

# Bioactive Compounds in Milk Fat and Their Impact on Human Health

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## Abstract

Milk and dairy products have long traditions in human nutrition. Milk composition is rather than complex. Its constituents have been for many years on the priority list of research, with their positive and negative effects on human health. The most variable component of milk is milk fat. It is one of the components which determine nutritive quality and technological performance of milk. Milk fat contains a number of components which are metabolically active such as: sphingolipids, conjugated linoleic acids (CLA), butyric acid, other fatty acids, vitamins A and D. A variety of health benefits have been associated with these compounds. The study of bioactive compounds in milk fat is very important for understanding their physiological and biochemical functions which have crucial impacts on human metabolism and health.

**Keywords:** milk fat, conjugated linoleic acids (CLA), health benefits

## Introduction

The changes in the alimentary patterns in the last years are the reasons for many human diseases. In recent years there is increased interest about foods which contain components that have bioactivity (Rogelj, 2000). Bovine milk and dairy products have long traditions in human nutrition. Milk and milk products are nutritious food items containing numerous essential nutrients (Huth *et al.*, 2006).

Milk composition is rather than complex. Its components, which per se may have negative or positive health effects, respectively are subject of research for many years. Milk alone is much more than the sum of its nutrients. It is composed of various substances with bioactive properties and therefore milk was given an epithet of functional food. Not only nutritional value but also other physiological properties of milk components are subject of interest (Miler *et al.*, 2007).

The analysis of biological active compounds in milk is very important because of their physiological and biochemical functions that have great impacts on human metabolism and health. Milk fat contains an array of bioactive compounds. Study of bioactive compounds in milk fat is of crucial importance for revealing their specific biochemical, physiological and nutritional functions and characteristics that have strong potential for beneficial effects on human health.

## Composition of milk fat

The most variable component of milk is milk fat. It is one of the components which determine milk nutritive quality and technological performance of milk. Milk fat has influence on smell and aroma of milk, and on consistence and texture of dairy products. Despite of other milk components milk fat has highest energetic value (9 kcal/g or 37 kJ/g).

Bovine milk contains about 3.5 to 5% total lipids, existing as emulsified globules, with size from 2 to 4  $\mu\text{m}$  in diameter and coated with a membrane derived from the secreting epithelial cell (Jensen, 2002). These fat globules are formed in the endoplasmatic reticulum of epithelial cells in the alveoli of mammary gland (Jensen *et al.*, 1991). The milk fat globule membrane is mainly composed of polar lipids and membrane associated proteins. The lipid fraction of membrane comprises about 30% and consists of: phospholipids (25%), cerebrosides (3%) and cholesterol (2%). The remaining 70% of the milk fat globule membrane are proteins, and many of them are enzymes (Keen and Mather, 2003; Evers, 2004).

Bovine milk fat is composed of triacylglycerides, diacylglycerides, monoacylglycerides, free fatty acids, cholesterol, phospholipids and cerebrosides. Mainly milk fat is composed of triglycerides, approximately 98%, while other milk lipids are less present (diacylglycerols about 2%, cholesterol less than 0.5%, phospholipids about 1% and free fatty acids FFA about 0.1%) (Jensen *et al.*, 1991, MeeGibbon and Taylor, 2006).

The major functional properties of milk fat are based on its triglyceride (TG) composition. Milk fat is uniquely complex in its TG composition because of the large number of fatty acids, which range from C4 to C28, and because of all of the isomers that have been identified. Milk fat contains fatty acids of complex structures, including monobranched, multibranched, dienes, trienes, hydroxy, etc. and it is the most complex fat of all natural fats (Jeminez-Flores, 1997).

