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REVIEW

# Fatty acid profile in bovine milk: Its role in human health and modification by selection

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ADDITIONAL KEYWORDS

Dairy cattle.
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## SUMMARY

Milk fat is predominantly composed of fatty acids. Bovine milk shows a high concentration of saturated fatty acids, some of them associated with an increase in the risk of cardiovascular diseases in human beings. However, many of these have neutral or positive effects on health, as well as some unsaturated fatty acids do. The fat profile of bovine milk can be changed by lipid supplementation in a fast and efficient way, but genetic variation is also verified in this profile and genetic breeding becomes more relevant than supplementation for presenting permanent results. This bibliographic review has the objective of gathering the main results referring to the genetic aspects of fatty acids profile in bovine milk.

**Perfil de ácidos graxos no leite bovino: seu papel na saúde humana e sua modificação por seleção**

PALAVRAS-CHAVE ADICIONAIS

Gado de leite.
Gordura do leite.
Parâmetros genéticos.

## RESUMO

A gordura do leite é composta, predominantemente, por ácidos graxos. O leite bovino apresenta alta concentração de ácidos graxos saturados, alguns associados ao aumento do risco de doenças cardiovasculares em humanos. Porém, muitos desses, possuem efeitos neutros ou positivos sobre a saúde, assim como alguns ácidos graxos insaturados. O perfil da gordura do leite de bovinos pode ser alterado por suplementação lipídica de maneira rápida e eficiente, porém, verifica-se também variação genética nesse perfil e o melhoramento genético se torna mais relevante do que a suplementação por apresentar resultados permanentes. Esta revisão de literatura teve como objetivo reunir os principais resultados referentes aos aspectos genéticos do perfil de ácidos graxos no leite de bovinos.

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## INTRODUCTION

The major part of fat in bovine milk is composed by triacylglycerols, consisting of three fatty acids and one glycerol molecule. Such fatty acids are predominantly in saturated form (Eifert, 2006), which are associated with the increase of the risk of cardiovascular diseases in human beings (Santos *et al.*, 2013). However, such effects are only related to lauric (C12:0), myristic (C14:0), and palmitic (C16:0) fatty acid, while the others have neutral or positive effects on human health (Mensink *et al.*, 2003). Regarding the unsaturated fatty acids, those which stand out are the oleic acid (C18:1 *cis*-9) and the isomers of conjugated linoleic acid (CLA), related to the cholesterol reduction and to the anticarcinogenic effects respectively (Haug *et al.*, 2007). The fat profile of bovine milk can be altered by dietary lipid supplementation (Santos *et al.*, 2001). This alteration can be induced by feed because of the amount of unsaturated fatty acids contained in the provided lipid and by its release rate in rumen; therefore, modifying the metabolism, it is possible to obtain a different fatty acids profile. The toxicity of unsaturated fatty acids through acting upon some bacteria species, leads to modification of ruminal microbiota. The use of animal breeding stands out among attempts of modifications of this profile, since there is a genetic variation in fat milk composition and between bovine breeds (Soyeurt *et al.*, 2006). Furthermore, even diet supplementation being the fastest and most efficient way to modify fatty acids composition in cow milk (Jenkins & McGuire, 2006), animal breeding becomes more relevant because it shows permanent advances, despite its slowness and long term planning. Moreover, recent researches by Bastin *et al.* (2013) and Bilal *et al.* (2014) have shown medium and high heritability for several fatty acids in Holstein cow milk, which suggests a feasible selection to those components. Thus, studies related to genetic behavior of fatty acids profile in milk might allow the use of tools aiming to improve such profile and promote better milk quality.

Therefore, the objective of this revision was to gather the main results regarding the influence of animal genetics on fatty acids profile of bovine milk.

## Chemical composition of bovine milk

Bovine milk is composed of water (87%), lactose (4.9%), fat (3.5%), protein (3.1%), minerals and vitamins in smaller proportions (Jensen, 1995). It is necessary to consider milk composition because it is important to determine its nutritional quality, capacity of being processed and consumption by humans. It varies influenced by multiple factors (Silva, 1997). Around 60% of the variation in milk composition is due to genetic aspects and environmental aspects such as nutrition, climate, diseases, and milk storage (Kitchen, 1981; Shearer *et al.*, 1992) causing rest.

