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Producing a spreadable butter using modified milkfat

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ABSTRACT

While traditional butter has been the spread of choice for many years because of the full flavour and excellent storage properties, since the advent of household refrigerators the lack of spreadability of butter when taken directly from the refrigerator has been seen as a negative characteristic. The approach taken in this study was to modify the composition of the milk from the cow through feeding trials carried out at Dexcel. However the final product must be able to be processed through a dairy plant and to have the performance that the customer requires. This means that it is not enough to know that the composition has changed but that the physical properties produced by these changes are advantageous. The goal therefore was to make the link between the properties required and to work to produce modifications that would produce those properties. This was achieved by defining the links between the product and the milkfat composition and making the physical properties such as solid fat content a target. The goal of producing a spreadable butter using modified milkfat was achieved however there is still a need to develop a profitable farm system.

Keywords: milkfat; butter; spreadability; solid fat content; hardness.

INTRODUCTION

Traditional butter has been the spread of choice for many years because of its full flavour, mouth feel and excellent storage properties. However, in recent times the negative health image of fat, along with a lack of convenience as a spread (with the advent of household refrigerators and the availability of polyunsaturated margarines) has led to a decline in sales. The lack of convenience is mainly the difficulty in spreading butter obtained directly from the refrigerator. Butter is too hard to spread easily at low temperature, a property that polyunsaturated margarines can achieve. The long-term trend of butter consumption is a slow decline, however, in the last few years there has been signs of a slowing of the decline, and in some cases a slight recovery. The demand from private households has been continually falling, but there has been a growth in the demand from catering outlets and food services (IDF Bulletin, 2000). It is interesting that consumption patterns are not universal but specific to each country. For instance New Zealand (7.5 kg *per capita per annum*), France (8.3) and Germany (6.8) are high butter consumers, while Australia (3.2), UK (3.2), Italy (2.3), USA (2.2), Denmark (1.7) and Argentina (1.2) are low consumers.

The requirement to retain the distinctive dairy flavour in milkfat products has been one of the contributing factors to the traditionally conservative processing in the dairy industry. This approach has had advantages in maintaining a natural image to the product, however it does limit the ways in which the butter can be modified, as compared with the wide variety of chemical and physical methods such as hydrogenation, interesterification, bleaching and deodorization used in the edible oils industry.

Two physical approaches have been used for the softening of butter in New Zealand: Double-churning (reworking) in which the chemical composition of the butter is unchanged, but the additional processing softens

the texture of the butter; and fractionation from the melt, in which the milkfat from cream processing is fractionated and the unwanted fractions not included in the final butter (Norris, 1974; Rajah, 1994). In the fractionation scheme the chemical composition is altered by the non-inclusion of unwanted fractions. Both these schemes have been used commercially in New Zealand. Even with fractionation from the melt the changes are limited to the extent that nothing is added, so one is working only with what was in the original milk. There would be greater options if there were changes in the composition of the original milk.

Targets

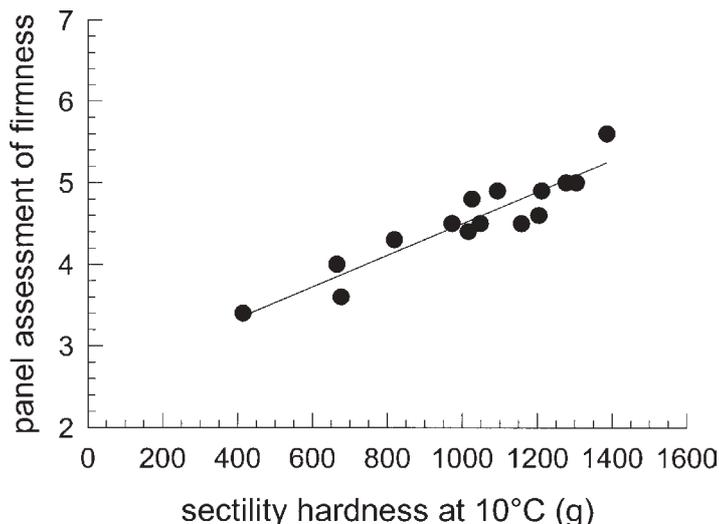
The aim of this work was to increase the potential for modification of the spreadability of butter by directed changes to the composition of the milkfat through changes in the diet of the cow (Thomson & MacGibbon, 2000; Thomson *et al.*, 2002). The goal was to be able to predict the required changes by the linkages to the product properties, to enable the production of a spreadable butter directly from the cow.

