53 + 93)			II_B (53 + 93)			II_C (53 + 93)			III (93)		
	sens.[1]	TBA[2]	PV[3]	sens.	TBA	PV	sens.	TBA	PV	sens.	TBA	PV	sens.	TBA	PV	sens.	TBA	PV
one week at 7 °C	6.0 (1.5)	0.058	0.21	6.5 (0.5)	0.029	0.09	6.0 (1)	0.020	0.13	6.1 (0.5)	0.025	0.10	6.0 os (1)	0.050	0.28	6.0 os (1.5)	0.040	0.33
one month at —10 °C	5.8 (2)	0.083	0.23	6.1 (1)	0.047	0.26	5.9 (1) os(1)	0.028	0.28	6.1 (1)	0.030	—	5.9 os(1)	0.059	0.38	5.7 os(2)	0.060	0.44

[1] Sens. = sensory evaluation of flavour. For scale, see legends of Table 2. Figures in parentheses refer to the degree of oxidation flavour (scale: 1 = slight; 2 = moderate; 3 = strong; 4 = very strong); os = oilseed flavour (intensity scale same as for oxidation).
[2] TBA = thiobarbituric acid value.
[3] PV = peroxide value.
* The figures on this line refer to the experimental periods.
** The figures on this line refer to the cows' numbers.

After one week of storage all samples had acceptable TBA and peroxide values (POV), except sample III with a POV of 0.33 and sample IIC with a POV of 0.28. After one month of storage the POV of all the butter samples, including reference sample I, were slightly higher than the limit of 0.2, particularly the samples II_C and III. The TBA value of samples II, II_C and III were on the high side, and the butter samples produced during the experimental periods II, II_B, II_C and III were somewhat lacking in the typical cultured-cream butter flavour.

At 4 °C, the firmness and spreadability of these butter samples were satisfactory. However, at 14 °C they became very soft and lost their firmness rapidly. The colour of the butter was a little pale, but not unusual for normal butter from the winter period.

The organoleptic evaluations of Gouda cheese produced from milk which was obtained in the different feeding experiments, are given in Table 4. The reference sample of Gouda cheese (I) was of acceptable quality after ripening for six weeks and for four months, but the texture of the cheese was slightly soft. The cheese produced from milk obtained during feeding the protected supply was of acceptable quality, though the flavour was somewhat flat. One sample (II), was slightly oxidized after four months of ripening. The texture of the cheese at a temperature of 14 °C was mostly soft and mealy and, in fact, of unsuitable quality. It should be noted that the texture of the cheese when evaluated at 4 °C was much better, although still slightly mealy.

Similar results were obtained with cheese from the period of infusion of sunflower oil; the cheese was soft and displayed a slight oilseed flavour.

4 Discussion

The present investigations have confirmed previous findings (1, 9) that it is possible to increase the PUFA content of milk if the linoleic acid content of the feed is protected against biohydrogenation. However, the transfer of linoleic acid to the milk remained on average below 40 %, as was shown in the first part of our paper (3).

The changes in the fatty acid composition of milk fat which we found as a result of feeding the protected supplement are in good agreement with earlier findings (1, 9), in that the increased linoleic acid content is accompanied by a decrease mainly of oleic and palmitic acid. During the period of infusing sunflower oil, however, the linoleic acid content seemed to increase only at the expense of oleic acid. It is clear that the present experiments have shown once more that it is possible to produce milk with a linoleic acid content of the fat of approximately 10 to 20 %. However, the economic potential of

Table 4. Results of the sensory evaluation of Gouda cheese produced from milk from the various feeding experiments. The cheese samples were kept at 4 °C during sensory evaluation.