Among bovine milk components, fat presents higher variation rates from 3.2% to 6%. About 98% of cow milk lipid fraction is composed by triacylglycerol. According to description by Hayes and Khosla (1992), the combination of lipids in milk that is more favorable to human health stands for 30% of saturated fatty acids, 60% of monounsatured fatty, and 10% of polyunsaturated fatty acids. The highest concentration of bovine milk is fatty acids (Eifert, 2006), but there are only three of them associated with increase in the risk of cardiovascular diseases in human beings: lauric acid; myristic acid; and palmitic acid (Mensink *et al.*, 2013). Researches indicate that, in the milk fat profile, there are compounds that are beneficial to human health (Eifert, 2006), such as some saturated and unsaturated fatty acids, as described below.

## Fatty acids composition and human health

Researches highlight the increase in risk of cardiovascular diseases (Grimsgaard *et al.*, 1999; Zheng *et al.*, 1999; Yli-Jama *et al.*, 2002; Matsumoto *et al.*, 2013) when there is fatty acid ingestion, but not all studies present the same ideas (Lemaitre *et al.*, 2010; Wu *et al.*, 2011). Saturated fat covers compounds that vary from 6 to 24 carbons, which originate in several foods and have different metabolic performances (Mozaffarian, 2015a). For instance, the palmitic acid (C16:0) might show adverse metabolic effects in vitro, while medium chain (C6:0 to C12:0), odd chain (C15:0 to C17:0), and very long chain (C20:0 to C24:0) saturated fatty acids might, in turn, show metabolic benefits (Forouhi *et al.*, 2014). Thus, it is incorrect to group all saturated fatty acids based on only one chemical trait, which is the absence of double bonds in the carbon chain (Mozaffarian, 2015a). The butyric acid (C4:0) can have anticarcinogenic effect (German, 1999), caprylic (C8:0) and capric (C10:0) acids might play antiviral roles, and the caprylic acid can even have functions related to the delay of tumor growth (Thormar *et al.*, 1994) and act against Gram-negative coliform (Sun *et al.*, 2002). There are reports that the lauric fatty acid (C12:0) can have antibacterial effects (Sun *et al.*, 2002) and might act as anticaries and antiplaque agent (Sun *et al.*, 2003). The increase in cardiovascular diseases among human beings is related to lauric (C12:0), myristic (C14:0), and palmitic fatty acids, because of low density lipoprotein (LDL) and high density lipoprotein (HDL), both of them linked to increased cholesterol. Other milk-saturated fatty acids have neutral or positive effect on health (Mensink *et al.*, 2003). Stearic fatty acid (C18:0) is not regarded as a promoter of increased cholesterol concentration (Grundy, 1994).

In relation to unsaturated fatty acids, the *trans* form shows worse effect in human health than the saturated ones, since it increases the levels of what is called "bad" cholesterol (LDL) and it decreases the levels of "good" cholesterol, HDL. However, only small amounts of natural *trans* fats are found in meat and ruminant milk, and they are not associated with cardiovascular diseases (Mozaffarian *et al.*, 2009). The C16:1 *trans*-7, a *trans* fatty acid that performs as a biomarker of milk fat, relates itself to a lower risk of diabetes mellitus development and sudden cardiac death (Mozaffarian, 2015b).

It is important to highlight that there is great distinction between *trans* fatty acids that are formed by animals and those industrially produced. Products originated from ruminants show a concentration from 3 to 8% of *trans* fatty acids in relation to total fatty acids, while industrialized products show 10 to 40% concentration (Martinez, 2009). High levels of industrially produced *trans* fatty acids can be consumed through partially hydrogenated vegetable oil, which usually contain from 30 to 60% of *trans* fatty acids (Mozaffarian, 2016). Besides a higher concentration of *trans* fatty acids in the total fatty acids, industrialization also causes the preferential production of elaidic acid (C18:1 *trans*-9). Rumen bacteria, mainly generate vaccenic acid (C18:1 *trans*-11), a precursor of a specific type of conjugated linoleic acid (CLA) (Martinez, 2009). The ingestion of *trans* fatty acids from partially hydrogenated oils is consistently associated with the risk of cardiovascular diseases and sudden death (Mozaffarian *et al.*, 2006; Mente *et al.*, 2009).

