TECHNICAL NOTE

Feeding for milk fat quality

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About

Studies from the LowInputBreeds project indicate that cows in organic or low input systems are likely to produce milk higher in beneficial components such as unsaturated fats, vitamins and antioxidants, compared to milk from conventional farms.

Based on these results and in accordance with other studies this technical note provides ideas, how the impact of dairy products in our diets may be improved naturally.

Introduction

We are all familiar with the view that milk is good for us because it is a valuable source of calcium and high quality protein; however, the impact of milk fat or butter on our health is a bit more contentious.

Fat is largely made up of fatty acids that vary in length from 4 to 24 carbon atoms, mostly even numbers. Shorter chains of less than 14 carbon atoms are all saturated (SFA) – that is, they have no double bonds between carbon atoms. Longer chains can also be monounsaturated (MUFA) (with one double bond) or polyunsaturated (PUFA) (with at least two double bonds).

Typically, whole milk only contains about 4 % fat with a relatively high proportion of saturated fatty acids. These saturated fats are thought to raise low-density lipoprotein or 'bad' cholesterol and increase the risk of heart disease (although this is debatable). On the other hand, milk fat also contains a number of unsaturated fatty acids that are positively good for our health (Haug et al. 2007).

Milk fatty acids beneficial to health

- Oleic acid (C18:1 c9, OA) is the main lipid in olive oil – one of the healthiest available oils – and is also the main monounsaturated fatty acids in milk composing about 15–29 % of total fatty acids. Oleic acid has preventative action against cardiovascular diseases, when substituted for saturated fat.
- Conjugated linoleic acid (C 18:2, CLA) is a group of, rather than an individual, fatty acid that is unique to ruminant products and is found in milk at 0.2–3.4 % of total fatty acids, dominated by the C18:2 c9t11 form or isomer. A small proportion is produced directly in the rumen, although most comes from conversion of VA (another product from rumen activity) in the udder. CLA is associated mainly with cardio vascular health and has anticancer properties.
- Vaccenic Acid (C18:1 t11, VA) is a natural trans-fat in milk at concentrations of 0.3–6.1 % of total fatty acids. It is not directly linked with health benefits but is converted in the human body to CLA. Individuals show conversion rates of VA to CLA up to 30 % with an average of about 19 % conversion.

Gillian Butler and Sokratis Stergiadis (2014): Feeding for milk fat quality.
LowInputBreeds technical note. Download at www.lowinputbreeds.org

- Omega 3 fatty acids (n-3) is another group of FA represented by α-linolenic acid (C18:3 c9,12,15, ALA) the main n-3 in milk, composing about 0.2-1.5 % of total FA. ALA decreases the risk of cardiovascular by various mechanisms, this is an essential FA we cannot synthesize and rely solely on dietary supply. ALA can also be converted to EPA, DPA and DHA, although this efficiency can be poor and unreliable. These long chain n-3 are necessary for brain and nerve development and normal function especially in youngsters. Oily fish is the most significant source, however, for individuals with low fish consumption, dairy products and meat can make a relevant contribution.
- Omega 6 fatty acids (n-6) in milk is almost exclusively linoleic acid (C18:2 c9,12, LA) which represent about 0.3–5.2 % of total FA and is another essential FA. Although n-6 decrease total and LDL cholesterol, overconsumption of n-6, from vegetable oils and cereal grains (particularly maize/corn) in Western diets, may promote cardiovascular, inflammatory and autoimmune diseases and cancer. Thus, a dietary ratio of n-6:n-3 between 1:1 and 4:1 is recommended to improve health by suppressing the risk of these diseases.

Ruminant lipid metabolism

Fatty acids in milk originate from one of three sources and the contribution of each influences the relative proportion of individual fatty acids. Fatty acids with less than 16 carbon atoms (plus some C16) are synthesised in the mammary gland from acetate and butyrate, precursors coming from microbial fermentation of forage feeds in the rumen. High forage diets tend to increase the proportion of short chain (saturated) fatty acids in milk.

Longer chain fatty acids are transferred from the diet or if cows are losing weight, come from fats released from stored adipose tissue. Ruminant livestock evolved eating forage plants, most of which are relatively low in lipid and the lipid present has a high proportion of unsaturated fatty acids, notably ALA and LA in cell and organelle membranes. Although all long chain (C16+) FA in milk are transferred from the diet, only 5-10 % of PUFA eaten makes it into milk. Activity by rumen microbes adds hydrogen ions (hydrogenation) causing loss of double bonds along the chains – turning PUFA into MUFA and subsequently into SFA. Hence the high proportion of SFA in ruminant milk and meat. The extend of this hydrogenation depends on rumen turnover and how long feeds stay exposed to the microbes; longer retention of forage feeds tends to lead to greater hydrogenation than in milled concentrate feeds.

Fortunately (for consumers) some fatty acids undergo further changes in the udder (and also in fat stores) before being secreted into milk. Enzymes (with desaturase activity) restore some double bonds along the carbon chains, converting VA into CLA and saturated C18:0 into OA among other changes, helping to restore fluidity to the milk fat.

Butter is also a valuable source of vitamins and antioxidants, such as vitamin E and a group of compounds known as carotenoids. As well as being nature's preservatives these protect consumers from the ravages of modern living and delay cell damage that might lead to chronic diseases such as cancer and heart disease. There is also growing evidence of positive health attributes, such as anticancer, antimicrobial, antifungal, opioid and immunomodulatory properties, from milk proteins, particularly those found of the whey fraction or bioactive peptide formed during fermentation or digestion.

