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Milkfat characteristics and functionality: opportunities for improvement

Introduction

Milkfat is a source of energy and nutrients, and is a valued ingredient that is used in many food applications, as it imparts desirable flavour and texture to a range of food products.

Milk contains 3-4% fat, which is comprised of:

- 97-98% triglycerides;
- 0.28-0.59% diglycerides;
- 0.016-0.038% monoglycerides;
- 0.10-0.44% free fatty acids;
- 0.2-1.0% phospholipids;
- 0.22-0.41% free sterols; and

Typically, milkfat contains 70% saturated fatty acids, 25% monounsaturated fatty acids and 5% polyunsaturated fatty acids. The carbon number of the triglycerides, the positional distribution of the fatty acids within the triglycerides and their degree of unsaturation influence the nutritional acceptance of milkfat, as well as its physical functionality in products such as butter, cream, confectionery and baked goods.

The high ratio of saturated to polyunsaturated fatty acids in dairy fats has generally been regarded as undesirable from a nutritional perspective due to the link between saturated fats and increased levels of serum cholesterol and heart disease. In recent years, there have been changing opinions about the significance of serum and dietary cholesterol, different types of saturated fatty acids and milkfat on heart disease (Majiha 2000). Milkfat contains a range of minor lipids and lipid-soluble components that have desirable health attributes. These include sphingomyelin, conjugated linoleic acid (CLA), ether lipids, butyric acid, fat-soluble vitamins, β-ionone and gossypol (Parodi 1996, 1999; Gurr 1997). Of these, there has been most interest in CLA.

Milkfat composition affects the flavour, nutritional properties and physical functionality of milkfat and, consequently, influences its suitability in food applications. Milkfat properties are affected by the type and amount of feed, stage of lactation, season, nutritional status, age of the cow, the number of successive lactations, the point during milking when the sample is taken, the interval between milkings, and the breed of cow. The fatty acid composition of milkfat can be readily altered through cow nutrition and genetic selection (International Dairy Federation 1991; Grummer 1991; Palmquist et al. 1993; Ashes et al. 1997). Feed and farm factors influencing milkfat composition and some of the effects on products have been reviewed by Palmquist et al. (1993). Milkfat composition can also be altered post-farm by the application of appropriate processing technologies (e.g. milkfat fractionation).

Summary

Manipulation of the composition of milkfat has the potential to improve the nutritional properties and physical functionality of milkfat and its acceptability in the market. The modifications that have been targeted from a nutritional perspective have included:

(a) reducing the ratio of saturated to unsaturated fatty acids;
(b) increasing the level of omega-3 polyunsaturated fatty acids; and
(c) increasing the content of conjugated linoleic acid.

From a physical functionality viewpoint, the outcome targeted has been an improvement in the spreadability of butter by altering milkfat composition to reduce the hardness of milkfat. Both on-farm strategies and the application of appropriate post-farm processing technologies may be used to alter the milkfat composition to enhance its nutritional image and its physical functionality for a range of product applications. However, changes in milkfat composition that are desirable for a specific nutritional purpose or for one type of milk-based product may not meet all the desirable requirements of another milkfat or dairy product. Furthermore, modification of the milkfat composition can also have an influence on the processing characteristics of milk and the quality of finished dairy products. It is essential to substantiate the benefits of specific target nutritional or physical functionality outcomes before the introduction of breeding goals, altered milk production systems or post-farm processing operations to manipulate milkfat composition. This paper reviews the variation in milkfat characteristics and the strategies that have been used to modify milkfat composition to achieve milkfat with altered nutritional and physical functional properties.

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This paper reviews the literature information on the variation in milkfat characteristics and the strategies that have been used to modify milkfat composition to achieve milkfat with altered nutritional and physical functional properties. Opportunities and strategies for enhancing the properties of milkfat and milk products are discussed.

Natural variation in milkfat characteristics

There is a significant natural variation in milkfat which affects both the nutritional and physical functionality of milkfat. The composition of milkfat is affected by stage of lactation, cow breed and cow diet. Jersey cows have 8-24% higher levels of C6 to C14 fatty acids, 13% higher levels of stearic acids and 15% lower levels of oleic acid than Holstein cows.