There are unsaturated fats that have positive effects on human health. Polyunsaturated ω-3 fatty acids can contribute to the treatment or prevention of cancer, arthritis, depression, and Alzheimer's disease. Polyunsaturated ω-6 fatty acids derivatives of linoleic acid take part in cell membrane structures, playing an important physiological role in the human body and influencing in blood viscosity, as well as vessel permeability, and also in blood pressure, inflammatory reactions, and platelet functions (Moraes & Colla, 2006).

Special attention has been given to CLA, a group of isormers of linoleic acid with some of its unsaturations being combined, in other words, without methylene between them (Roche *et al.*, 2001). Several beneficial effects of the CLA to human health have been reported in the last years, such as antidiabetic and anticarcinogenic effects. Among other benefits, there are also modulations of the immune system, energy partition,

**Table I. Heritability values for groups of fatty acids in bovine milk** (Valores de herdabilidade para grupos de ácidos graxos no leite bovino).

| Common denomination of fatty acid | Designation | Heritability | Source |
|---|---|---|---|
| Saturated | AGS | 0.14 - 0.46 | Soyeurt *et al.* (2007)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Monounsaturated | AGMI | 0.21 - 0.26 | Soyeurt *et al.* (2007)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Polyunsaturated | AGPI | 0.15 - 0.31 | Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Unsaturated | AGI | 0.27 | Bastin *et al.* (2013) |

and reduction in the development of atherosclerosis (Bauman *et al.*, 1999; Zacarchenco *et al.*, 2013). For this reason, CLA has become the focus of many researches. The major sources of CLA in human diet are the milk and its derived products, and the enrichment of those foods with CLA can be a very interesting alternative due to its benefits (De Luca & Jenkins, 2000). The most abundant CLA isomer in milk fat is the C18:2 *cis*-9 *trans* 11 (rumenic acid), which represents from 75 to 90% of the total CLA (Bauman *et al.*, 2003).

Animal breeding is gradually allowing the increase of milk production. However, due to market changes, the goals of the programs are being expanded to include cow's longevity, continuing production, and, more recently, quality traits of milk, in relation to human health, food safety, and industrial yield of dairy products.

## Genetic parameters of fatty acids profile in bovine milk

### *Heritability*

Results show that heritability values have varied from 0.15 to 0.46 to groups of saturated, monounsaturated, polyunsaturated, and unsaturated fatty acids

**Table II. Heritability values for diverse saturated fatty acids in bovine milk** (Valores de herdabilidade para diversos ácidos graxos saturados no leite bovino).

| Common denomination of fatty acid | Designation | Heritability | Source |
|---|---|---|---|
| Butyric acid | C4:0 | 0.08 - 0.37 | Stoop *et al.* (2008)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Caproic acid | C6:0 | 0.14 - 0.46 | Stoop *et al.* (2008)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Caprylic acid | C8:0 | 0.24 - 0.48 | Stoop *et al.* (2008)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Capric acid | C10:0 | 0.34 - 0.54 | Stoop *et al.* (2008)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Lauric acid | C12:0 | 0.09 - 0.46 | Soyeurt *et al.* (2007)<br>Stoop *et al.* (2008)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Myristic acid | C14:0 | 0.07 - 0.49 | Soyeurt *et al.* (2007)<br>Stoop *et al.* (2008)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Palmitic acid | C16:0 | 0.03 - 0.43 | Soyeurt *et al.* (2007)<br>Stoop *et al.* (2008)<br>Mele *et al.* (2009)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Margaric acid | C17:0 | 0.21 - 0.40 | Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Stearic acid | C18:0 | 0.08 - 0.28 | Soyeurt *et al.* (2007)<br>Stoop *et al.* (2008)<br>Mele *et al.* (2009)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |

**Table III. Heritability values for diverse unsaturated fatty acids in bovine milk** (Valores de herdabilidade para diversos ácidos graxos insaturados no leite bovino).

