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LINK BETWEEN DAIRY COWS DIET AND MILK LIPID PROFILE VARIABILITY

Iuliana GAJAILA, Gabriel GAJAILA

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: iuliana_gajaila@yahoo.com

Abstract

Milk and dairy products are important sources of biologically active lipid substances. Interest in the nutritional qualities of dairy fats is not recent. It is now well established that milk and dairy products contain many fatty acids, some of which, with specific and sought-after physiological effects, not found in any other food. Milk, however, is not a standard product. Its fatty acid composition is very variable. At the farm level, it can be modulated either through genetics or husbandry practices. Among them, diet is the quickest and most effective way and its effects are quickly reversible. The objective of this article is to present the results of a study on the link between the feeding dairy cow's diets and the milk fatty acid profile. Two winter feeding diets were compared: A diet - maize forages as the main component of the feeding diet. B diet - maize forages and grass forage. The obtained results confirm the influence of feeding dairy cows diets in obtaining ideal milk in terms of lipid profile.

Key words: *feeding dairy caw, milk fatty acids profile.*

INTRODUCTION

Cow's milk is considered by health and nutrition specialists to be a very complete food, balanced in nutrients, rich in minerals (calcium) and containing almost all vitamins (except vitamin C). Dairy fat contains a complex mixture of triacylglycerols, diacylglycerols, monoacylglycerols, phospholipids, cholesterol, glycolipids and free fatty acids (Christie, 1995). The lipid profile of milk is very variable. The triacylglycerols in the milk are made up of over 400 different fatty acids in terms of the number of carbon atoms in the chain, the number of double bonds, their position and configuration (cis, trans) and obviously by their biological properties (Amores, 2019). The main sources of milk fatty acid variability are mainly related to the impact of genetic (breed), physiological (calving's number, lactation stage) and zootechnical factors (milking, food management) (Hanus et al., 2018). Due to these sources of variability the ruminant dairy fat contains different proportions of saturated fatty acids and unsaturated fatty acids (Figure 1). Even though saturated fatty acids (SFAs) are generally considered risk factors for cardiovascular health (Michas, 2014), milk fats have proven beneficial effects, determined by the presence in the composition of certain monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) that are involved in various physiological processes: oleic acid (C18:1 *cis-9*), linoleic acid (C18:2 *cis-9, cis-12*), rumenic acid (C18:2 *cis-9, trans-11*), α-linolenic acid (C18:3 *cis-9, cis-12, cis-15*), rumelenic acid (C18:2 *cis-9, trans-11, cis-15*), eicosapentaenoic acid (C20:5 *cis-5, cis-8, cis-11, cis-14, cis-17*), docosapentaenoic acid (C22:5 *cis-7, cis-10, cis-13, cis-16, cis-19*) (Glasser et al., 2008).

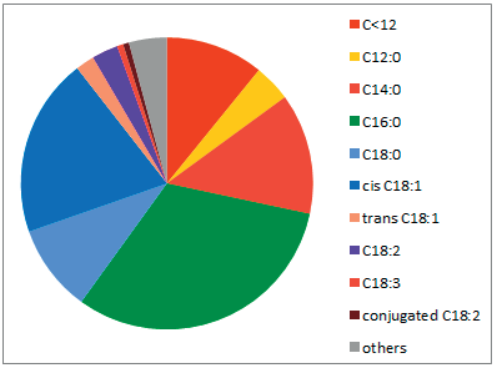

Figure 1. Average fatty acid profile of cow's milk (Glasser et al., 2008)

The physiological effects of all fatty acids are not yet fully established, but the main criteria for so-called ideal milk are known: lower concentrations of saturated fatty acid, greater concentrations of polyunsaturated omega-3 and omega-6 fatty acids (essential fatty acids), an ω-6 fatty acids/ω-3 fatty acids ratio of less than 5, a reduced content of *trans* fatty acids and an appreciable content of rumenic acid. This fatty acid is specific to ruminants (is also known as bovinic acid) but it has important beneficial effects: immune-stimulating, anti-carcinogenic, anti-inflammatory (Benjamin, 2009).

It's obviously the milk obtained in dairy farms has a fatty acid profile that cannot meet all the previously mentioned criteria. That is why real ways are being sought to obtain a milk lipid profile suitable for the requirements.

Genetic selection is one of the main ways to obtain ideal milk from the point of view of the lipid profile. But this option involves a relatively large amount of time.

A variant that can provide immediate results regarding the improvement of the lipid profile of milk is monitoring the dairy cows feed.

