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***Original Contribution***

# FATTY ACID PROFILE AND HEALTHY LIPID INDICES OF BULGARIAN GOAT MILK FROM BREEDS, PASTURE-RAISED IN A MOUNTAIN REGION

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**ABSTRACT**
The aim of the present study was to characterize the fatty acids profile and the related health lipid indices of goat`s milk from different Bulgarian breeds in order to add information on its nutritional quality. The study was performed with goat milk from a private farm in the Stara Planina Mountain. Milk samples were collected from three breeds – Bulgarian White Dairy Goat, Toggenburg and local goats. The content of saturated fatty acids was the highest in the milk of the local breed – 83.6% compared to for Bulgarian White Dairy Goat - 75.4% and Toggenburg - 75.2%. The atherogenic index was calculated on the obtained values for lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acids and the unsaturated fatty acids. The data for the Bulgarian White Dairy Goat was – 3.12; Toggenburg – 3.14 and for local breed – 5.54. The values of the atherogenic index showed that it is the lowest for the Toggenburg, following Bulgarian White Dairy Goat and local breed. Omega 6/Omega 3 ratio varies from 1.58 for local breed to 2.44 for Toggenburg which is within the range of the optimal values for healthy nutrition.

**Keywords:** goat milk, healthy indexes, Bulgarian White Dairy Goat, Toggenburg, local goats

## INTRODUCTION

The popularity of goat milk has shown a gradual increase due to its properties (which differentiate it from other milks) and beneficial effects on human health (1, 2). In comparison with cow`s milk, goat milk has a higher concentration of short and medium chain fatty acids (3) and lipoprotein lipase associated with the fat phase (4) and lower allergenic properties (5). The nutritional and health properties of goat milk are linked to the high content of medium chain fatty acids that are rapidly absorbed in the intestines and are of particular therapeutic interest. Medium chain fatty acids are known to have antibacterial and anti-viral effects, and their high relative share in human diet may affect the intensity of cholesterol deposition (6).

Goats' milk fat is rich in short-chain fatty acids (SCFAs) (e.g., caproic (C6:0), caprylic (C8:0), and capric (C10:0) acids) and medium-chain fatty acids (MCFAs) (e.g., lauric acid (C12:0)). SCFAs represent up to 15–18% of the FAs in goats' milk, but only 5–9% in cows' milk, because of differences in the polymerization of the acetate produced by the rumen bacteria in goat, and are associated with the characteristic odor and flavor of goats' milk cheeses (7).

Studying the fatty acid profile of milk from Bulgarian white dairy goats and their crossbreeds with Anglo-Nubian and Toggenburg breeds, Mihaylova and Zunev (8) found that saturated fatty acids predominate in the milk of the three groups - palmitic (C16 ), followed by stearic (C: 18), capric (C: 10) and myristic (C: 14). The concentration of

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saturated fatty acids ranges from 73.48 to 75.23%. The total amount of neutral saturated fatty acids (C: 4; C: 6; C: 8; C: 10 and C: 18) is 35.66 - 36.06% and the omega 6 : omega 3 ratio is 2.4 – 2.5 : 1.

A recent development in FA-related research is using the milk fatty acid profile as a diagnostic biomarker for prediction of subacute ruminal acidosis (9)**.** The different lipid and fatty acid compounds are deemed to be positive or negative factors with respect to the health of human consumers (10). Improving the methods of research has led to a significant development in understanding the importance of lipids to the human organism and their role in the pathology of many diseases (11**).**

Increasing public awareness regarding health benefits of fatty acids as anticarcinogenic, antiatherogenic, antiobesity and antidiabetic factors (12) has stimulated interest in sources of these fatty acids for human consumption. Regardless of these facts, it must be acknowledged that animal products have a different lipid profile from the currently recommended for humans (13). Modern guidelines for a healthy diet recommend, however, reducing animal fat consumption, especially if rich in saturated fatty acids.

The aim of the present study was to characterize the fatty acids profile and the related health lipid indices of goat`s milk from different Bulgarian breeds in order to add information on its nutritional quality.

## MATERIAL AND METHODS

*Milk*

The study was performed with individual samples goat milk, obtained from three breeds – Bulgarian White Dairy Goat (N=10), Toggenburg (N=15) and local breed (N=10), reared in the herd of the private farm. Animals were pasture-raised. Five controls (from May to September) were carried out and a total of n=175 milk samples were collected by hand milking in the mornings and the evenings, proportionally to the milk yield, according to rules for milk sampling.