| Common denomination of fatty acid | Designation | Heritability | Source |
|---|---|---|---|
| Myristelaidic acid | C14:1 *trans*-9 | 0.02 | Bilal *et al.* (2014) |
| Myristoleic acid | C14:1 *cis*-9 | 0.19 - 0.39 | Mele *et al.* (2009)<br>Bilal *et al.* (2014) |
| *Trans*-palmitoleic acid | C16:1 *trans*-9 | 0.05 | Bilal *et al.* (2014) |
| Palmitoleic acid | C16:1 *cis*-9 | 0.14 - 0.30 | Mele *et al.* (2009)<br>Bilal *et al.* (2014) |
| Oleic acid | C18:1 *cis*-9 | 0.17 - 0.22 | Stoop *et al.* (2008)<br>Mele *et al.* (2009)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Elaidic acid | C18:1 *trans*-9 | 0.01 - 0.11 | Stoop *et al.* (2008)<br>Bilal *et al.* (2014) |
| Vaccenic acid | C18:1 *trans*-11 | 0.03 - 0.12 | Stoop *et al.* (2008)<br>Mele *et al.* (2009)<br>Bilal *et al.* (2014) |
| Linolelaidic acid | C18:2 *trans*-9,12 | 0.02 - 0.13 | Stoop *et al.* (2008)<br>Bilal *et al.* (2014) |
| Linoleic acid | C18:2 *cis*-9,12 | 0.15 | Soyeurt *et al.* (2007)<br>Bilal *et al.* (2014) |
| Rumenic acid | C18:2 *cis*-9, *trans*-11 | 0.07 - 0.21 | Stoop *et al.* (2008)<br>Mele *et al.* (2009)<br>Bilal *et al.* (2014) |
| *Trans*-10, *cis*-12 linoleic acid | C18:2 *trans*-10, *cis*-12 | 0.01 | Bilal *et al.* (2014) |
| Alpha-linolenic | C18:3 *cis*-9,12,15 | 0.06 - 0.09 | Stoop *et al.* (2008)<br>Bilal *et al.* (2014) |

**(table I)**. According to several authors, estimated heritability for specific saturated fatty acids have varied from 0.03 to 0.54 **(table II)**, and for specific unsaturated fatty acids, from 0.01 to 0.39 **(table III)**.

The estimates of heritability to various fatty acids have shown wide variation according to the sources researched. This variation occurs most likely because heritability is not a fixed parameter. In other words, it can vary according to population diversity, sample size, number and types of environments, precision in conducting the experiment and data recording, as well as estimation of the methods used.

So far, the researches conduced showed medium and high heritability estimates for many fatty acids found in bovine milk, this suggests a larger share of additive genetic effect on these traits, and they can respond well to selection. Thus, genetics can be used in the manipulation of several of the levels of fatty acids of milk.

### Genetic correlations

The values for genetic correlation between the fatty acids groups and the milk production reported by researchers vary from -0.48 to 0.15, and between the fatty acids groups and the fat percentage, from -0.89 to 0.97 **(table IV)**. The specific genetic correlations between saturated fatty acids and milk production vary from -0.50 to 0.30, and those between acids and fat percentage vary from -0.43 to 0.83 **(table V)**. The genetic correlations between unsaturated fatty acids and milk production vary from -0.31 to 0.77, and those

**Table IV. Genetic correlation values among fatty acids, milk production, and fat percentage in bovine milk** (Valores de correlação genética entre ácidos graxos, produção de leite e porcentagem de gordura no leite bovino).

| Common denomination of fatty acid | Designation | Genetic correlation with milk production | Genetic correlation with fat percentage | Source |
|---|---|---|---|---|
| Saturated | AGS | -0.48 to -0.16 | 0.91 to 0.97 | Soyeurt *et al.* (2007)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Monounsaturated | AGMI | -0.35 to 0.15 | -0.89 to 0.74 | Soyeurt *et al.* (2007)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Polyunsaturated | AGPI | -0.37 to 0.19 | -0.80 to 0.69 | Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Unsaturated | AGI | -0.36 | 0.73 | Bastin *et al.* (2013) |

**Table V. Genetic correlation values among saturated fatty acids, milk production, and fat percentage in bovine milk** (Valores de correlação genética entre ácidos graxos saturados, produção de leite e porcentagem de gordura no leite bovino).