The content of short-chain fatty acids is low at the beginning of lactation and increases until about the 8th to 10th week of lactation (International Dairy Federation 1991; Grummer 1991; Palmquist et al. 1993; Ashes et al. 1987). In Australia, the short-chain fatty saturated fatty acids are higher in spring to summer and lower in autumn, and the long-chain saturated fatty acids are higher in summer to autumn and lower in winter and early spring; making summer fat harder than winter fat. The average content of long-chain saturated fatty acids increased by about 5% from 1975 to 1994, and saturated fatty acids have increased in milkfat as the yield of milkfat has increased (Black 1985; Papalois et al. 1996; Thomas and Rowney 1996); this possibly reflects changes in herd composition and feeding practices in Australia.

Animal and feed factors also influence the minor components of milkfat. The CLA content of milkfat ranges from 2.4-28.1 mg/g fat (Riel 1963). The high values of CLA in milk produced in Australia and New Zealand has been linked to pasture feeding (Parodi 1999). Cow breed and diet affect carotene content of milk (Keen and Wilson 1993; Knight and Waghorn 1993), with the strongest colours occurring in late winter and spring, and the weakest colours when the grass is mature during summer (Black 1977).

The fat in milk exists mostly in discrete globules enveloped by a membrane. Fat globules become smaller as lactation advances (Katzyar et al. 1973; Brunner 1974; Thirupathy and Sosamma 1997). Cows fed with more dry feed produced smaller globules than those given succulent feeds (Brunner 1974). The composition of the lipids of the milkfat globule membrane is different in summer and winter (Anderson and Cheeseman 1971). Membrane composition is affected by diet but the phospholipids do not increase relative to the surface area of fat globules with advancing lactation (McPherson and Kitchen 1983). The size of the milkfat globule and integrity of the fat globule membrane affect the processing behaviour of milk and its susceptibility to lipolysis. Feed also has an effect on lipolysis and the development of oxidised flavour of dairy products (Forss 1993).

Knowledge of the variation in milkfat composition and the factors affecting it provides the opportunity for strategies for segregation of milkfat for target applications and the base from which strategies for manipulation of milkfat can be developed.

Modifying milkfat characteristics

Various fatty acids have different effects on human health and an alteration in the content of specific fatty acids or class of fatty acids may be targeted for specific desirable human nutritional effects. The modifications that have been targeted from a nutritional perspective have included:

(a) reducing the ratio of saturated to unsaturated fatty acids;
(b) increasing the level of omega-3 polyunsaturated fatty acids; and
(c) increasing the content of conjugated linoleic acid.

The view of researchers at the 1988 Wisconsin Milk Board Round Table was that the ideal nutritional milkfat would have 8% saturated fatty acids, 82% monounsaturated fatty acids and 10% polyunsaturated fatty acids (Grummer 1991). A reduction in saturated fatty acid content is desirable for reduction in the cholesterol-raising activity of fat (Noakes et al. 1996). However, Kennelly and Glimm (1998) suggest that an acceptable fatty acid profile does not require extreme changes in fatty acid composition of milkfat but that a lower fat content milk is desirable. It appears that the ideal composition may require additional thought in the light of the new evidence of the health effects of individual fatty acids. Gurr (1999) has critically reviewed the role of lipids in nutrition. The interest in CLA has been relatively recent in comparison to that in targeting changes in the ratio of saturated to unsaturated fatty acids.

When milkfat composition is manipulated to achieve a target outcome that may have specific desired nutritional effects, there are often accompanying changes in the physical functionality of milkfat and milk products. The impact of the change in milkfat composition on product properties depends primarily on the magnitude of the change in the level of unsaturation, but other co-introduced changes in other milk components can also alter product properties. As a general rule, increased levels of unsaturation increases the susceptibility of fats to oxidation, decreases the hardness of the milkfat, which results in a softer butter that is more spreadable at refrigeration temperatures, and decreases viscosity and whippability of cream. A change in the content of unsaturated fatty acids may be accompanied by other changes in milk components, such as proteins, urea, citrate and soluble calcium (Palmquist et al. 1993); these can affect the heat stability, and emulsifying, foaming and gelling properties of milk and milk products. A change in the level of pro-oxidants, antioxidants and free fatty acids, which may be co-introduced, influences the susceptibility of the modified milkfat to oxidation. All these potential changes in milkfat and milk product properties, in addition to the effects of altered milkfat composition on the processing characteristics of the milk, have to be considered when estimating the value of altering milkfat composition to achieve a specific outcome.

