CAS Paper 37

Future global, EU and UK markets for milk and milk products – *implications for the UK dairy industry*

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4 New and alternative uses for milk in food products

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INTRODUCTION

In 1993 the government Nutrition Task Force published its report *The Health of the Nation*, and this year saw the publication of its successor *Our Healthier Nation*. Both documents have a number of objectives, the second rather less than the first, but in both there is a recognition that implementation would only come about if all sectors of the community were involved - education providers, primary food producers, the food manufacturers and retailers, caterers and health care providers. An early objective for the Food Manufacturing Industry was to encourage exploration of ways and means of reducing fat consumption. For the dairy industry this was an unwelcome message because it targeted three of its best loved products: butter, cream and hard cheese. These products were synonymous with luxury and good quality foods, where in past years, milk and cheese were the cornerstone of a good diet and our children were provided with free milk at school. The consumer enjoys and values the flavour and texture provided by the fat of milk. The new ingredients offered by food manufacturers which serve to replace the attributes of milk-derived ingredients are being sold with the descriptors 'creaminess' and 'good mouthfeel', the very descriptions we could reserve for dairy cream. The dairy industry can retaliate by repackaging their products - such as the Channel Island milk that is marketed in attractive Tetra Paks as 'Breakfast Milk'; marketing yoghurt as rich and creamy or promoting real dairy cream as 'Naughty but Nice'. This does not, however meet the requirement of the Nutrition Task Force and new ways of recovering lost markets for milk and dairy products must be found.

Milk components form a significant part of the food ingredient market. Milk powder is used extensively by the confectionery industry and whey proteins have been incorporated into sports drinks and blended with caseinates and/or egg albumen for bakery products (see review by Russell,1998). The blending of whey proteins and caseinates produces properties such as browning and binding ability. The physical attributes are the important factors for this market. Flavour and aroma are also important and milk, as a natural product is notoriously variable. Milk, however, is in fact bland and it is fortunate, as Nursten (1997) points out "that a real fresh milk aroma is belief rather than fact" as the wide adoption of milk as a food ingredient is as a consequence of its blandness. Nevertheless milk can harbour a number of important aroma compounds.

Milk composition varies with species and time of year and the aroma compounds change if milk is processed (homogenised, pasteurised, sterilised). Over 30 hydrocarbons, more than 20 alcohols, around 50 aldehydes and ketones, about 20 acids, 20 esters and 15 bases have been identified. Unfortunately this does not help us understand the sensory attributes of milk and its components as we would need to know the value and the intensity of the odour compound (the use of 'odour unit' is useful - this is determined as odour intensity divided by the detection threshold) and a number of studies have resulted in sensory analysis of milk and dairy products that have yielded a good deal of information (Adda, 1986; Bodyfelt *et al,* 1988; Calvo & de la Hoz, 1992). Flavour and aroma compounds can arise from lactose or from citrate, from fat, or from protein. These will contribute to the sensory attributes that are familiar in products such as creme fraiche, yoghurt and cheese. Such products themselves are finding their way into the food ingredients market: more than 30% of the USA cheese market is as a food ingredient and yoghurt also is now widely available in powdered form for the food manufacturer.