| Common denomination of fatty acid | Designation | Genetic correlation with milk production | Genetic correlation with fat percentage | Source |
|---|---|---|---|---|
| Butyric acid | C4:0 | 0.05 and 0.09 | 0.03 and 0.16 | Stoop *et al.* (2008)<br>Bilal *et al.* (2014) |
| Caproic acid | C6:0 | -0.28 and 0.01 | 0.46 and 0.83 | Stoop *et al.* (2008)<br>Bastin *et al.* (2013) |
| Caprylic acid | C8:0 | -0.31 and 0.03 | 0.34 and 0.81 | Stoop *et al.* (2008)<br>Bastin *et al.* (2013) |
| Capric acid | C10:0 | -0.32 and 0.10 | 0.09 and 0.77 | Stoop *et al.* (2008)<br>Bastin *et al.* (2013) |
| Lauric acid | C12:0 | -0.34 and -0.26 | 0.43 and 0.77 | Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Myristic acid | C14:0 | -0.34 and 0.30 | -0.43 and 0.04 | Stoop *et al.* (2008)<br>Mele *et al.* (2009)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Palmitic acid | C16:0 | -0.50 and -0.33 | 0.65 and 0.74 | Stoop *et al.* (2008)<br>Mele *et al.* (2009) |
| Stearic acid | C18:0 | -0.30 and -0.20 | -0.10 and 0.71 | Mele *et al.* (2009)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |

between acids and fat percentage vary from -0.85 to 0.69 **(table VI).**

Besides the estimated genetic correlations among fatty acids, milk production, and fat percentage, estimates between fatty acids in one to one basis were also related. Stoop *et al.* (2008) have estimated positive and negative genetic correlations among several fatty acids found in Holstein cow milk and found values ranging from -0.84 to 0.99, with negative correlations from -0.84 to -0.01 and positive correlations from 0.01 to 0.99. Positive and strong correlations were reported from C6:0 to 14:0 and unsaturated fatty acids, but between C6:0 to C14:0 and saturated fatty acids the genetic correlations were negative. The same occurred with C4:0, C16:0, and C18:0 when genetically correlated to other studied fatty acids.

Bastin *et al.* (2013) estimated genetic correlations of milk fatty acid among the three first deliveries, finding values from 0.51 to 0.76 between the first and second birth, from 0.48 to 0.74 between second and third birth, and from 0.44 to 0.70 between first and third birth. The results show that the level of fatty acids in milk tend not to vary much among the three first lactations so that if a cow shows high levels of fatty acid in the

**Table VI. Genetic correlation values among unsaturated fatty acids, milk production, and fat percentage in bovine milk** (Valores de correlação genética entre ácidos graxos insaturados, produção de leite e porcentagem de gordura no leite bovino).

| Common denomination of fatty acid | Designation | Genetic correlation with milk production | Genetic correlation with fat percentage | Source |
|---|---|---|---|---|
| Myristoleic acid | C14:1 *cis*-9 | 0.05 | -0.05 and 0.10 | Mele *et al.* (2009)<br>Bilal *et al.* (2014) |
| Palmitoleic acid | C16:1 *cis*-9 | 0.09 | 0.24 and 0.34 | Mele *et al.* (2009)<br>Bilal *et al.* (2014) |
| Oleic acid | C18:1 *cis*-9 | -0.31 to 0.32 | -0.85 to 0.64 | Stoop *et al.* (2008)<br>Bastin *et al.* (2013)<br>Bilal *et al.* (2014) |
| Vaccenic acid | C18:1 *trans*-11 | -0.07 and 0.34 | -0.69 to -0.43 | Stoop *et al.* (2008)<br>Mele *et al.* (2009)<br>Bilal *et al.* (2014) |
| Linoleic acid | C18:2 *cis*-9,12 | 0.24 and 0.77 | -0.70 and -0.69 | Stoop *et al.* (2008)<br>Bilal *et al.* (2014) |
| Rumenic acid | C18:2 *cis*-9, *trans*-11 | 0.33 to 0.35 | -0.68 to -0.55 | Stoop *et al.* (2008)<br>Mele *et al.* (2009)<br>Bilal *et al.* (2014) |
| Alpha-linolenic | C18:3 *cis*-9,12,15 | 0.15 and 0.53 | -0.75 and -0.55 | Stoop *et al.* (2008)<br>Bilal *et al.* (2014) |

first lactation, it will also show high levels in second and third lactations. The estimates among fatty acids varied from 0.31 to 0.99, suggesting that the selection of one fatty acid can affect the others.

According to Bilal *et al.* (2014), genetic correlations estimates among studied fatty acids were from -0.72 to 0.97, with negative correlations from -0.72 to -0.01, and positive ones from 0.01 to 0.97. Null genetic correlation was reported between C18:3 *cis*-9,12,15 and C12:0 fatty acids.