Modifying the ratio of saturated to unsaturated fatty acids

Nutritionists are mainly concerned with the high ratio of the saturated to unsaturated fatty acids in dairy fats as lower ratios are more desirable from a health perspective (Noakes et al. 1996). The principal fatty acids in milkfat that raise low-density lipoprotein, a risk factor for coronary heart disease, are myristic acid (C14:0) and palmitic acid (C16:0). Lauric acid
(C12:0) is also considered to be cholesterol-raising. The short-
chain saturated fatty acids (C4:0 to C10:0) have previously been
considered to be not hypercholesterolemic but there is now
some controversy about the cholesterol-raising effects of C8:0
and C10:0 (Tholstrup et al. 1988). Stearic acid (C18:0), which
was previously regarded as undesirable, is now considered to
be neutral or to have positive health attributes (Kennelly and
Glimm 1998).

Modifying the fatty acid profile of milk by substituting myr-
ristic and palmitic acids with predominantly oleic acid (C18:1)
and some linoleic acid (C18:2) and linolenic acid (C18:3), by
feeding cows protected canola seed, improved the plasma lipopro-
tein profile in humans consuming the modified milk (Noakes et al. 1996). However, in other studies it was found that
consumption of a diet with modified milkfat, where there
had been an alteration of cow diet to produce modified milkfat
with a 16% reduction in the hypercholesterolemic saturated fatty
acids (C12:0-C16:0) replaced by mainly oleic acid (C18:1) and
to a smaller extent stearic acid (C18:0), did not lower the low
density lipoprotein cholesterol (Tholstrup et al. 1998). The
authors suggested that the high trans fatty acids in the milkfat
in these modified diets (5% w/w increase in trans fatty acids)
might have counteracted the cholesterol neutral or decreasing
effect and increased plasma triglycerides. They also indicated
that further studies were needed to ascertain the effects of trans fatty acids (Tholstrup et al. 1998). In both of
these studies there was a similar reduction in the level of C12:0
to C16:0 fatty acids, but the diets fed to the cows were differ-
ent. This suggests that when a reduction in hyper-
cholesterolemic saturated fatty acids is targeted, the effects of
other components in the feed on some of the minor components
in the fat need to be considered. Although further nutritional
studies are needed to confirm that the desired nutritional effects
in humans are obtained with the targeted change in fatty acid
composition, it appears that a modified milkfat with reduced
levels of C14:0 and C16:0 and enhanced levels of C18:0 or
C18:1 is desirable.

Feeding rumen-protected polyunsaturated fatty acids, which
results in milkfat with >20% C18:2, make these fats highly
susceptible to oxidation. The susceptibility to oxidation can be
reduced by addition of tocopherol through the diet, although
this is less effective than the addition of tocopherol to milk. The
issue of addition of antioxidants to milk and milk
products will need to be addressed as there are strict guidelines
about the use of additives in milk and milk products. The sus-
cceptibility of milkfat to oxidation was increased by 30-40% when
oilsseeds (550 g/day of extruded rapeseed plus linseed) were
added to the cow’s feed. However, the daily addition of 9616 IU
of vitamin E supplement increased the alpha-tocopherol concen-
tration in milk by approximately 45%, and improved the resis-
tance of milk fat to oxidation (Focant et al. 1998). The
incorporation of naked oats in cow diets resulted in milkfat with
a higher level of monounsaturated fatty acids than milkfat from
cows offered a control (barley) diet. Contrary to what might
have been expected, the milkfat with higher monounsaturated
fatty acid was less susceptible to oxidation as judged by per-
oxide value and thiobarbituric acid value. However, with the
use of sensory testing, off-odours were picked up in milkfat
with high levels of monounsaturated fatty acids (Feron et al.
1998). This illustrates the importance of both objective and
sensory tests to assess the modified milkfat. Ultimately it is
the sensory properties that are more important in determining
acceptability.

Badings et al. (1976) evaluated the effects of using milk high
in polyunsaturated fatty acid on the properties of pasteurised
milk, butter and cheese. Pasteurised milk with higher C18:2
content than conventional milk was of similar quality. Butter
made from milk with increased C18:2 was more susceptible to
oxidation, and gouda cheese was acceptable although it had a
more bland flavour. Others have found that, compared to the
conventional products, pasteurised milks with high levels of
C18:2 were more prone to flavour deterioration with the effects
being more prominent on storage, cream with 16% C18:2 took
twice as long to churn as conventional cream, and cheese qual-
ity was similar (Edmondson et al. 1974).