Evaluation after	Low-producing cows			High-producing cows											
	protected suppl.			unprotected suppl.			protected suppl.						infusing sunflower oil		
	II* (30 + 37)**			I (93)			IIA (53 + 94)			IIC (53 + 93)			III (93)		
	S	C	F	S	C	F	S	C	F	S	C	F	S	C	F
six weeks	6.0 os(1)	5.5 s.m.	2.5	6.0	6.1 s	3.4	6.3	6.0 s	4.3	6.0 ox (0.5)	6.0	3.3	6.0	5.7 s	2.9
four months	5.8 ox(1)	5.0 s.m.	3.0	6.0	6.1	3.6	6.0	5.6 m	4.2	6.0	5.3 m	3.8	6.0 os (0.5)	5.6 s	2.7

S = sensory evaluation of flavour (scale: see Table 2); C = consistency (same scale as for S); F = firmness (scale: 2 = very soft, 3 = soft, 4 = normal, 5 = firm, 6 = very firm). ox = oxidation (intensity scale (1–4) see legends in Table 3); os = oilseed flavour (same scale as for oxidation); s = soft; m = mealy.

* The figures on this line refer to the experimental periods.

** The figures on this line refer to the cows' numbers.

producing PUFA milk by this method does not seem very promising (3).

The evaluation of pasteurized milk, ripened-cream butter and Gouda cheese produced from the milk obtained in the different feeding experiments leads to the following conclusions.

Pasteurized milk produced from milk with an increased PUFA content (fatty acid composition 10 - 20 % linoleic acid) was of equal quality to the reference sample (3.8 % linoleic acid). Even after one week storage at 4 °C no oxidation defects were observed. Other studies have shown that an increased linoleic acid content of milk may lead to a higher oxidation susceptibility (10). The addition of an antioxidant to the fresh milk in the present experiments, possibly together with antioxidants from the protected feed, may be the cause of the absence of oxidation flavours.

Ripened-cream butter produced from milk with an increased linoleic acid content displayed a slightly higher oxidation susceptibility than did normal butter, which is in line with the findings of Kristensen et al. (10). This effect was not evident in all experiments, but together with an oilseed flavour in a number of the experimental samples the flavour score was lower than that for the reference sample with a normal linoleic acid content. Also, the experimental samples displayed a more or less bland flavour. It may be that this effect is due to inhibition of the pyruvate pathway which may occur in the presence of unsaturated fatty acids (11).

Kieseker & Eustace (12, 13) also found that sweet-cream butter from milk with an increased linoleic acid content was generally of satisfactory quality, although normal butter was slightly superior in flavour. The experimental butter displayed a good texture and spreadability at 4 °C but not at $\geqslant$14 °C when it was too soft. Concerning its use in the household, it is clear that this butter can be used directly from the refrigerator. In this respect it has advantages over traditional butter. The colour of the experimental butter was a little paler, but not unusual for normal butter from the winter season.

Gouda cheese produced from milk with an increased linoleic acid content was usually of acceptable flavour quality, although one sample had a slightly oxidized flavour after four months of ripening. Also, the flavour was more bland than that of the control cheese. This observation is in line with the finding of Czulak et al. (14, 15), who attributed this phenomenon to inhibition of the pyruvic dehydrogenase system. It has also been found (10) that lipolysis is reduced in milk fat with higher linoleic acid levels. The texture of the cheese at 4 °C was slightly mealy but acceptable. At 14 °C, however, the cheese was very soft and there was some tendency to fat separation.

Acknowledgments

The authors wish to thank Mrs G. Tuitert-Wijnen for gas-chromatographic analysis, Mr H. Hagedoorn for the determination of melting thermograms and Alfa Lipids Ltd for providing the protected supplement.

Samenvatting

H. T. Badings, S. Tamminga & J. E. Schaap, *Produktie van melk met een hoog gehalte aan meervoudig onverzadigde vetzuren. 2. Het verband tussen de vetzuursamenstelling van melk en de kwaliteit van eruit bereide gepasteuriseerde melk, boter en kaas*

Een onderzoek werd uitgevoerd om na te gaan welke invloed het gehalte aan linolzuur in melk had op de kwaliteit van de eruit bereide melk en zuivelprodukten. Oudmelkse en nieuwmelkse koeien werden gevoederd met een supplement van vermalen zonnebloemzaad (onbeschermd, dan wel beschermd tegen biohydrogenering in de pens) of met een supplement van ontvet zonnebloemzaad gecombineerd met infusie van zonnebloemolie in de dunne darm.