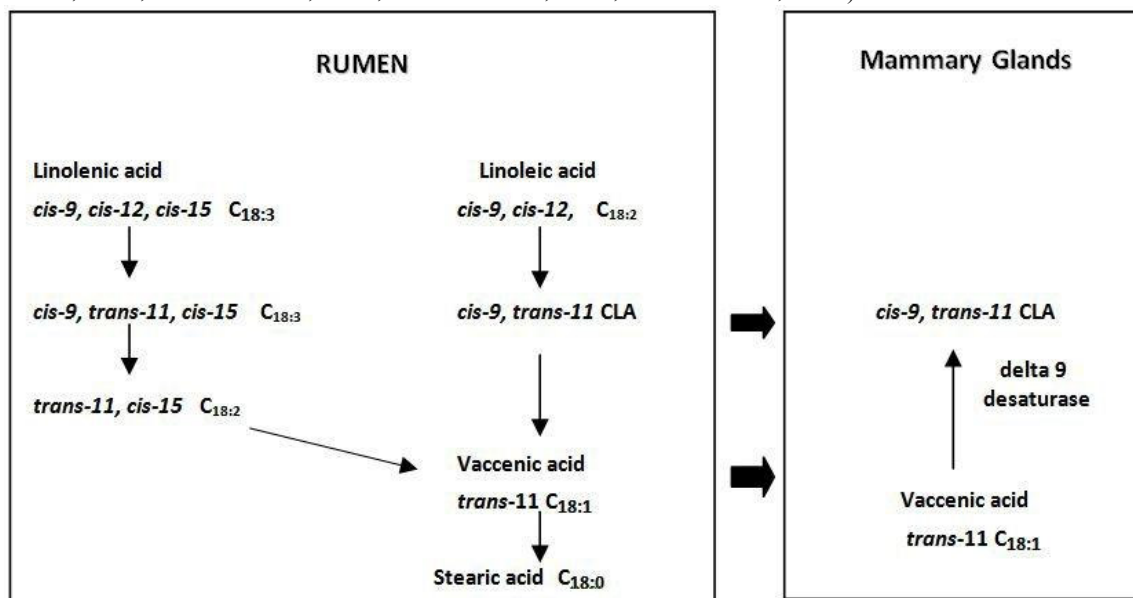
Bovine milk fat contains 70-75% saturated fatty acids, 20-25% monounsaturated fatty acids, and 2-5% polyunsaturated fatty acids. Percentage of fatty acids with short chain is higher in milk from ruminates than in milk from unruminate. The fatty acid synthesising system in bovine mammary gland produces fatty acids with even number of carbons. This *de novo* synthesis in the mammary gland includes fatty acids with short and medium chain (from C4:0 to C14:0) as well as half of the C16:0. Precursors for their synthesis are acetate and  $\beta$ -hydroxybutyrate. Acetate and butyric acid are generated in the rumen by fermentation of feed components. The butyric acid is converted to  $\beta$ -hydroxybutyrate during absorption through the rumen epithelium. Bovine fat contains certain fatty acids with odd number of carbons, such as pentadecanoic acid (C15:0) and heptadecanoic acid (C17:0), which are synthesised by the bacterial flora in the rumen. The remaining half of C16:0 and the long-chain fatty acids originate from dietary lipids and from lipolysis of adipose tissue triacylglycerols. Medium and long-chain fatty acids, but mainly C18:0, may be desaturated in the mammary gland to form the corresponding monosaturated acids. Profile of fatty acids present in milk fat determines uniqueness of its composition as well as its physiological characteristics (Jensen, 2002; Chilliard *et al.*, 2003; German and Dillard, 2006).

### Health benefits of bioactive components of milk fat

Milk fat is composed of components which are needed for normal performing of physiological functions of human. It contains a number of components which are metabolically active such as: sphingolipids, conjugated linoleic acids (CLA), butyric acid, other fatty acids, vitamins A and D. A variety of health benefits have been associated with these compounds.

CLA which are naturally occurring fatty acids found in animal and dairy fats, exhibit a number of health benefits. CLA are found in relatively large quantities in the milk and/or meat of ruminant animals and appears to be metabolized differently than linoleic acid. In the diet of many consumers, meat and dairy products would be a significant source of CLA (Barbosa *et al.* 2003).

CLA refers to a mixture of 28 positional and geometric isomers of linoleic acid (C18:2, *cis*-9, *cis*-12) with two conjugated double bonds at various carbon position in the fatty chain. The most abundant isomer in food products from ruminants is *cis*-9, *trans*-11 (rumenic acid) comprising 80-90% of the total CLA, where as *cis*-12, *trans*-10 is present in smaller amounts, 3-5%. Both isomers have been proven to have biological activities. CLA found in milk and meat of ruminants originates from two sources. It is formed as an intermediate during the biohydrogenation of linoleic acid by linoleic acid isomerase from the rumen bacteria *Butyrivibrio fibrisolvens* or from the endogenous conversion of *trans*-11, C18:1 (vaccenic acid) another intermediate of linoleic or linolenic acid biohydrogenation by  $\Delta$ 9-desaturase in the mammary gland (Figure 1.) (Christie, 1990; Griinari *et al.*, 2000; Bauman *et al.*, 2003; Dhiman *et al.*, 2005).