Products made from milks produced using Rumen tekn tech-
nology (milkfat with 48% saturates, 37% monounsaturates and
10% polyunsaturates) and control milks (milkfat with 64% satu-
rates, 27% monounsaturates and 3% polyunsaturates) have been
examined (Blakeley 1996). It was found that Rumen tekn whole
milk was acceptable and that inclusion of vitamin E in the cow’s
diet improved oxidative stability. Cream from Rumen tekn milk
was less viscous than cream from conventional milk but its
whipping properties and acceptability were not appreciably dif-
ferent. Butter from Rumen tekn milk was softer than that made
from conventional milk. Modifications to the buttermaking
process were required for production of butter from Rumen tekn
milk and further it was necessary to take steps to improve its
flavour stability. Cheese, yogurt and ice-cream made from
Rumen tekn milk were acceptable. UHT Rumen tekn milks
stored at low temperature (13°C) had acceptable flavour after
6 months, but that at high temperature (>20°C), the milk was
less shelf-stable.

Increasing the level of omega-3 fatty acids

Milk is inherently low in long-chain omega-3 fatty acids, par-
ticularly eicosapentaenoic acid (EPA, C20:5) and
dodecahexaenoic acid (DHA, C22:6). There is growing aware-
ness of the beneficial effects of these fatty acids on the develop-
ment of the central nervous system and the retina, and
cognitive development, as well as in reducing the risk of coro-

On-farm strategies for increasing the level of omega-3 fatty
acids have generally been based on incorporation of fish oil in
the cow diet. The addition of rumen-protected tuna oil in feeds
was found to significantly enrich milkfat with omega-3 fatty
acids without affecting milk production of grazing cows
(Kitessa et al. 2001) whereas, with fish meal supplements, EPA
and DHA in milk were increased but milk yield was reduced
(Cant et al. 1997). Post-farm strategies that have been exam-
ined include the incorporation of fish oil or microencapsulated
fish oil in milk and dairy products (Andersen 1998). The sus-
cceptibility of these milks and milk products high in EPA and
DHA to oxidation need to be evaluated, as unprotected poly-
unsaturated fatty acids are very prone to the development of off-
flavours.
Increasing the content of conjugated linoleic acid

The interest in CLA stems from its desirable health benefits. CLA has anti-carcinogenic and anti-atherogenic, immuno-modulating properties (Parodi 1996) and anti-diabetic effects (Fritsche 1998). The 9-cis, 11-trans isomer, which is the isomer that is predominant in milkfat, has anti-cancer properties (Parodi 1996), while the 10-trans, 12-cis isomer is the active isomer affecting lipid levels (Deckere et al. 1999). Others have found that the anti-atherogenic properties of CLA was due to a mixture of CLA isomers, but not pure 9-cis, 11-trans isomer (Gavino et al. 2000).

The CLA content of milk can be altered by diet and farm management practices (Jahreis et al. 1996; Palmquist 2001; Jensen 2002). Lowering the ratio of concentrate to forage in the cow’s diet increased CLA levels. In this study, the variation in CLA content in milks from different diets ranged from 2.5 to 17.7 mg/g fat (Jiang et al. 1996). Recent studies carried out in Australia have shown that cow diet and cow condition have an effect on the CLA content of milkfat (Wiesundera et al. 2001). CLA in milkfat can be enhanced by dietary supplements through abdominal infusion of CLA but this is accompanied by changes in fatty acid composition and milk yield (Chouinard et al. 1999). A recent study reported that the incorporation of menhaden fish oil in the cow diet increased the levels of CLA, transvaccenic acid as well as total unsaturated fatty acids in milk, but reduced the total fat content of the milk (Baer et al. 2001). These authors also concluded that there were no significant differences in the flavour characteristics of the milk and butter produced with milk from cows fed a control or fish oil diets, but that the peroxide value of stored butters (3 months) from cows fed fish oil diets were higher.

Jensen (2002) has recently reviewed the literature on the effects of alteration of CLA content by processing. Methods used to increase CLA content include interesterification of milkfat with a CLA mixture using lipase and use of supercritical carbon dioxide to enrich fractions of milkfat.

Improving the spreadability of butter

Butter has a desirable flavour and natural image, but a drawback, from a consumer point of view, is its lack of spreadability when removed from the refrigerator. Hence, the opportunity to alter milkfat composition to obtain a more spreadable butter has been a target outcome for the dairy industry. It would be desirable to decrease the hardness of butter to make it spreadable. Values of about 25% and 45% solid fat at 20°C and 10°C, respectively, have been considered to be desirable for satisfactory spreadability of butter (Wood et al. 1975). However, in the vegetable spreads industry, lower solid fat contents of ~10% and ~20% solid fat at 20°C and 10°C, respectively are desirable for spreads that are spreadable from the refrigerator (Rod Smith, personal communication).