Wanneer onbeschermd zonnebloemzaad werd gevoederd, had de melk een normale vetzuursamenstelling. Na voedering van beschermd zonnebloemzaad of infusie van zonnebloemolie steeg het linolzuurgehalte van het melkvet tot 10 à 22 %.

Na toevoeging van 10 mg BHA (als antioxidant) per liter verse melk, werd deze gebruikt voor bereiding van gepasteuriseerde melk, gezuurde boter en Goudse kaas. De kwaliteit van deze produkten werd onderzocht en in relatie gebracht met het linolzuurgehalte van het melkvet.

Gepasteuriseerde melk met een verhoogd linolzuurgehalte bleek van dezelfde organoleptische kwaliteit te zijn als melk met een normaal linolzuurgehalte. Dit bleek eveneens het geval te zijn nadat de melk gedurende een week bij 4 °C was bewaard.

Gezuurde boter met een verhoogd linolzuurgehalte was iets gevoeliger voor oxidatie dan normale boter. Het aroma van de proefboter was wat vlakker en vertoonde enkele malen een lichte oliezaadsmaak. De verse boter was van voldoende kwaliteit, maar na een maand bewaring bij —10 °C werd de boter iets beneden deze grens beoordeeld.

Bij 4 °C waren de smeerbaarheid en consistentie van de experimentele boter goed. Dit betekent dat deze boter in de huishouding direct uit de koelkast gebruikt kan worden. Bij hogere temperaturen werd de experimentele boter echter zeer zacht en slap, waardoor de consistentie als onvoldoende werd beoordeeld.

Goudse kaas die werd bereid uit melk met een verhoogd linolzuurgehalte, was doorgaans van voldoende kwaliteit. De kaas was echter iets vlakker van smaak dan normale kaas en vertoonde soms na vier maanden rijping enige oxidatiesmaak. De consistentie van de kaas bij 4°C was voldoende, hoewel iets griezig. Bij 14°C was de kaas echter zeer zacht en sterk griezig.

References

1. T. W. Scott, L. J. Cook, K. A. Ferguson, I. W. McDonald, R. A. Buchanan & G. Loftus Hills, *Aust. J. Sci.* 32 (1970) 291.
2. Anonymous, Rural Res. CSIRO 79 (1973) 2.
3. S. Tamminga, A. Steg-Beers, W. van Hoven & H. T. Badings, *Neth. Milk Dairy J.* 30 (1976) 106.
4. J. Koops, *Res. Rep. Neth. Inst. Dairy Res.* V80 (1963).
5. G. Loftus Hills & C. C. Thiel, *J. Dairy Res.* 14 (1946) 340.
6. J. M. de Man, *J. Inst. Can. Technol. Aliment.* 1 (1968) 126.
7. H. T. Badings, J. J. G. van der Pol & J. G. Wassink, *Chromatographia* 8 (1975) 440.
8. J. E. Schaap & G. A. M. Rutten, *Neth. Milk Dairy J.* 28 (1974) 166-174.
9. L. J. Cook, T. W. Scott & Y. S. Pan, *J. Dairy Res.* 39 (1972) 211.
10. V. F. Kristensen, P. E. Andersen, G. K. Jensen, P. S. Hansen, A. N. Fisker & B. K. Mortensen, Faeelsudvalget for Statens. Mejeri- og Husdyrbrugsforsøg, 1. Beretning (1974).
11. R. F. Anders & G. R. Jago, *J. Dairy Res.* 37 (1970) 445.
12. F. G. Kieseker, *Aust. J. Dairy Technol.* 30 (1975) 7.
13. F. G. Kieseker & I. J. Eustace, *Aust. J. Dairy Technol.* 30 (1975) 17.