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FACTORS AFFECTING FATTY ACID PROFILE OF SHEEP MILK FAT: A REVIEW

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Abstract

Milk fat fraction was considered to have negative effects on consumers' health due to the high content of saturated fatty acids and trans fatty acids, which are responsible for the associated cardiovascular disease and obesity. However numerous studies have shown that whole milk is more effective in preventing cardiovascular disease in humans than skimmed milk. These positive effects are attributed fatty acids (FA) functionality present in the fat of whole milk. Functional fatty acids are: omega-3 (n-3 FA), conjugated linoleic acid (CLA; C18:2 cis-9, trans-11) and trans-vaccenic acid (C18: 1 trans-11, VA). Functional fatty acid content of milk is influenced by genetic and physiological side and on the other by a number of factors nutritionally. Most studies have shown that nutritional factors are sovereign in handling fatty acid profile of milk fat.

Key words: animal and nutritional factors, functional fatty acids, linolenic acid, CLA, vaccenic acid.

INTRODUCTION

Lately, more strikingly manifest propensity of consumers to switch to healthy food and good quality, which undertakes research studies to give up on the quantitative aspects of food production in favor of the quality. Consumer means quality, safe product for his health (unpolluted), which in addition to nutrients must contain a series of biocomponents active greenhouse sanogenous (Omega-3, conjugated linoleic acid - CLA), *trans* - vaccenic acid - VA, antioxidants, vitamins, trace elements, etc.), important role in ensuring "quality of life". It urgently needs a new approach to the concept of quality food products, to represent as closely as interests and preferences of consumers.

Milk fat fraction was considered to have negative effects on consumers' health due to the high content of saturated fatty acids and *trans* fatty acids, which are responsible for the associated cardiovascular disease and obesity. However numerous studies have shown that whole milk is more effective in preventing cardiovascular disease in humans than skimmed milk (Steinmetz et al., 1994). These positive effects are attributed fatty acids (FA) functionality present in the fat of whole milk. The fatty acids are functionally represented by: omega-3, conjugated linoleic acid (CLA; isomer C18:2 *cis*-9, *trans*-11; also known as acid rumen - RA and isomer C18:2 *trans*-10, *cis*-12) and *trans*-vaccenic acid (C18:1 *trans*-11, VA). Most important FA n-3 (omega-3) with effect sanogenous are: C18:3n-3 (α-linolenic acid ALA); C20:5n-3 (eicosapentaenoic acid, EPA) and C22:6n-3 (docosahexaenoic acid, DHA).

FA functional importance lies in the role they play in the human diet.

Omega-3 fatty acids: reduce LDL (bad cholesterol) in the blood and increase the level of high density lipoprotein (HDL, good cholesterol) that have important role in preventing cardiovascular disease; reduce hypertension; regulates hormonal secretions; and processes involved in inflammatory arthritis therapy (Rubino et al., 2006); protects and preserves the integrity of the vascular endothelium; stimulating nerve cell growth in children (Hu, 2001).

Conjugated linoleic acid (CLA) is actually a mixture of several isomers of linoleic acid with conjugated double bonds, located in particular on the carbon atoms 9:11 (*cis*-9, *trans*-11 C18:2, acid rumen; which is 80-90% of the total CLA isomers). Research conducted on animal models have shown that CLA has anticancer effects, prevents obesity by reducing capacity lipoformatoare body, has antioxidant (reduces oxidative degradation of polyunsaturated fatty acids in cell membranes) and in the prevention of atherosclerosis (Rubino et al., 2006); it has immunomodulating action. CLA is provided in human nutrition through food products derived from ruminants.

Trans-vaccenic acid, which is the substrate for the enzymatic synthesis of CLA, obtained, as an intermediate product in the biohydrogenation of rumen mono- and polyunsaturated fatty acids (MUFA and PUFA) in the diet. Of the total CLA *c*9,*t*11 in milk, 70-90% of VA derived from the enzymatic desaturation (C18:1 *t*11) in the mammary gland, while the remainder, including other CLA isomers (in particular CLA *trans*-10, *cis*-12) arising as intermediates in the rumen biohydrogenation unsaturated fatty acids from food (Chilliard et al., 2007).