The properties required were spreadability from the refrigerator, good flavour and no increase in oxidation or lipolysis of the fat, as well as the ability to be processed through existing equipment. An important requirement for butter is that it have good standup at high temperature (20°C). It is of no advantage if the butter is spreadable at refrigerator temperature and yet becomes a messy liquid after it has been left on the table. Thus, the simple solution of removing the hard fats would not lead to an acceptable product and in fact would have a value much less than ordinary milkfat for this purpose. This reinforces the point that the product must be processable and perform to expectations.

Consumer testing every butter sample for spreadability would be a time-consuming and costly exercise so the customer-perceived spreadability needs to be related to a

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FIGURE 1. Correlation of sectility hardness at 10°C and trained panel assessment of firmness.

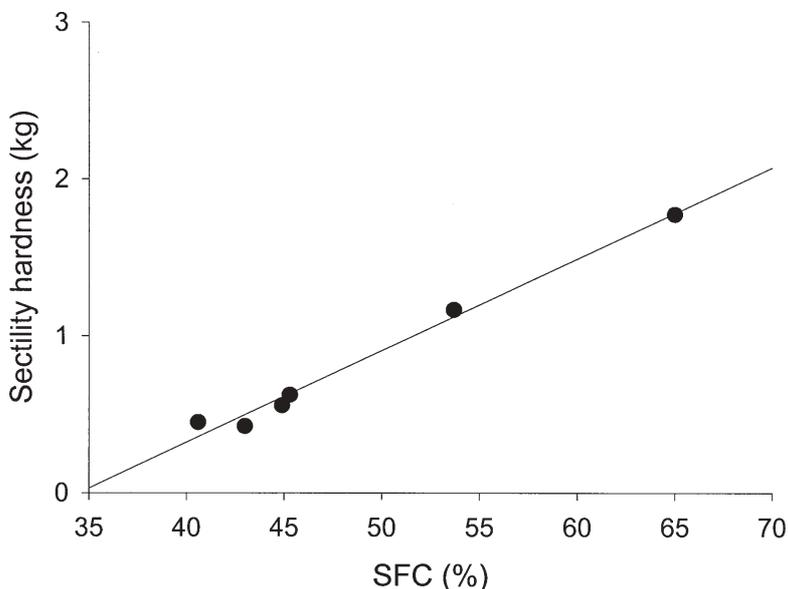


laboratory test. The sectility hardness method (MacGibbon & McLennan, 1987) which measures the force required for a wire moving at constant speed to cut through a slice of butter has proved to be a reliable test. Figure 1 shows the correlation between consumer panel perception of spreadability and the test method carried out on a range of butter samples from around the world, made using a variety of buttermaking processes. The correlation ($r = 0.93$) is very good considering the very wide range of samples and the inherent variability in consumer panel testing.

From Figure 1 an estimate of an acceptable spreadability from the refrigerator would be a sectility hardness value of below 650 g. This is a target value. However, using this test requires butter to be made from each sample, so a relationship to a test on the bulk milkfat would make testing simpler. There is a proviso, and that is that testing of the product, such as testing sectility hardness, encompasses both the properties due to the chemical composition of the cream, and the properties which have been incorporated due to processing. The

way that milkfat crystallises has a large bearing on the final properties. If it can be assumed that all the products will endure the same processing it is possible to relate the properties to the chemical composition of the fat. The most convenient method is to measure the solid fat content (SFC) by pulsed nuclear magnetic resonance (NMR). The SFC is a measure of the percentage of milkfat, which is solid at a specified temperature and relates well to the sectility hardness under constant processing conditions (MacGibbon & McLennan, 1987). Figure 2 shows the correlation between the sectility hardness and the SFC at 5°C. These samples were all made on the same day using a mini-churn with conditions as close to constant as practical. Depending on the range of samples the relationship may not always be linear but may be a curve, however the ranking of sectility hardness and SFC is the same. The advantage of a physical measurement is that it is sum of the all the effects of composition and so produces a more definite response than fatty acid analysis, where the overall effect of the positive and negative contributions of the individual fatty acids are difficult to determine. This

FIGURE 2. Relationship between SFC at 5°C and the sectility hardness at 5°C



is because the triacylglycerols are made up of three fatty acids and the actual fatty acids associated with individual triacylglycerols are important in determining the resultant properties (Creamer & MacGibbon, 1996). Fatty acid analyses are helpful in determining relative changes (Mackle *et al.*, 1997) and relationships may be established. However these are usually only applicable to the range of samples analysed, as there are a variety of triacylglycerol combinations which can produce the same SFC.