DAIRY FLAVOUR COMPONENTS

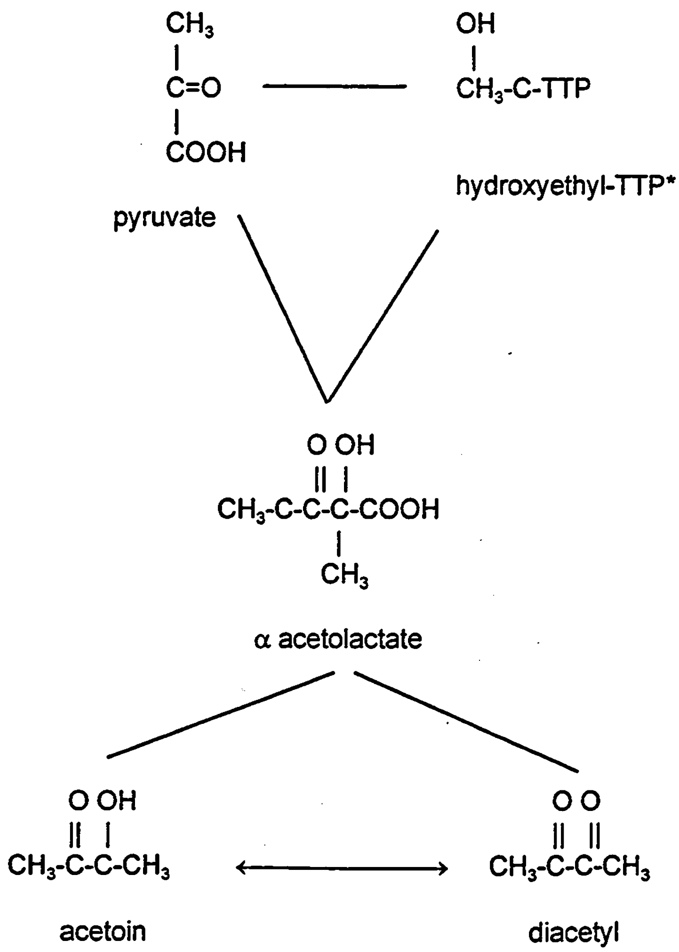
Butter flavour for yellow fat spreads

The market for butter declined as the demand for the new spreadable margarine grew. Margarine, however, became popular only when the manufacturers were able to make it with the taste of butter. Many margarine formulations today need to have milk components (whey and/or skimmed milk) included for good flavour to develop. The milk components are 'dairy' and will therefore bring those 'dairy' aromas and flavours with them. Typical butter flavour comprises decanoic acid, δ-decanolide, ρ-cresol, indole and scatole, with the latter two being particularly significant (Urbach *et al* 1972; Stark *et al*, 1976 a,b). However, early work on flavour of cultured (ripened) butter showed that an essential flavour volatile is diacetyl (2,3 butandione) and that reproduction of the butter flavour was possible by including diacetyl, acetic acid and lactic acid. Such a cocktail is easily obtained in the dairy industry. Milk can be fermented with starter organisms such as *Lactococcus lactis* ssp. *diacetilactis* or *Leuconostoc cremoris* which are used to make the Scandinavian buttermilks. These organisms are particularly adept at producing diacetyl (see Figure 1) and the fermented milk, or the whey, when dried using technology which limits the loss of the volatiles will provide just the ingredient for the creaminess that equates with butter flavour.

Yoghurt and caramelised milk as flavour ingredients

Yoghurt is now available as a powder and advertised as having a smooth creamy taste when blended with denatured whey proteins. The powders may also be blended so that they have zero fat. Other products available are caramelised skim milk powder which provides the flavour characteristic required by chocolate manufactures and whey powders with a mineral content similar to skim milk and promoted as providing a better taste for chocolate products (Russell, 1998).