Functional fatty acid content of milk is influenced by genetic and physiological side and on the other by a number of factors nutritionally. Most studies have shown that nutritional factors are sovereign in handling fatty acid profile of milk fat.

1. ANIMAL FACTORS AFFECTING FATTY ACID COMPOSITION OF SHEEP MILK FAT.

Handling the fatty acid profile of milk fat by means of genetic factors and physiological may provide benefits to human health, by increasing fatty acid functional (n-3 FA, CLA and VA) involved in cardiovascular disease prevention (Bucher et al., 2002; Hu et al., 2002 Munday et al., 2007), the prevention of cancers (Rose et al., 1999; Sadatian-Elahi et al., 2004), improvement of neurological function (Contreras et al., 2002) and of the immune system (Lai et al., 2005).

The effects of genetic and physiological factors, such as race, parity and stage of lactation, the milk fat profile FA have received little attention. Studies cited in the literature are mainly focused on dairy cows (Kelsey et al., 2003; Kay et al., 2005; Pesek et al., 2005, 2006; Ferlay et al., 2006; Palladino et al. 2010), while information on sheep, are still limited. Also, limited information is available on the fatty acid profile of milk from local breeds of sheep (Federica et al., 2008; Talpur et al., 2008; Mierliță et al., 2011).

The influence of race on the content of the FA milk sheep is not unanimous, as some studies have shown significant differences between races (Dhiman et al., 2005; Mihaylova et al., 2004; Federica et al., 2008; Mierliță et al ., 2011) and others not (Tsiplakou et al., 2006). Also no effects of stage of lactation on the content of n-3 FA, CLA and VA are not clear because some authors talk about an increase in the content of milk FA functional with increasing lactation (Melle et al., 2007; Gerchev et al ., 2009) and others not (Tsiplakou et al., 2006).

In many sheep feeding studies it relied on natural pastures throughout the experimental period. Such a diet can not guarantee comparable results, because studies have shown that the composition of botany and plant vegetative stage can affect the fatty acid composition of milk fat (Cabiddu et al., 2003).

2. THE EFFECTS OF FEEDING VARIOUS FORAGES ON FATTY ACID COMPOSITION OF SHEEP MILK FAT

2.1. Influence of energy and protein diets

Nature and extent of feed volume and concentrates structure fodder ratios can have a significant effect on production and milk composition sheep (Kukuk et al., 2001; Mele et al., 2006; Bocouier et al. 2001).

Raising energy feed lactating sheep (0.90 UFL/kg DM *vs*. 0.97 UFL/kg DM) by increasing the share of concentrates in the ration structure (from 27% to 43% in the DM) and protein level (the crude protein from 14% to 16% of DM) by introducing soybean meal in the ration (5.5% of DM), has positively influenced the quantity and quality of milk production and, in particular fatty acid profile (Mierliță et al., 2009) . Thus increased milk production by up to 14.7% ($p < 0,05$) and its protein and lactose content, but low fat content, casein (which could reduce performance processing milk in cheese) and non-protein nitrogen. Improved nutritional quality sheep milk due to lower degree of saturation of fat by reducing the proportion of SFA and increasing weights FA omega-3 (ALA, EPA and

DHA), CLA (C18:2 *c*9, *t*11) and VA (C18:1 *t*11). Best quality milk analyzed in terms of influence on human health due to the high content of omega-3 FA, CLA and VA, was obtained from sheep fed with ration of 0.97 UFL/kg and 16% CP.

2.2. The influence the type of feeding

Traditionally, in our country during the summer sheep are kept on mountain pastures without completing other feed ration. On the other hand, it is known that mixed rations of feed formats preserved and concentrated increase the production of milk and milk components (Susin et al., 1995). However, the increase in milk production is often associated with altered fatty acid profile due to the increasing share of saturated fatty acids (SFA) in the structure of fat (Federica et al., 2008; Signorelli et al., 2008; Gómez-Cortés et al ., 2009). The pasture is an important source of PUFA (especially C18:3n-3) to ruminants, but the fatty acid composition of milk fat is influenced by the nutritional value of pasture, floristic composition, stage of vegetation (seasonal) and the amount consumed (Marques et al., 2001). Sheep milk is more rich in n-3 FA, CLA and VA than cow's milk; a possible reason could be that sheep during lactation are maintained on pasture, while dairy cows fed rations are usually made up of mixed fodder preserved (silage, hay) and concentrated.