The melting properties of milkfat, which are influenced by its fatty acid composition and the distribution of the fatty acids on the triglycerides, have the major impact on the rheological properties of butter. Processing such as reworking can reduce the hardness of butter (MacGibbon and McLennan 1987). Although it is possible to induce a metastable fat crystallisation state that gives improved spreadability to butter, repeated transfers to and from the refrigerator can cause transformation of the fat into a stable crystalline state and increases in hardness (Banks and Christie 1990). The soft fraction of milkfat (olein) obtained upon fractionation of milkfat may be used to improve the spreadability of butter, but with the use of this post-farm strategy, the whole image and natural delicate flavour of butter is compromised.

An alternative approach to obtaining spreadable butter of applying on-farm strategies, such as an alteration of cow diets, offers the potential to improve spreadability of butter while retaining the positive attributes of butter. Achieving a more spreadable butter requires an increase in the low-melting triglycerides in milkfat, which in turn reduces the solid fat content of the butter at low temperature. Increasing low-melting triglycerides may be achieved by increasing the relative amount of short-chain fatty acids or by increasing the level of unsaturation. Banks and Christie (1990) have reviewed feeding strategies to alter fatty acid composition to achieve butter with desirable spreadability. They also compared the relative benefits of using protected fat containing polysaturated oil to increase the content of C18:unsaturated fatty acids, and diets high in C18 fatty acids relative to fatty acids of other chain lengths to increase C18:1 and reduce C16:0. Both methods improved the spreadability of butter. The alternative approach of increasing short-chain fatty acid by manipulating the cow’s diet appears to be more difficult, as an increase in short-chain fatty acid also results in a increase in C16:0, which increase fat hardness.

Incorporation of full-fat soyabean and rapeseeds in the diet resulted in reduced levels of C8:0 to C16:0, increased levels of C18:0, C18:1 and C18:2, and lower solid fat content (Murphy et al. 1990; Murphy et al. 1995); this would make butter made from it more spreadable. The feeding of cows with oilseeds that contain unsaturated fatty acids which are greater than 75% protected from metabolism in the rumen has been used to produce spreadable butter (Gulati et al. 1999). Farmers in
Ireland are producing milk for manufacture of a naturally spreadable butter (Fearon 2001).

It should be recognised that reducing high-melting fat to improve spreadability can have effects on other properties. Increasing unsaturated fatty acid composition (which improves the nutritional image) renders the milkfat more susceptible to oxidative deterioration. Softer fat in butter has been found to increase the oiling off in butter (Cullinan et al. 1984). The addition of Ca salts of unsaturated fatty acids to the diet of cows improved the thermal properties of butter made from the milk produced. The butter had less solid fat at 5°C (making it more spreadable from the refrigerator) but had similar solid fat content at 20°C to control butter (Chouinard et al. 1998). Softer fats also have impaired whipping properties and would therefore not be suitable for whipping cream applications. They are also less suited for bakery applications such as puff pastry.

Altering the physical properties of cream

The whipping properties of cream vary with season, and poor performance of whipping cream has been related to the low-melting fat, due primarily to the high levels of C18:1 (Banks et al. 1989; Rohm et al. 1989). Creaming or plug formation can also occur at certain times of the year in whipping cream (Precht and Peters 1984). The plug formation is dependent on the solvent-extractable fat content, the size of the fat globules, the mechanical stress exerted on the cream, and interruptions to the cooling chain. Whipping cream that has the shortest whipping time has the poorest storage stability (compact cream plugs) and whipping cream that has the longest whipping time has the best storage stability (Ronkilde-Poulsen et al. 1981). Cows grazing old pastures gave the best quality cream (Precht and Peters 1984). It was found that cow diet affected the fatty acid composition of Friesian milkfat but this did not cause a significant change in whipping properties of cream. However, the whipping properties of Jersey cream was affected by cow diet. Although the fatty acid composition, via its effect on melting behaviour, affected whipping properties, it was evident that changes in fatty acid composition interact with other compositional factors (Banks et al. 1989).

