Dairy fats and the milk matrix

Although dairy contains saturated fats, recent evidence shows dairy foods may have benefits for heart health. Erica Hocking, Lydia Cooper and Anne Mullen from The Dairy Council and Dr Adam Lock, Michigan State University detail the nutrient compositon of dairy and its relationship to cardiometabolic health

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Milk and dairy foods have been an important part of the human diet for many thousands of years. They provide high-quality protein, calcium, iodine, phosphorus and vitamins B2 and B12 in significant amounts. Over time, the dairy industry has advanced to produce a wide variety of products from milk, including cheese and yogurt, and their lower-fat versions.

For decades the public health message has been to reduce fat, particularly saturated fat, from the diet. However, recent evidence suggests saturated fats may not have a negative effect on cardiometabolic health. Even more interestingly – they point to the beneficial role of dairy, despite its saturated fat content, on heart and vascular health.

Dairy has many other components within its food matrix. Interest in the bioactive properties of milk components has grown considerably over the years. In turn, research and product development has grown in the area of 'bioactives' or 'functional food components'. Bioactive food components may play an important role in the prevention of chronic diseases, cancer and coronary heart disease (CHD). Epidemiological studies suggest risk for certain diseases can be substantially reduced by diet modification. However, the importance of these functions may be outweighed by the overall message around single nutrients, i.e. to reduce saturated fat in the diet, and their impact on health.

UK milk composition and consumption

The nutrient composition of milk will vary depending on cow breed, stage of lactation, feed composition, season of milking and even geographical location. Generally though, cow's milk is high in protein, calcium, iodine, riboflavin (B2) and vitamin B12 and is a source of phosphorus, pantothenic acid (B5) and potassium. Skimmed and semi-skimmed milks are low in fat. Whole milk, however, is not high in fat as is often perceived.

The main constituent of milk is water, at approximately 88-90%, followed by carbohydrate (lactose) at 4.6-4.8%, protein at 3.3-3.5%, fat ranging from 0.3% (skimmed milk) to 3.5% (whole milk) and the remaining percent represents milk's rich mineral and vitamin content.

The main constituent of milk fat is triglycerides, which accounts for about 97-98% of total fat. The remaining 2-3% is composed of phospholipids, cholesterol, diacylglycerol, monoacylglycerol and free fatty acids. About 64% of the fatty acids found in whole milk fat are saturated fatty acids (SFA). Of these about 12% are short-chain SFA (C4:0-C10:0) and stearic acid (C18:0) makes up a further 12%. The remaining SFA are a mixture of lauric acid (C12:0), myristic acid (C14:0) and palmitic acid (C16:0). Approximately 30% of the fatty acids in milk are monounsaturated fatty acids (MUFA) and 4% are polyunsaturated fatty acids (PUFA). The majority of these contain only *cis*-double bonds. A smaller proportion, approximately 4%, are naturally occurring *trans* fatty acids (TFA), which have one or more *trans*-double bonds.

SFA and cardiometabolic health

The term saturated fat is an umbrella term for a now recognised diverse family of SFA. For the past several decades, public health advice has been to limit the intake of saturated fat in the diet. The Seven Countries Study is credited with the 'diet-heart hypothesis' whereby dietary SFA were associated with raised total plasma cholesterol and total plasma cholesterol was associated with cardiovascular mortality. It was proposed that a diet low in SFA would reduce plasma cholesterol and therefore reduce risk of CHD. This association was translated into public health messaging in many Western countries and has been the given dogma in the UK since the 1980s.

In the UK, current government public health advice is to reduce all types of fat in the diet and to replace saturated fat with unsaturated fat, according to the Department for Health. The Scientific Advisory Committee on Nutrition (SACN) advise that intakes of saturated fat should not exceed 11% of total energy intake. This equates to a daily recommendation of around 20g SFA for a women and 30g SFA for a man; current National Diet and Nutrition Survey (NDNS) data shows that women in the UK consume 22.1g and men consume 28.4g SFA per day, about a fifth of which comes from dairy.

More recently, research suggests that the relationship described in the 'diet-heart hypothesis' is overly simplistic. With over 270 factors now identified as affecting plasma cholesterol, dietary saturated fatty acids are no longer thought to be the sole causal agent of increased plasma cholesterol. Furthermore, an Institute of Medicine expert panel recently question whether LDL ('bad') cholesterol is a good biomarker for cardiovascular outcomes in dietary interventions. The relationship of fats, cholesterol and health is far more complex than initially thought. After reviewing the 50 years of research related to the diet-heart hypothesis, Taubes concluded that there was little evidence that a diet low in saturated fat prolongs life.