In ruminant diets typically consisting of forages and concentrates, fatty acids represent less than 3% of the dry matter. The majority of the dietary fatty acids are 18-carbon unsaturated fatty acids: oleic acid, linoleic acid (polyunsaturated omega-6 fatty acid) and α-linolenic acid (polyunsaturated omega-3 fatty acid). If in the concentrates the fatty acids are generally present in the form of triglycerides, in the forages most fatty acids are in the form of galactolipids (lipids with a galactose attached) what makes them more bioavailable than free fatty acids (Glasser et al., 2013).

But not all fatty acids present in dairy cows feed are found in milk, because their transfer into milk is influenced by digestive and metabolic particularities specific to ruminants (Glasser et al., 2008). Following lipolysis under the action of specific enzymes from the rumen flora, dietary unsaturated fatty acids are converted to saturated fatty acids by a process called ruminal biohydrogenation. This conversion involves PUFAs isomerization into conjugated derivatives and desaturation into C18:1-*trans* isomers, then into stearic acid (C18:0). All the intermediate fatty acids formed during ruminal metabolism are absorbed, passed into the blood and then into the mammary tissue. There, under the action of a desaturase, the C18:1-*trans* fatty acids are transformed into rumenic acid (C18:2 *cis-9, trans-11*). This transformation explains the preponderance of rumenic acid in milk fat (Jenkins et al., 2006).

Given this link between dietary fatty acids profile and milk fatty acids profile, the monitoring certain nutritional factors (e.g. type of forage and forage-concentrate ratio or use of lipid supplements) remains the most effective method to control the lipid profile. It is now known that the rapeseed it is a good source of oleic acid, the soybeans or the sunflower are rich in linoleic acid (ω-6 fatty acid) and grass is a good source of α-linolenic acid (ω-3 fatty acid) (Akbaridoust et al., 2014). Numerous experimental studies have highlighted the ability of oilseed lipid supplements to significantly reduce the proportion of saturated fatty acids in milk and to increase the proportion of unsaturated fatty acids (Glaser et al., 2008; Faulkner et al., 2018).

In this context, the paper presents the results of a study on the link between the diet of dairy cows and the fatty acid profile of milk.

MATERIALS AND METHODS

This study was conducted out in two intensive dairy farms, located in Braila County, during October 2020 - March 2021. The dairy farms raising Holsteins and Romanian Bălțata and have the same feeding strategy - winter feeding based on forages feed, supplemented with hay and concentrates - but apply different proportions of the ingredients. The first farm (A diet) has maize silage as the main component of the feeding diet. At the second farm (B diet) replaced part of the maize silage with grass silage. Both feeding diets are supplemented with other fodder crops and straw from cereals or cereal-leguminous straw (Table 1). The morning milk samples were collected from each farm, in the middle of each month. Raw milk was sampled directly from each farm milk tank during the morning milking, in standard containers (250 mL), stored at 5°C and transported to the laboratory. The milk samples were frozen until analysis.

Table 1. Ingredients (% of DM) of the two feeding diets

Ingredient	A diet	B diet
Maize silage	40	25
Grass silage	-	20
Grass hay	23	18
Concentrates	20	24
Other fodder corps	10	5
Co-products[1]	7	8

[1]Co-products including straw, bran, beet pulps, salts, mineral-vitamin premix

Fatty acids content from raw milk was analysed by gas chromatography-mass spectrometry (GC-MS) as described by Coppa et al. (2015). Chromatograms and spectra corresponding to the lipid profile of interest were analysed and interpreted by the peak area percentage method (Chilliard et al., 2009; Reis, 2011). Based on the obtained results, the concentrations of the fatty acids identified were calculated for the samples of raw milk taken into study and subsequently the fatty acid unsaturation indexes were determined.

RESULTS AND DISCUSSIONS

The lipid profile of milk corresponding to the two diets types was analysed, identifying the main fatty acids. From a quantitative point of view, the main saturated fatty acids quantified in the 12 raw milk samples analysed were long-chain fatty acids consisting of 13-21 carbon atoms: myristic acid (C14:0), pentadecylic acid (C15:0), palmitic acid (C16:0), margaric acid (C17:0) and stearic acid (C18:0). The main mono- and polyunsaturated fatty acids identified were fatty acids with an even number of carbon atoms, most of them with *cis* configuration: oleic acid (C18:1 *cis*-9), linoleic acid (C18:2 *cis*-9, *cis*-12), linolenic acid (C18:3 *cis*-9, *cis*-12, *cis*-15) and rumenic acid (C18:2 *cis*-9, *trans*-11).

The fatty acids concentrations were calculated as the ratio of each individual fatty acid to sum of all fatty acids identified in the respective milk sample. Subsequently, for each milk type, the fatty acid unsaturation indexes were calculated as the ratio of the concentration unsaturated fatty acid to the result of summing concentrations unsaturated fatty acid and corresponding saturated fatty acid, multiplied by 100 (Schennink et al, 2008). We calculated C14 index, C18 index and total index.