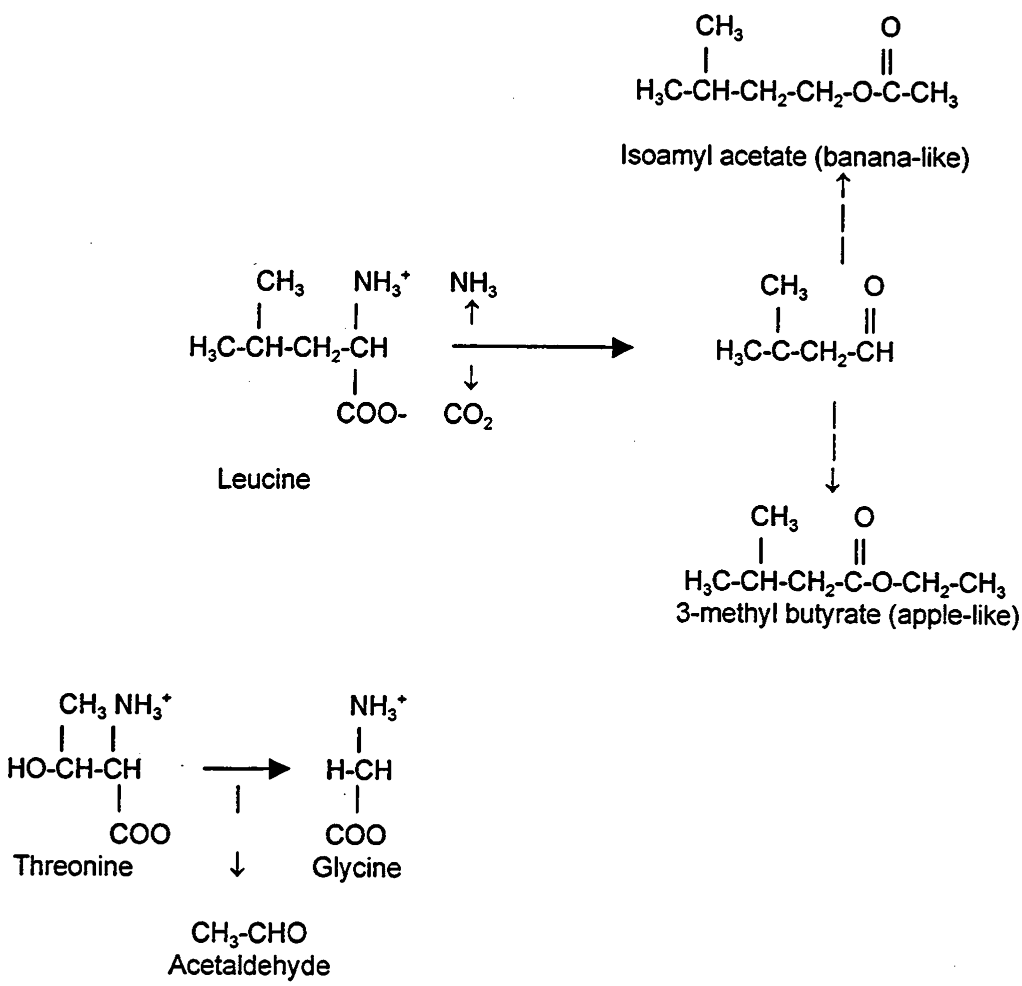
Figure 1
Diacetyl production from pyruvate



* = thiamine pyrophosphate

Essential to yoghurt flavour and aroma are lactic acid and acetaldehyde. Diacetyl is also important. Acetaldehyde can arise from microbial metabolism of lactose, but it is becoming apparent that nitrogen metabolism has a significant role. Release of aroma compounds as a result of proteolysis of milk protein is paramount to development of cheese flavour. Peptides containing the sulphur amino acids, cysteine and methionine are the source of aroma compounds such as hydrogen sulphide, methanediol and dimethyl sulphide. Amino acid conversions (Figure 2) however may not be fully exploited by the dairy scientists of the nineties. Flavour ingredients from yeast have a market value of approximately $200 million. Branched chain amino acids for example can evolve, during the transamination and decarboxylation processes of the 'Strecker degradation', into flavour compounds such as methional from methionine (important in boiling potatoes and in cheese-cracker flavours); and fruity volatiles such as isoamyl acetate (banana-like) and 3-methyl-butyrate (apple-like). In addition, these reactions may be achieved *via* a dairy lactic-acid bacterial fermentation. The lactococci are able to produce fruity ketones and the thermophilic organisms *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp *bulgaricus* produce the yoghurt aroma compound acetaldehyde *via* conversion of threonine to glycine (Figure 2). Thus fermentation will result in a natural (biotechnological) production of new flavouring compounds borne by bland milk-based vehicles (skim milk and/or whey proteins) for the food ingredients market.

Figure 2
Flavour volatiles from amino acids



TEXTURISING ATTRIBUTES

Table 1 places thickeners and stabilisers as the most important food additive group in Western Europe with the third largest growth, after non-nutritive sweeteners and enzymes. The most used dairy-derived thickener/stabilisers are the caseinates which are used primarily for their water-holding properties and their ability to stabilise foams. Caseinates, however, do not satisfy the new demand for 'mouthfeel' nor can they be used as a fat substitute. These attributes are largely the domain of the gums such as carrageenan, alginates, xanthan. The former two are from marine sources where the extraction processes involve chemical and mechanical procedures. There are also seasonal and geographical variations which can influence product quality. The latter is a polysaccharide of microbial origin and has fuelled recent research interest in microbial sources of polysaccharide as novel food thickeners and/or stabilisers, the production of which may be better controlled.