Processing effects

The crystallisation of milkfat plays an important part in the properties of butter. Milkfat can crystallise into three different crystal forms (alpha, beta prime and beta) each with different properties, and the different triacylglycerols can crystallise at different rates. In addition, because of the wide range of triacylglycerols in milkfat, most crystals form as mixed crystals, a combination of a variety of triacylglycerols, and the extent of mixed-crystal formation also plays a role in the properties. Crystallisation is affected by the temperature and rate of cooling of the milkfat. This means that care must be taken when comparing samples made under differing processing conditions. The solid fat content method eliminates the effects of processing from the sample by melting the fat and recrystallising under constant conditions. Those standard conditions should relate to the processing of the product. Measuring the SFC at 30°C, close to the melting point of the milkfat, would not give useful information about the properties at lower temperatures. Similarly the American Oil Chemist's Society (AOCS) has different tempering procedures for non-stabilising fats and oils, and confectionary fats (AOCS, 1998).

Spreadable butter

Thomson *et al.*, (2002) have described the feeding regimes that were used to change the composition of the milkfat in the milk produced from the cows. This involved the feeding of unprotected oilseed and oilseed protected against ruminal biohydrogenation by different process. These were crushed canola and canola ruminally protected by two different procedures. This study was carried out at the end of the dairy season (May) and so the control sample had a lower solid fat content than typical mid-season values (MacGibbon & McLennan, 1987). Thomson *et al.*, (2002) collected milk from 4 experimental groups (Table 1) and the milk from each group was separated to cream and the cream churned in a mini-churn at the New Zealand Dairy Research Institute. Some reduction in the crystallising temperature had to be

TABLE 1: The effect on the characteristics of milkfat to feeding the same amount of canola either non-ruminally protected or ruminally protected by two different processes. Analysis at 5°C of butters produced from milk collection.

	Control	Canola 1	Canola 2	Canola 3
SFC 5°C	52.8	49.4	47.5	38.9
Sectility hardness (g)	840	570	540	380

Canola 1, Crushed canola – non-ruminally protected
 Canola 2, Ruminally protected
 Canola 3, Ruminally protected

made to allow the softer cream to churn. The butters were allowed to set up for 30 days at 4°C to reach a plateau of hardness prior to measurement of sectility hardness. Fat was extracted from the butter for the SFC measurements. Table 1 shows that there was a variation in the extent of reduction in SFC, which was related to the extent of protection of the fat from ruminal hydrogenation in each of the feed samples. The canola 3 sample showed the greatest change and even at 5°C had a sectility hardness that was lower than the 650g target for spreadability. The standup at higher temperatures was good and the mouthfeel and flavour was excellent.

CONCLUSION

The aim has been to stress the importance of linkages in the value chain and how defined targets from the market end of the business need to be linked through the production chain all the way down to the milk supply.

There is a large advantage in the coordination of the on-farm modification of milk composition with the knowledge and monitoring of processability and product performance. If this is part of the target rather than simply a milk composition parameter then the work may be focussed to produce the desired outcome more quickly and practically. In fact it is essential for efficient transfer of research knowledge. This is opposed to the wishful thinking approach to changes in the composition of milk on the farm in isolation of production factors and the equally problematical production led attempts to change farming practices without the knowledge of practical and reasonable farm systems. The collaboration between the farm management specialists at Dexel and the product-related researchers at the Fonterra Research Centre and dairy companies has been very rewarding in this regard. New Zealand is ideally placed to take advantage of this vertical integration.

While the goal of producing a spreadable butter using modified milkfat was achieved, there is still a need to develop a profitable farm system. However the benefits of the experimental designs, product-related targets and scientific knowledge gained are already profiting the New Zealand industry.

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