**Figure 1.** Metabolic pathways involved in the biosynthesis of CLA in ruminants (Bauman *et al.*, 2003)

Milk fat and meat of ruminants are the richest natural dietary source of CLA. Reported beneficial health-related effects of CLA include anti-carcinogenic, anti-atherogenic, anti-diabetic and immune modulating properties. Hence CLA is considered as functional food. Most of the research on CLA is associated with its anti-carcinogenic properties. CLA reportedly has anti-carcinogenic effects at various stages

of cancer development, including initiation, progression and metastasis. Proposed mechanisms of CLA and its anti-carcinogenic activities include a reduction in cell proliferation, and prostaglandin metabolism. CLA seems to significantly reduce prostaglandin E synthesis which could inhibit tumor formation. It has been demonstrated that CLA has the ability to affect mammary cancer, stomach cancer, skin cancer and prostate cancer. Most of the anticarcinogens are of plant origin but CLA is unique, it is present in food from animal sources and its anti-cancer efficacy is expressed at concentrations close to human consumption level. The unique structural and functional properties of CLA appear to modulate cellular process involved in carcinogenesis. (Ip *et al.*, 1994; Belury, 2002; Alkalin *et al.* 2006).

The anti-atherogenic effects of CLA have been established in animal models and in humans, as outcomes of changes in lipoprotein and cholesterol effects and anti-inflammatory effects (Bauman and Lock, 2010). It has been reported that CLA can reduced plasma lipoproteins and early atherosclerosis in animal models, and can impaired glucose tolerance in diabetic rats (Lee *et al.*, 1994; Houseknecht *et al.*, 1998). Also, CLA has been shown to have immunomodulatory properties by enhancing mitogen induced lymphocyte blastogenesis, lymphocyte cytotoxic activity and macrophage killing ability.

This discovery is of special importance in considerations of “*designing foods*” because *cis*-9, *trans*-11 CLA is among the most potent naturally occurring anti-carcinogens (Bauman *et al.*, 2003).

Milk fat contains high percentage of saturated fatty acids (70-75%). They vary in structure and most of them have no effect on circulating cholesterol and no negative implication on human health, with exception of lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acids, which have been shown to increase blood levels of total cholesterol and LDL cholesterol when added as dietary supplements (Bauman and Lock, 2010).

Also, a variety of health benefits have been associated with sphingolipids and their digestion products, ceramides and sphingosines. They are suggested to be important in prevention from carcinogenesis, reduction of serum LDL cholesterol, regulation of the immune system and inhibition of foodborne pathogens.

Among other bioactive compounds of milk fat are butyric acid, vitamins, etc. Butyric acid has been suggested to have an anti-tumour role and it is especially effective in colon cancer prevention. Vitamin A and D and  $\beta$ -carotene are also offered as natural anti-cancerogens in numerous reviews. As health benefits of these bioactive components of milk fat has been studied mostly *in vitro* conditions. So, further research is required to establish the contribution of these dietary components to host metabolism and health (Alkalin *et al.*, 2006).

Moderate intake of milk fat has no negative health effects, on the contrary, many milk fat components have important roles in the human health.

Recent discoveries in the functional foods area indicate that specific fatty acids produced in the rumen may have beneficial effects on human health, and there is an increased interest in the possibility of designing natural food products with enhanced levels of these fatty acids.

Bovine milk fat represents a rich source of biologically active molecules, many of which offer potential for commercial exploitation in health-promoting functional food products.

Study of bioactive compounds of milk fat can be exploiting for their applications in functional foods and for potential pharmaceutical use.

Taking in advance the health benefits of some constitutes of milk fat, future research can be forward to improve the nutritive value and health benefits of milk. Because the feeding the regime of dairy animal is the predominant factor affecting milk fat, future research should be directed to alter the composition of milk fat and enhance the concentration of fatty acids which have beneficial health effects in humans.

Future research of bioactive compounds of milk fat should be toward to enhance human health through nutrition.

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