Table 1
Western European sales of food additives (US $ million)

Food additive	1995	2000*	annual growth
fat substitutes	19	21	2.5%
non nutritive sweeteners	248	302	4.0
enzymes	111	139	4.6
colours	181	202	2.2
vitamins	270	290	1.5
antioxidants	28	31	2.0
thickeners/stabilisers	1,204	1,316	3.0
emulsifiers	176	192	1.8
preservatives	37	40	1.4

* Estimate

Microbial polysaccharides are expensive to produce as there is a requirement for fermentation and process technology. The dairy industry has this in place and is very used to these processes. A feedstock for such fermentations could well be dairy-based (eg whey). However the downstream processing and purification steps that would be necessary to produce a novel polysaccharide for use as a food additive (and therefore requiring formal approval with accession of a suitable 'E number') from a dairy feedstock is likely to be expensive. A more attractive alternative therefore might be to ferment milk with the polysaccharide-producing organisms and market the processed product as a food ingredient having stabilising and texturising properties. Milk fermented with polysaccharide-producing strains of *Streptococcus thermophilus* and/or *Lactobacillus delbrueckii* ssp *bulgaricus* results in products with increased viscosity, greater ability to recover lost viscosity as a result of mechanical disruption of texture and a higher sensory score for 'mouthfeel' and 'thickening' (Rohm & Kovac, 1994; Rawson & Marshall, 1997; Rawson, 1997). Furthermore the structures of the polysaccharide from some strains of these organisms are known (Gruter *et al* 1993; Stingele *et al*, 1996; Grobben *et al*, 1997; Lemoine *et al*, 1997). They are generally heteropolysaccharides composed principally of galactose and glucose and have branched structures. So far structure has not been directly related to texturising properties. This idea of using fermented milks as a food ingredient is already receiving attention from the bakery industry where they may be used as flavour enhancers and for improved loaf volume (Gelinas & Lachance, 1995; Gelinas *et al*, 1995; Erdogduarnoczky *et al*, 1996).

HEALTHIER, SAFER, MORE NUTRITIOUS FOODS

Milk is a safe, nutritious product. It is also a natural product, although it is perishable and has a short shelf life. Improvements can be made through fermentation and there are many claims that fermented milks add value, are better for us and will make us feel more healthy (see review by Buttriss, 1997). Many claims have yet to be fully substantiated. Milk can provide a vehicle for bacteria that may be beneficial for the gastro-intestinal tract (Marshall & Tamime 1997). These may persist in the gut and continue to metabolise. Thus they could digest lactose and help alleviate the problems experienced by lactose maldigesters. There are claims that the bacteria can 'prime' the immune system, keeping it in a state of readiness, should invasion by pathogens occur. There are also claims that the bacteria could influence the reactions that occur in the colon and help prevent onset of cancers. In future years any of these claims could be supported by evidence from ongoing research programmes and the mechanisms of action elucidated. In the meantime the market for 'bio-yoghurts' continues to grow as there is no contrary evidence nor are there contra-indications against its consumption. The idea of 'nutraceuticals' (which can be defined as foods having a health-promoting function in addition to having nutritive value) may well be adopted by the European consumer (it is an accepted concept in China and Japan) and the dairy industry is well placed to take advantage of such a shift.

Many dairy lactic acid bacteria are able to produce antimicrobial compounds (bacteriocin), the presence of which can help keep milk from degradation by other bacteria. One such bacteriocin, nisin, has particular application as it prevents outgrowth of spore-forming bacteria (useful in skim milk powders?) and is also inhibitory to *Listeria monocytogenes*. Its presence in milk powders for use as an addition in soft cheese manufacture could perhaps be explored.

CONCLUSIONS

Milk is regarded as a wholesome food. Perhaps because its has always served consumers so well we take it for granted. The UK dairy industry 50 years ago did not have a high regard for any fermented product other than cheese. Yoghurt is now very much part of the dairy scene as are good quality dairy desserts and butter that spreads straight from the refrigerator. The first was the result of adoption of a second fermentation process and the second two are a consequence of an understanding of the functions of milk components. Increasing the market for dairy ingredients should naturally follow, with perhaps the combining of fermentation and further processing so that milk becomes the natural vehicle for flavour, texture and can be used as a neutraceutical or functional food product. The progression from the fermentation that results in traditional and universally accepted products such as cheese and yoghurt to the new fermentations described in this paper is a natural one. The latter processes will be regarded as biotechnology. The use of organisms to provide functional ingredients may require biochemical engineering (this is the process of persuading the organisms to produce a desired compound) or the organism may be genetically engineered to perform the same function. These terms should not be alarming but be understood by most of us in the years beyond 2000.