Siri-Tarino *et al* and Chowdhury *et al* have both demonstrated that there is insufficient evidence from prospective epidemiologic studies to conclude that dietary saturated fat is associated with an increased risk of cardiovascular disease (CVD), CHD or stroke. Chowdhury *et al* also suggested that not all saturated fatty acids are equal in

TABLES: THE DAIRY COUNCIL

TABLE 1: NUTRIENT CONTENT OF MILK, YOGURT AND CHEESE PER 100G

	Milk			Yogurt			Cheese		
	Whole	Semi-skimmed	Skimmed	Plain	Plain low-fat	Fromage frais	Cheddar	Cottage cheese	Cheese spread
Energy (kcal)	63	46	34	79	57	99	416	103	237
Protein (g)	3.4	3.5	3.5	5.7	4.8	5.8	25.4	9.4	11.3
Carbohydrate (g)	4.6	4.7	4.8	7.8	7.8	13.2	0.1	3.1	6.5
Total Fat (g)	3.6	1.7	0.3	3.0	1.0	2.9	34.9	6.0	18.6
Sat Fat (g)	2.3	1.1	0.1	1.9	0.7	1.9	21.7	3.2	12.9
Trans fat (g)	0.1	0.1	Trace	0.1	Trace	N	1.4	0.30	0.9
MUFA (g)	1.0	0.4	0.1	0.8	0.2	N	9.4	1.7	4.8
PUFA (g)	0.1	Trace	Trace	0.1	Trace	N	1.1	0.2	0.7
Potassium (mg)	157	156	162	280	228	143	75	161	219
Calcium (mg)	120	120	125	200	162	140	739	127	498
Phosphorus (mg)	96	94	96	170	143	123	505	171	835
Iodine (µg)	31	30	30	63	34	17	30	24	29
Thiamin (mg)	0.03	0.03	0.03	0.06	0.12	0.11	0.03	0.05	0.05
Riboflavin (mg)	0.23	0.24	0.22	0.27	0.22	0.29	0.39	0.24	0.36
B12 (µg)	0.9	0.9	0.8	0.2	0.3	0.5	2.4	0.6	0.6

TABLE 2: PARTIAL LIST OF BIOACTIVE COMPONENTS IN MILK THAT HAVE HUMAN HEALTH IMPLICATIONS

Milk Protein Components	Milk Fat Components	Other Components
Cancer		
Whey proteins	Conjugated linoleic acid	Calcium
Casein	Vaccenic acid Sphingolipids	Lactose
Lactoferrin	Butyric acid	Vitamins A and D
a-Lactalbumin	13-Methyltetradecanoic	Oligosaccharides
Peptides	Acid	Nucleosides
	Ether lipids	Probiotics
Cardiovascular Health		
Whey proteins	Conjugated linoleic acid	Calcium
Casein	Oleic acid	Vitamin D
	Omega-3 fatty acids	
Hypertension		
Whey proteins		Calcium
		Potassium
Immune Response		
Whey proteins	Conjugated linoleic acid	Probiotics
MFGM* proteins		
Bone Health		
Peptides	Conjugated linoleic acid	Calcium
		Phosphorus
		Vitamin K

*MILK FAT GLOBULE MEMBRANE

their effects on coronary outcomes and current recommendations should be reviewed, as has been done in France where individual SFA were recently drawn into consideration in updated dietary guidelines. Chowdhury's research shows that some of the SFA biomarkers associated with milk intakes are associated with lower CHD risk, particularly circulating levels of pentadecaenoic acid, which was associated with a reduced incidence of coronary outcomes.

Indeed, further research is beginning to investigate the effect of SFA on other cardiometabolic diseases, including obesity and type 2 diabetes (T2DM). A systematic review by De Souza et al recently reported that saturated fats are not associated with all-cause mortality, CVD, CHD, ischemic stroke or T2DM.

However the story is not the same for *trans* fat (TFA). TFA have been associated with all-cause mortality, total CHD, and CHD mortality in several studies.

TFA have been suggested as being the most potent cholesterol-raising dietary fatty acids and are found in the diet by means of:

1) Processing of hydrogenated vegetable oils
2) Naturally occurring in ruminant meats and milk products

Over the years, TFA have been reduced significantly from industrial food processing and the latest NDNS data shows that around 1.3g of TFA are consumed by adults daily in the UK, with 27% (0.35g) of those coming from milk and milk products, excluding butter.