*Fatty acids extraction and analysis*

The extraction of milk fat was done by the method of Rose Gottlieb using diethyl ether and petroleum (14). After that the solvents were evaporated on a vacuum-rotary evaporator. Sodium methylate (CHONa) was used for obtaining methyl esters of the fatty acids (15). The fatty acid content of raw milk was determined by gas chromatography "Clarus 500" with flame ionization detector and column ThermoScientific, 60 m, ID 0.25 mm, Film:0,5 μm.

From the data on the fatty acid composition, the following were calculated:

1) Index of atherogenicity (IA) – indicating the relationship between the sum of the lauric, myristic and palmitic fatty acids and that of the main classes of unsaturated, the former being considered proatherogenic and the latter anti-atherogenic (16):

$$IA = \frac{\mathrm{C12{:}0} + 4\mathrm{xC14{:}0} + \mathrm{C16{:}0}}{\sum(MUFA + PUFA)}$$

2) Index of thrombogenicity (IT) – showing the tendency to form clots in the blood vessels. This is defined as the relationship between the pro-thrombogenetic fatty acids (saturated) and the antithrombogenetic fatty acids (MUFAs, PUFAs – n 6 and PUFAs – n3) (16):

$$\mathrm{IT} = \frac{\mathrm{C14:0} + \mathrm{C16:0} + \mathrm{C18:0}}{0.5\mathrm{xC18{:}1} + 0.5\mathrm{x}\sum\mathrm{MUFA} + 0.5\mathrm{xPUFA} - \sum\mathrm{n6} + 3\mathrm{xPUFA\ n3} + (\frac{\mathrm{PUFAn3}}{\mathrm{PUFAn6}})}$$

3)Hypocholesterolemic/Hypercholesterolemic ratio (h/H) was calculated according to Fernandez et al. (17):

h/H=(C18:1+C18:2+C18:3+C20:3+C20:4+C20:5+C22:4+C22:5+C22:6)/(C14:0+C16:0)

*Statistics*

Statistical software (Statistica 6.0) was used for statistical analysis (mean, standard error of mean).

## RESULTS AND DISCUSSION

**Table 1** shows fatty acid profile of milk from the three studied breeds. In the milk of the local breed there was a smaller content in butyric acid, caproic acid, capric acid and stearic acid comparing with the other breeds **(Table 1).**

Butyric acid varied from 0.93% (local breed) to 3.96% for Toggenburg breed. It is known that it inhibits cell growth and induces

differentiation in a wide spectrum of cancer cell lines including breast and colon, where butyric acid can induce apoptosis and may prevent metastases due to the liver (18).

The presence of relatively high levels of C6 to C10 fatty acids in goat milk fat could be responsible for its inferior flavor (19). These fatty acids varied from 18.20% for local breed and Toggenburg to 19.29% for Bulgarian White Dairy Goat. These data are higher than those estimated by Haenlein (20) for goat milk.

***Table 1.*** *Fatty acids composition of goat`s milk from five controls, n=175*

| % | BWDG, N= 10 | | Toggenburg, N=15 | | Local breed, N=10 | |
|---|---|---|---|---|---|---|
| | mean | SEM | mean | SEM | mean | SEM |
| C4:0 | 2.85 | 0.353 | 3.96 | 0.610 | 0.93 | 0.137 |
| C6:0 | 3.41 | 0.382 | 3.61 | 0.567 | 2.45 | 0.324 |
| C8:0 | 4.03 | 1.201 | 3.68 | 0.448 | 5.84 | 1.975 |
| C10:0 | 11.85 | 0.798 | 10.91 | 1.301 | 9.91 | 3.916 |
| C12:0 | 4.03 | 0.245 | 4.12 | 0.690 | 5.18 | 0.362 |
| C12:1 | 0.09 | 0.002 | 0.08 | 0.020 | - | - |
| C 13:0 | 0.12 | 0.032 | 0.14 | 0.040 | - | - |
| C14:0 | 10.27 | 0.189 | 10.12 | 1.697 | 12.52 | 0.149 |
| C14:1 | 0.21 | 0.031 | 0.17 | 0.029 | - | - |
| C15:0 | 0.81 | 0.189 | 0.61 | 0.111 | 1.25 | 0.425 |
| C16:0 | 23.39 | 1.918 | 23.85 | 1.331 | 28.83 | 1.578 |
| C16:1 | 0.58 | 0.075 | 0.61 | 0.117 | - | - |
| C17:0 | 1.44 | 0.040 | 0.67 | 0.126 | 3.98 | 0.271 |
| C17:1 | 0.22 | 0.003 | 0.20 | 0.044 | - | - |
| C18:0 | 13.09 | 0.455 | 13.50 | 0.915 | 12.37 | 0.433 |
| C18:1 | 21.08***a*** | 0.554 | 20.90***a*** | 3.717 | 14.35 | 1.298 |
| C18:2 | 1.89 | 0.271 | 2.00 | 0.269 | 1.31 | 0.043 |
| C18:3 | 0.84 | 0.110 | 0.82 | 0.106 | 0.83 | 0.050 |