REFERENCES

Adda, J (1986) Flavour of dairy products. In: Birch, G G & Lindley, M G (Eds) *Developments in food flavours.* London: Elsevier Applied Science.

Bodyfelt, F W, Tobias, J & Trout, G M (1988) *The sensory analysis of dairy products.* New York: Van Nostrand Reinholt.

Buttriss, J (1997) Nutritional properties of fermented milk products. *International Journal of Dairy Technology* **50,** 21-27.

Calvo, M M & de la Hoz, L (1992) Flavour of heated milks:a review. *International Dairy Journal* **2,** 69-81.

Erdogduarnoczky, N, Czuchajowska, Z & Pomeranz, Y (1996) Functionality of whey and casein in fermentation and in breadmaking by fixed and optimized procedures. *Cereal Chemistry* **73,** 309-316.

Gelinas, P & Lachance, O (1995) Development of fermented dairy ingredients as flavour enhancers for bread. *Cereal Chemistry* **72,** 17-21.

Gelinas, P, Audet, J, Lachance, O & Vachon, M (1995) Fermented dairy ingredients for bread - effects on dough rheology and bread characteristics. *Cereal Chemistry* **72,** 151-154.

Grobben, G J, van Casteren, W H M, Schols, H A, Oosterveld, A, Sala, G, Smith, M R, Sikkema, J & de Bont, J A M (1997) Analysis of the exoploysaccharides produced by *Lactobacillus delbrueckii* ssp *bulgaricus* NCFB 2772 grown in continuous culture on glucose and fructose. *Applied Microbiology and Biotechnology* **48,** 516-521.

Gruter, M, Leeflang, B R, Kniper, J, Kamerling, J P & Vliegenthart, J F G (1993) Structural characterisation of the exopolysaccharide produced by *Lactobacillus delbrueckii* ssp *bulgaricus* RR grown in skimmilk. *Carbohydrate Research* **239,** 209-226.

Lemoine, J, Chirat, F, Wieruszeski, J-M, Streker, G, Favre, N & Neeser, J-R (1997) Structural characterisation of the exocellular polysaccharides produced by *Streptococcus thermophilus* SFi 39 and SFi 12. *Applied and Environmental Microbiology* **63,** 3512-3518.

Marshall, V M & Tamime, A Y (1997) Starter cultures employed in the manufacture of biofermented milks. *International Journal of Dairy Technology* **50,** 35-41.

Nursten, H E (1997) The flavour of milk and dairy products I. *International Journal of Dairy Technology* **50,** 48-56.

Rawson, H L (1997) *Polysaccharide producting strains of lactic acid bacteria and their effects on yoghurt rheology.* PhD thesis University of Huddersfield.

Rawson, H L & Marshall, V M (1997) Effect of ropy strains of *Lactobacillus delbrueckii* ssp *bulgaricus* and *Streptococcus thermophilus* on texture of stirred yoghurt. *International Journal of Food Science and Technology* **32,** 213-220.

Rhom, H & Kovac, A (1994) Effects of starter cultures on linear viscoelastic and physical properties of yoghurt gels. *Journal of Texture Studies* 25, 311-329.

Russell, P (1998) New ingredients for food products. *Milk Industry International; Technical and Research Supplement* February, 6-9.

Stark, W, Urbach G & Hamilton, J S (1976a) Volatile compounds in butter oil IV. *Journal of Dairy Research* **43,** 469-477.

Stark, W, Urbach G & Hamilton, J S (1976b) Volatile compounds in butter oil V. *Journal of Dairy Research* **43,** 479-489.

Stingele, F, Neeser, J-R & Mollet, B (1996) Identification and characterisation of the eps (exopolysaccharide) gene cluster in *Streptococcus thermophilus* Sfi6. *Journal of Bacteriology* **178,** 1680-1690.

Urbach, G, Stark, W & Forss, D A (1972) Volatile compounds in butter oil II. *Journal of Dairy Research* **39,** 35-47.