The content and isomeric profile of TFA found in dairy products differs significantly from those in industrialised TFA and growing evidence suggests that TFA from natural sources may not have the same adverse effect on human health as those from industrial sources. These differences are of importance because the position of the *trans*-double bond can influence both physiological properties and the rate of biochemical reactions.

Dairy and cardiometabolic disease

Despite the fact that 64% of milk fat is SFA, there is a growing body of evidence which supports the positive role of dairy in cardiometabolic health, as shown by a number of prospective epidemiologic studies. In meta-analysis, Soedamah-Muthu *et al* examined the associations of milk, total dairy, and high-and low-fat dairy with the risk of CVD; including CHD, stroke and total mortality, and found that milk intake was not associated with total mortality but may be inversely associated with overall CVD risk. Further studies by Soedamah-Muthu *et al* investigated dairy consumption and incidence of hypertension.

The dose-response meta-analysis of prospective cohort studies suggested that low-fat milk and dairy can play a role in the prevention of hypertension but needed further randomised control trials to

confirm this. In addition, dairy fat consumption does not appear to be associated with obesity, CVD or T2DM. Several recent literature reviews in this area also support the beneficial role of dairy in cardiometabolic health.

The milk matrix

It has been suggested that components found in milk such as milk proteins/peptides, fat and calcium are beneficial for reducing blood pressure, inflammation and T2DM risk. Hjerpsted *et al* demonstrated that there is no association between cheese consumption and elevated blood pressure. Soerensen *et al* found that total cholesterol and LDL cholesterol were significantly lower following a short dietary intervention with milk and cheese, each containing 1,700mg calcium per day among healthy young men, compared to an isocaloric non-dairy diet containing 500mg calcium per day. Chen *et al* concluded that no association was found between consumption of cheese with risk of T2DM. Tapsell *et al* concluded that there is a reduced risk of CVD to consumers of fermented dairy foods, such as cheese and yogurt.

Conjugated linoleic acid (CLA) isomers from milk fat, including rumenic acid have been found to have beneficial properties in relation to cancer and atherosclerosis due to their anti-inflammatory properties. However, it should be noted that extensive work supports these effects of CLA *in vitro* and in animal studies; studies in human subjects have been less conclusive.

A new area of research on the role of milk components appears to be moving towards the investigation of the milk fat globule membrane (MFGM) in human health. Milk contains a unique fat globule, which is encased within a double layered membrane. It comprises carbohydrates, membrane-specific proteins, glycoproteins, phospholipids, and sphingolipids. The composition and form of the globule varies in different dairy products and possesses different physicochemical properties specific to each dairy product depending on the size of the globule.

Rosqvist *et al* hypothesised that different dairy foods may have distinct effects on plasma lipids because of their varying content of MFGM. Their feeding study among overweight subjects showed that milk fat enclosed by MFGM did not impair lipoprotein profile whereas the control diet of butter oil, which has a greatly reduced MFGM content, increased plasma lipids.

Conway *et al* found that consumption of buttermilk MFGM significantly reduced systolic blood pressure, mean arterial blood pressure and plasma levels of the angiotensin I converting enzyme compared with the placebo, indicating that short-term buttermilk consumption reduces blood pressure in normotensive individuals. An earlier study by this group investigated the effect of buttermilk MFGM consumption in humans and suggested that reduced cholesterol concentrations in men and women may be primarily through inhibition of intestinal absorption of cholesterol.

It seems clear that the relationship between dairy fats and cardiometabolic disease is more complex than initially thought, and not all fats are created equal or have negative implications for metabolic health. Milk and dairy products contain a number of bioactive food components, for which there is a growing interest in their role in human health. Milk contains an impressive array of bioactive proteins, peptides and fatty acids (*see Table 2, left*). Fermented milk products have also shown beneficial effects on health-related variables and may have a beneficial role to play in cardiometabolic disease, but there are limited interventional trials in this area.

Summary

In summary, milk and dairy foods are nutritious and provide a number of nutrients to the diet. Emerging research suggests that saturated fats may not appear to have such a negative effect on cardiometabolic health as once perceived. Further investigation is needed to clarify the amounts that are suitable for a healthy lifestyle. More interestingly, dairy components – including fats and dairy bioactive components – appear to have a protective role in cardiometabolic disease, including CHD, T2DM, hypertension and stroke, and mortality. Larger human randomised controlled trials are needed to confirm the bioactive properties found in milk. ●

This feature was written by Erica Hocking, Lydia Cooper and Anne Mullen, registered nutritionists and dietitians from The Dairy Council; and Dr Adam Lock of Michigan State University; and reproduced with permission. For references please go to www.ofimagazine.com/milkmatrix