Like the heritability estimates, there was a variation between genetic correlations and fatty acids, and production variables when compared to published researches. In the same way, estimates in different works can differ according to the studied population, the sample size, endogamy, and estimation methodologies used.

According to the published studies about genetic correlations among fatty acids, it is possible to assure that a selection directed to one acid affects the others, since it required the precise definition of goals in breeding programs so that there will not be losses in milk quality. A favorable change aiming good fatty acids profile in milk is still uncertain and the objectives should be well defined before those traits are included in breeding programs (Bastin *et al.*, 2013).

### *Tools for genomic selection applied to fatty acids profile in bovine milk*

The identification of molecular marker for fatty acids profile in milk as well as other techniques linked to molecular genetics, appears as an assisting tool for understanding genetic control of traits and, consequently, as an auxiliary tool to selection programs.

With the growth of researches regarding the determination of loci that are responsible for fatty acids in milk, and the use of molecular markers, a better understanding about genetic control of these traits is expected. Research on genomic selection for fatty acids profile in milk is also recent.

Taniguchi *et al.* (2004) have verified a polymorphism linked to the Δ9-desaturase enzyme (SCD1) in bovines of the Japanese Black breed. Schennink *et al.* (2008) have reported that larger proportions of C10:0; C12:0. C14:0. C16:1; and CLA were associated with C allele of the locus SCD1, while smaller proportions of C10:1; C12:1; C14:1; C18:0; and C18:1 were linked to T allele of the same locus.

An example of SNP polymorphism is the exchange of a cytosine (C allele) for a thymine (T allele), which results in the replacement of a valine by the alanine in position 293 of the protein (A293V) (Taniguchi *et al.*, 2004). According to Mosley & McGuire (2007), SCD1 A293V polymorphism contributes in 32% to 51% when it explains genetic variance referring to unsaturation levels of C10. C12, C14, and C16, 18% of CLA, and 6% of C18.

A research by Brym *et al.* (2004) reports the influence of STAT5A – transcription factor and protein activator located in chromosome 19 – on the level of milk fat. A replacement of an adenine (A allele) by a guanine (G allele) in intron 9 has been found, in which samples of Jersey cow milk with AA genotype had a lower fat level value. On the other hand, Khatib *et al.* (2008) identified a polymorphism related to lower fat levels in the replacement of a cytosine (C allele) by a guanine (G allele) in exon 8 of the same gene, since the G allele is related to this lower level.

In the bovine chromosome 19 (BTA19), a significant QTL was recognized in the same spot that contains the synthase fatty acid gene (FASN) (Morris *et al.*, 2007). The FASN is an enzyme that catalyzes once again the synthesis of fatty acids in mammals (Ciecierska *et al.*, 2013). For this reason, and also because of its function of fatty acids synthesis, FASN gene is a candidate for some traits of milk production (Morris *et al.*, 2007). According to Ciecierska *et al.* (2013), one of the FASN polymorphisms is the FASN17924A>G, which characterizes only one exchange of the threonine amino acids for the alanine. These authors have identified that there were relations between FASN17924A>G polymorphism and the fat percentage in Holstein cow milk.

The main transcription factor that regulates the expression of genes involved in fatty acids synthesis and cholesterol is the Sterol Regulatory Element Binding Protein (SREBPs; Brown & Goldstein, 1999). Nafikov *et al.* (2013) have showed there is a significant association of SREBF1 haplotypes with concentrations of the C12:0 and C14:0 fatty acids, being the H1 haplotype related to lower concentrations of those acids.

Genomic selection tools confirm that genetics interferes in milk fatty acids profile so that more researches involving biotechnology and traditional breeding methodologies are required in order to understand this profile formation better.

## FINAL CONSIDERATIONS

Conducted studies based on traditional breeding methodologies and genomic selection assure that there is an influence of the animal genetic on milk fatty acids profile. Therefore, researches look for better understanding the behavior of fatty acids production in bovines, aiming better milk quality.

In the studies regarding genetic parameters, Holstein animals were used, but it is important to include other breeds. There have been variations in heritability estimates and genetic correlations among fatty acids in the analyzed studies. Besides, there has also been divergence in literature regarding beneficial and harmful effects in human health related to saturated fatty acids. Thus, further studies should be conducted about genetic parameters and genomic selection on milk fatty acids profile so that the most appropriate selection strategies can be determined in breeding programs.

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