The pasture was shown to be an important source of polyunsaturated FA, in particular α-linolenic acid, which improves the lipid profile and clues sanogenic FA of milk fat (Mierliță, 2012). Sheep maintained on pasture and whose ration is supplemented with other feed, were in milk fat lowest concentration of HFA (FA hipercoleserolemianti) (C12:0, C14:0 and C16:0) and the highest content in FA functional: C18:3n-3 (ALA), C20:5n-3 (EPA), C22:6n-3 (DHA), C18:2 *c*9, *t*11 (CLA - acid rumenic) and C18:1 *t*11 (VA - acid *trans*-vaccenic). Ration TMR (total mixed rations) resulted in a significant increase in milk production and fat content, but the content increased FA saturated (especially HFA) to the detriment of unsaturated and especially those functional compromise quality sanogen fat milk.

2.3. The influence of feed preservation method

In most studies, to improve the fatty acid profile of milk, feed was supplemented with different sources of polyunsaturated fatty acids (fish oil, various vegetable oils and oilseeds), being overlooked that the most important source of fat the feed sheep feed is the basis of their diet (pasture, hay, silage, concentrates). Natural pasture is an important source of PUFA and especially C18:3n-3, and the lipophilic antioxidants, feed. Sun drying hay lead to significant loss of unsaturated fatty acids in the grass (Boufaied et al., 2003). Shingfield et al., (2005) have established that the milk from animals fed a ration based on hay has a higher content of C18:2n-6, C18:2 *c*9, *t*11 and C18:3n-3, as compared to that one from those fed a ration based silage, although PUFA was lower.

Of the two methods of conservation of pasture grasses (drying or silage), hay provided a higher concentration of functional fatty acids in milk, compared to the silo (Mierliță, 2016).

2.4. Influence of fat by-pass

The negative effects of fat on the rumen fermentation processes can minimize the transformation of the calcium salts of fatty acids (saponified) (Hashem et al., 2000). Because the calcium salts will not be affected in the rumen, eventually they will undergo enzymatic digestion and absorption in the abomasum and duodenum in the form of fatty acids (Asgari and Daghigh, 2013). Furthermore, prevention of essential fatty acids in the rumen biohydrogenation, further increases their absorption in the small intestine and thus increase the supply of PUFA metabolism, which may lead to an increase in the concentration of functional fatty acids in milk and meat. Calcium soaps are the most simple and economical to obtain and at the same time can be easily incorporated into feed being "fat dry" (Jenkins, 1993).

Fats used in ruminant feed are hydrogenated in the rumen, leading to increasing their saturation. A solution for improving the recovery of fats and especially PUFA increasing absorption in the small intestine should be protecting them against ruminal fermentation. The most effective way to protect fat is to treat them with calcium salts (Chilliard, 2003).

Unprotected form sheep fats are recommended in the feed in an amount of 20 to 25 g / day (Mele et al. 2007), and in protected form may be introduced in the feed at a maximum of 190 g/day, depending on the level of production of milk and feed intake structure (Gargouri, 2005).

Maximum percentage of protected fat that can be used in feeding sheep without significant influence rumen fermentation processes, is 6% of the ration DM (Mierliță et al., 2010). The presence of fat in food has reduced intake DM, but milk production and its content in fat increased, although the report acetic acid : propionic acid changed in favor of propionic acid, thus becoming less and less favorable for milk production.

The fat saponified used in the feed had a higher content of linoleic acid (C18:2), both in the rumen to form a greater amount of CLA and VA, and the fatty acid profile of milk, the weight FA n-3 (ALA, EPA and DHA), CLA and VA (Mierliță et al., 2010).