The variability of the milk lipid profile depending on the diet of dairy cows is presented in Table 2. From the data obtained, it can be seen how the type and concentration of fatty acids in the analysed milk samples was significantly influenced by the diet of dairy cows.

Table 2. Variation in fatty acids content in milk according to dairy cows diet

Fatty acid (g/100 g total fatty acids)	A diet	B diet	*p*-value
SFA	68.14	66.09	**0.002**
< C14:0	13.08	14.17	**0.046**
Myristic acid (C14:0)	11,32	10.51	**0.048**
C15:0 - C17:0	33.68	32.34	0.114
Stearic acid (C18:0)	9.75	8.70	**0.037**
> C18:0	0.31	0.37	0.176
MUFA	26.93	28.51	**0.016**
Myristoleic acid (C14:1 *cis*-9)	0.92	1.05	0.274
Oleic acid (C18:1 *cis*-9)	18.43	19.39	**0.048**
Other MUFA	7.58	8.07	**0.004**
PUFA	3.92	4.39	**0.032**
Linoleic acid (C18:2 *cis*-9, cis-12)	1.63	1.98	**0.045**
Rumenic acid (C18:2 *cis*-9, *trans*-11)	0.31	0.41	**0.001**
Linolenic acid (C18:3 *cis*-9, *cis*-12, *cis*-15)	0.28	0.46	**0.049**
Other PUFA	1.70	1.54	**0.004**
C14 index[1]	7.52	9.08	0.583
C18 index[2]	65.40	69.03	**0.044**
Total index[3]	47.87	51.55	**0.022**

[1]C14 index = C14:1 *cis*-9/(C14:1 *cis*-9 + C14:0) x 100

[2]C18 index = C18:1 *cis*-9/(C18:1 *cis*-9 + C18:0) x 100

[3]Total index = [(C14:1 *cis*-9 + C18:1 cis-9)/(C14:1 cis-9 + C14:0 + C18:1 *cis*-9 + C18:0)] x 100

The content of saturated fatty acids is about 2% lower for milk from the B diet which replaced part of the maize silage in the cow diet with grass silage (P<0.05). At the same time compared to milk in A diet, the milk from B diet has reduced levels of 1.06% for short and medium chain saturated fatty acids (P<0.05) and reduced by approx. 1% for long chain saturated fatty acids (P<0.05).

Parallel to the reduction in the content of saturated fatty acids in the milk of diet B is a significantly higher content of MUFA (monounsaturated fatty acids) and PUFA (polyunsaturated fatty acids) (P<0.05).

These results show that milk produced with rations based on grass silage are richer in polyunsaturated fatty acids (rumenic acid linolenic acid, linolenic acid) (P<0.05) and lower in stearic acid (P<0.05) compared to rations based on maize silage.

The influence of the grass silage presence in the feeding diet is also highlighted by the values of the unsaturation indices. Thus, if the values of the C14 index (unsaturation indices of medium-chain fatty acids) are not significantly different (7.52 in A diet vs 9.08 in B diet) the C18 index (unsaturation indices of long-chain fatty acids) and the total index have much higher values for milk from diet B (P < 0.05). These much higher values of the milk fatty acid unsaturation index of diet B are due to the balance between the proportion of maize silage and grass silage that provides both polyunsaturated fatty acids and fibre that favours pH values close to pH optimum of biohydrogenation enzymes, simultaneously stimulating the cellulolytic microflora (Chilliard et al., 2009). Higher content of polyunsaturated fatty acids, including rumenic acid can be determined by impact of grass silage on the rumen activities (Michas et al., 2014). A high proportion of grass hay (A diet) increases the content of saturated fatty acids (SFA), while the proportion of linolenic acid decreases significantly (P < 0.05).

The proportion of linoleic acid in milk fatty acids is generally between 2 and 3%. The relatively low content of linoleic acid in both types of milk indicates the hydrogenation of this acid in the rumen, which severely limits its incorporation into the fatty acids of milk (Faulkner et al., 2018).

One of the requirements for milk with good nutritional qualities is a high C18:1/C18:0 ratio. The C18:1/C18:0 ratio was 1.89 in milk from diet A compared to 2.23 in milk from diet B, suggesting according to Jenkins et al., (2006) an increase in delta-9 desaturase activity that converts stearic acid to oleic acid.

CONCLUSIONS

The fatty acid profile of milk can by strongly influenced by the feeding diet type. A feeding diet incorporating grass silage alongside maize silage can provide milk with lower saturated fatty acid content (possible risk factors) and a good proportion of mono and polyunsaturated fatty acids (known for beneficial effects). The type and proportion of ingredients in the fodder offered to dairy cows is an effective way of modulating the nutritional quality of milk fat.

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