Manipulation of milkfat for bakery and confectionery applications

While softer milkfats are desirable for manufacture of spreadable butter, harder milk fat performs better in puff pastry, where the higher melting triglycerides are needed to provide the lift in puffed products. Fractionation of milkfat has been used to obtain the hard fraction (stearin) with a melting point of 40-44°C for improving the physical functionality of milkfat in puff-pastry products (International Dairy Federation 1991; MacGibbon 1996). Specialty milkfat fractions have also been produced for use in chocolate, where they have the advantage of providing better anti-bloom properties than unfractionated milkfat.

Modifying milkfat globules

The fatty acid composition of the milkfat globule membrane is affected by diet (Palmquist and Schanbacher 1991). Supplementation of feed with C16:0 increased the membrane content of this fatty acid, a diet high in corn increased the level of C18:1 and a soy oil emulsion increased the C18:2 and decreased the C18:1 and C20:4 in the fat globule membrane. The effect of these changes on products has not been examined but it may be expected that the robustness of the milk fat globule membrane would be influenced by changes in its lipid composition. Dry feed has been linked to weaker milkfat globule membranes in late lactation and the increased incidence of spontaneous lipolysis (Fox and McSweeney 1998), which causes the development of off-flavours and has the potential to impair the physical functionality of milk products. The size of fat globules may be modified by diet as evidenced by the work of Ingr et al. (1972) who found that fat globules were larger in milk from cows fed conventional diets than those fed haylage or half haylage. Although the efficiency of cream separation may be reduced when fat globule size is decreased, there can be beneficial effects of reduced particle size in some applications where resistance to creaming is desirable.

Controlling the level of free fatty acids

Milkfat-containing products are sometimes described as having off-flavours arising from deterioration of fats. These off-flavours can be due to lipolysis or oxidation of milkfat (Weihrauch 1988). It has been found that the hard milk fat that arises from stall feeding results in a high free fatty acid content (Precht and Peters 1984). The levels of free fatty acids tend to be highest in late lactation from cows that have conceived but not in cows that have not conceived (Chazal and Chilliard 1985). Free fatty acid levels in late lactation are higher when silage is fed than when hay is fed. In late lactation, the free fatty acid content was not affected by moderate energy restriction, adding whey to the diet, or replacing soybean meal with lucerne silage (Chazal and Chilliard 1985). Underfeeding can result in spontaneous lipolysis and increased lipolytic activity in milk (Forss 1993). The addition of dietary zinc was found to decrease free fatty acid formation during cold storage for 72 hours (Hermansen et al. 1995). The free fatty acids in milk increased with high stocking density and decreased with silage and concentrate supplementation indicating that an increase in the plane of nutrition of the cow decreases free fatty acids (O'Brien et al. 1996, 1999). Elevated free fatty acid levels are undesirable as they have the potential to cause off-flavour problems, particularly in stored products. Increased lipolysis in milk and milk products may also be linked to some of the problems that occur during late lactation such as inefficiencies in fat separation, and the lack of foam formation and stability in cappuccino applications. Hence, developing strategies for controlling free fatty acid content is desirable.

Conclusion

There are a number of opportunities for improving the consumer value of milkfat, including the design of milkfat with improved nutritional characteristics and/or desirable physical attributes of target milkfat products. On-farm strategies (e.g. alteration of feeding regimes and genetic improvement) and the application of appropriate post-farm processing technologies may be used to alter the composition of milkfat.
However, changes in milkfat composition that are beneficial for nutritional purposes or for one type of milk-based product can have detrimental effects on other products. When on-farm strategies are adopted to alter specific modifications of milkfat for improving its nutritional or physical properties, they need to be considered in conjunction with the accompanying changes to other milk components and the effects of these changes on the processing properties of milk (e.g., cream separation, butter churning time). Strategies to improve the consistency of milkfat offer the advantages of better control of processing behaviour and product attributes and this should also be addressed. Irrespective of what changes are targeted, milk should be appropriately handled to minimise the risk of fat deteriorative reactions occurring post-milking and during processing of milk. The value of milkfat depends on a complex interplay of many factors. These include the costs associated with milk production on the farm and its processing and the value it attracts in the marketplace, which is influenced by its composition, flavour, quality, and its ability to be transformed into products of consistent quality that consumers desire. It is beyond the scope of this review to examine the complex issues which influence the relative value of on-farm and post-farm manipulation for adding value to milkfat. However, it is essential to substantiate the benefits of specific target nutritional or physical functionality outcomes prior to the introduction of breeding goals, altered milk production systems or post-farm processing operations to manipulate milkfat composition.

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References