Since milk is a complex matrix of many compounds, it is possible that the negative impact of some (such as the SFA increasing the risk of cardiovascular diseases) is counterbalanced by other beneficial components. This is implied by the fact that consumers with high intakes of milk and dairy products have a lower risk of coronary heart disease, stroke or hypertension against the popular belief, and also have reduced risk of type II diabetes and of certain cancers (Klein and Givens 2011).

Research aims when improving milk fat quality

Even if milk as a whole is not as harmful as once believed, it must still be sensible to 'improve' the profile of nutrients supplied. Given that the main public concern about milk composition is its SFA content, research tends to focus on:

(a) Substituting SFA with MUFA and PUFA. Recent studies have shown that this would improve health by decreasing the levels of LDL-cholesterol.

(b) Particularly increasing the content of individual FA with proven health benefits, such as OA, CLA and n-3 (especially long chain n-3).

(c) Sustaining a good (low) ratio of n-6:n-3 in accordance with dietary recommendations – although these apply to the whole diet, individual foods with a low n-6:n-3 ratio will improve the overall ratio.

Improving milk fat quality in practice

The main means of achieving these aims is changing cows' diet, since much of the variation in milk FA is related to lipid or fat intake and its metabolism during digestion and milk synthesis. Whilst most ruminant diets are low in lipid, increasing their PUFA intake (up to a point) is a quick and relatively effective means of raising milk PUFA content, although more permanent improvements might be made by genetic changes. Farms interested in manipulating milk fat composition have a number of tools at their disposal:

A) Grazing

It is well recognised that cows with a high proportion of grazing in their diet (also goats and ewes) produce milk high in CLA, n-3 and antioxidants and these levels diminish if diets change and the proportion of concentrate feeds and/or conserved forage, such as silage, increase. Fresh grass, clover and other pasture plants improve milk quality in this way by a direct supply of ALA, LA and antioxidants, some of which pass into the milk. Short leafy forages have relatively high lipid content (5–6 %) and are more effective in this respect than mature, stemmy plants.

B) Grass v legumes and other plant species

Legumes act in two ways to improve milk FA profile. Firstly, they are higher in ALA than grasses, so even at the same rate of transfer from diet, n-3 levels in milk will be higher. In addition, compared with grasses, legumes are less susceptible to microbial attack with more leaving the rumen intact, so a higher proportion of ALA and LA escape hydrogenation. Hence legumes are more likely to increasing milk supply of ALA and n-3 than grasses although less effective for VA and CLA. This effect is supported by a number of studies from various countries showing organic milk (with heavy reliance on legumes in grazing and conservation swards) is consistently higher n-3 than conventional milk. Studies with dairy cows on diverse alpine pastures show other dicotyledonous plants also have a major impact on milk FA profiles and can elevate some of minor CLA isomers.

C) Oilseed supplementation

Silage, hay, cereals and most other commonly used concentrated feeds are poor sources of unsaturated fats and antioxidants and most countries see seasonal fluctuation in milk fat composition; being higher in beneficial components when cows have access to pasture and falling as the proportion of silage and concentrate feeds in the diet increases. We know vegetable oils such as soya, rape or linseed can compensate for the lack of unsaturated fats in feeds typically used in the absence of grazing and can reduce seasonal changes in milk quality. Work carried out under LowInputBreeds showed rolled linseed (high in ALA) and rapeseed (high in OA) were both effective at raising in milk CLA content but only linseed boosted ALA levels in milk – although interestingly, it depressed levels of longer chain n-3.

D) Selective breeding

Genetics also controls milk fat composition, all be it to a lesser extent than diet, and variation within breeds appears to be as great as between breeds. Milk FA profiles do differ between individual cows of the same breed on the same diet, indicating the potential for selective breeding. Improving milk quality by changing diets might well be quick and effective but it is also transient and will disappear with a return to the initial diet. On the other hand, breeding for milk quality would have a more permanent impact and resulting cows could maximise desirable FA output under any given diet. However, changes through genetic selection and/or crossbreeding takes longer and having additional target traits may slow progress with production or functional traits of greater importance.

Conclusions

Most studies carried out under LowInputBreeds and other EU projects suggest low-input or organic management with a high reliance on grazed forage, rather than silage and concentrate feeds, is likely to result in milk fat higher in n-3 and/or CLA and antioxidants. This effect is likely to be particularly strong if cows have access to diverse swards, with clovers and other legumes raising n-3 content and diverse dicotyledonous plants increasing minor CLA isomers. To some extent linseed can be used to reduce seasonal changes in milk fat composition, although less effective than grazing to elevate important long chain n-3 fatty acids. In addition to dietary changes, the industry ought to consider selective breeding of dairy cows for more permanent improvements in milk fat composition.

References and further reading

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Imprint

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LowInputBreeds

LowInputBreeds is the acronym of the project 'Development of integrated livestock breeding and management strategies to improve animal health, product quality and performance in European organic and 'low input' milk, meat and egg production'. It is funded under the Seventh Framework Programme of the European Community for Research, Technological Development and Demonstration Activities (Contract No. 222623).

Disclaimer

Editing

Gillian Butler, Newcastle University, UK

Layout

Gilles Weidmann, Research Institute of Organic Agriculture (FiBL), Frick, Switzerland

Cover picture

Newcastle University

Publishers

Consortium of the LowInputBreeds project, c/ Newcastle University, UK, and Research Institute of Organic Agriculture (FiBL), Frick, Switzerland

Acknowledgements

The work presented here was supported by the European Community under the 6th framework programme Integrated Project QualityLowInputFood and 7th framework project LowInputBreeds, the Greek State scholarship foundation and the Yorkshire Agricultural Society.

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