Mean values in columns with the same letter are statistically different (P≤ 0.05)

The capric acid (10:0) in milk was from 9.91% for local breed to 11.85% for Bulgarian White Dairy Goat. Some authors indicated values from 8.4 to 11% (21).

The fat present in goat milk is a rich source of short- and medium-chain fatty acids (22). Capric, caprylic acids and medium-chain triglycerides have become established medical treatments for an array of clinical disorders, including malabsorption syndromes, intestinal resection, premature infant feeding, because of their unique metabolic ability to provide direct energy instead of being adipose tissues and because of their actions of lowering serum cholesterol, inhibiting and limiting cholesterol deposition (23). Therefore, goat milk is recommended for infants and old people. The total of short- chain fatty acids (C4-C10) and medium-chain fatty acids (C11-C17) in milk was higher for goats from local breed, while the lowest was for Toggenburg breed **(Figure 1).** In the same time, the sum of the lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acids was the highest for the goats from local breed and lowest for Bulgarian White Dairy Goat. Lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acids are associated with elevated serum levels of low density lipoprotein (LDL)-cholesterol, whereas stearic acid (C18:0), which is poorly absorbed in the gut has no effect on LDL-cholesterol (24).

The highest content of the analyzed fatty acids showed 10:0, C14:0, C16:0, C18:0 and C18:1 which represents 77.98 to 79.68% of the total fat in the milk of the three breeds. These values are lower than those of Zan et al. (25) – 80.3 – 83.5% and Ataşoğlu et al., (26) - 88%.

Some authors consider milk as a risk factor for atherosclerosis and coronary heart disease because of its saturated fatty acids (SFA) content. A meta-analysis of prospective epidemiologic studies showed that there is no significant evidence for concluding that dietary saturated fat is associated with an increased risk of CHD or CVD (27). The SFA in the Bulgarian breeds varied from 75.21% (BWDG) to 83.26% (local breed) **(Figure 2).** The lipid fraction of goat milk is characterized by relatively high content of monounsaturated fatty acids – from 14.35% for local breed to 22.06% for Bulgarian White Dairy Goat.