Increased intake of linoleic acid and α-linolenic make vegetable oils saponified, which were positively correlated with a higher content of milk fat into fatty acids functional (FA n-3, CLA and VA) has reduced significant ($p < 0.01$) the ratio of n-6/n-3 FA, demonstrating improved quality sanogene fat milk (Mierliță et al., 2010). Entering fat salified rich in linoleic acid (sunflower or canola oil) in feeding sheep led to increased intensity of processes desaturation enzyme (DI 18), which explains the lower strength of stearic acid (C18:0) in milk (Mierliță et al., 2010).

2.5. The influence of diet supplementation on pasture with different feed

Increasing milk ewes on pasture is justified not only by the low cost of feeding, especially the nutritional quality of milk produced and upper sanogena (Mierliță, 2012; Renobales et al., 2012).

In summer (July-August), due to high temperatures and reduced precipitation, production and quality of pasture decreases, so to support milk production, filling ration feed preserved (in particular concentrates and / or hay) is a practice common farms profile (Molle et al., 2008). This has a negative influence on the quality sanogene of milk fat (Addis et al., 2009; Gómez-Cortés et al., 2009; Harvas et al., 2009; Valvo et al., 2006). To improve the nutritional characteristics of milk fat and the impact on human health, FA profile must be modified by increasing the percentage of functional FA (omega-3, CLA and VA) to the detriment of SFA.

Increasing the share of FA functional milk is achieved by increasing the intake of linoleic acid (C18:2n-6) and acid α-linolenic acid (C18:3n-3) in food (AbuGhazaleh et al., 2002, 2003; Rego et al. 2005). Therefore proposed use of seeds / oil camelina (*Camelina sativa* L) as a strategy for feeding the sheep in hot periods to avoid compromising profile FA milk due to their high content of linoleic acid and linolenic (Mierliță et al., 2011).

Sheep pasture ration supplementation improved milk production and its fat content ($p < 0.01$). Filling ration on pasture with hay and concentrates negatively influenced standard milk FA profile, increasing the proportion of saturated FA synthesized *de novo* and decreasing the weight of PUFA. When the diet was supplemented with hay and concentrates rich in seeds camelina profile FA milk was improved by decreasing content HFA and increased content FA functional (FA omega-3, CLA *c*9, *t*11 and C18: 1 *t*11).

Part-time grazing and supplementation with concentrated or hay ration, even if they increased milk production, milk FA profile compromised, by increasing SFA (Mierliță, 2015). The feeding of sheep in hot periods in summer, by limiting the time grazing (6 hours/day, in two innings) and completion ration in shelter, moderate amounts of concentrates, hay and fats salified rich FA essential allows increase milk production without alter the fatty acid profile of milk. Thus, the use of fats rich in FA essential strategies for supplementing the diet of sheep in periods of high temperature, is a good choice for both daily production of milk but especially for the quality sanogena fat milk (Mierliță, 2015, 2016).

3. INFLUENCE OF MILK PROCESSING METHODS

Sheep's milk represents only 1.4% of global consumption of fresh milk (fresh milk), mostly milk production is converted to dairy products, especially yogurt and cheese (Nudda et al., 2014). Producers of sheep pays special attention FA profile of milk and dairy products, as they have a direct influence on human health and on the other hand affects the aroma and taste of cheese caused by the oxidation of fatty acids.

The level of CLA in milk cheese is determined by the content in the fatty acid, but also by processing conditions and the ripening of the cheese. Several authors have demonstrated that strains of lactic acid bacteria used as starter cultures in dairy processing, produce CLA from linoleic acid (Sieber et al., 2004; Buccioni et al., 2010).

Sheep milk pasteurization and its inoculation with cultures of lactic acid bacteria has led to decreasing the proportion of C18:1 t11 (VA) and ripening cheese had a positive influence on the fatty acid profile, leading to an increase by approx. 10% of the total CLA content and especially C18:2 *c*9, *t*11 (Buccioni et al., 2010; Mierliță et al., 2009).

CONCLUSIONS

Profile of fatty acids in milk is influenced on the one hand the genetic and physiological and a number of factors nutritionally, who are sovereign in handling the fatty acid composition of milk fat, by increasing fatty acid functional (n-3 FA, CLA and VA) that can provide benefits to human health.

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