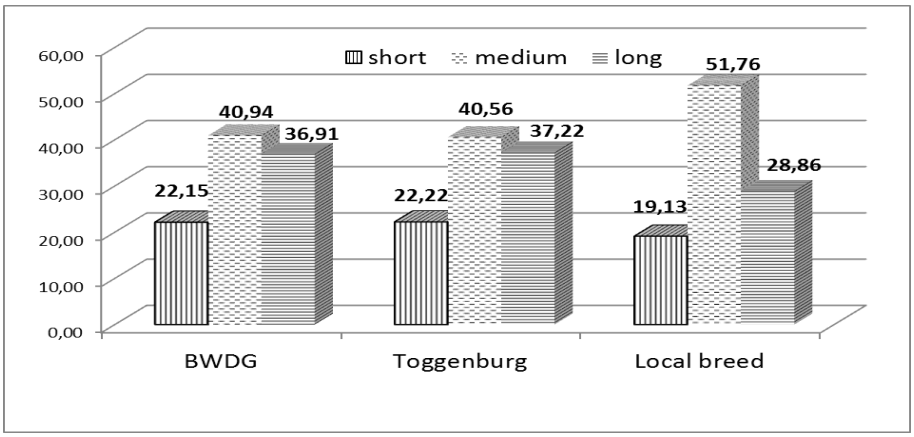


**Figure 1.** Short-, medium and long chain fatty acids in goat milk

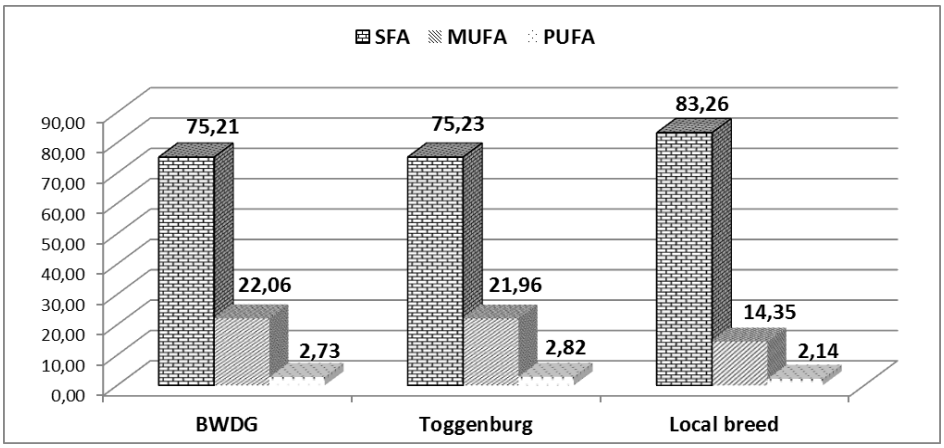


**Figure 2.** Saturated and unsaturated fatty acids in goat milk

Nutrition studies have shown that unsaturated fatty acids have different functions and metabolism in the human body (they play a key role in the metabolism of the body). A number of fatty acids, part of the so called omega-3 and omega-6 fatty acids have been of particular interest over the recent years (28, 29). In the diet of people in developed countries, the content of omega 6 fatty acids is significantly higher than omega 3 fatty acids (30). Clinical studies in the last decade pointed out the need of reducing the omega-6/omega-3 ratio. The English Health Department (31) recommends that the omega-6/omega-3 ratio should be below 4. The values recommended during the last few years are 4 and 5.1 (32). The ratio of n-6/n-3 fatty acids in the diet of most people ranges from 15:1 to 16.7:1 (33). However, it is recommended to maintain a markedly lower proportion of n-6 fatty acids. According to Simopoulus (33), an optimal n-6/n-3 fatty acids ratio is specific to different diseases. This ratio in the investigated goat milk varied from 1.58 for local breed to 2.44 for Toggenburg breed, which is within the recommended levels and slightly lower than the ratio found by Haile et. al. (34) **(Figure 3).**

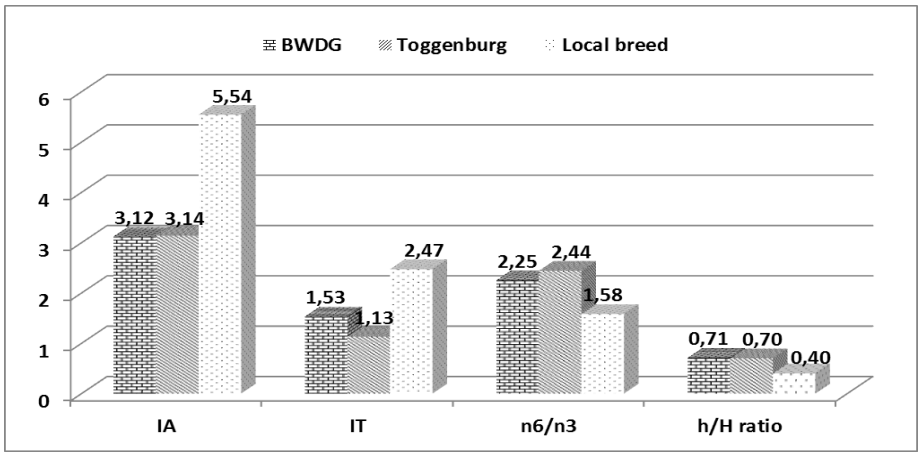


**Figure 3.** Healthy indexes of goat milk

In this study two distinct indices were investigated: atherogenic and thrombogenic (fig. 3). These indices take into account the different effects that single fatty acids might have on human health and in particular on the probability of increasing atheroma and thrombus formation (35). The atherogenic index was calculated on the obtained values for the lauric (C12:0), (C14:0) and palmitic (C16:0) acids and the unsaturated fatty acids. This index, calculated for goat milk was slightly higher (from 3.12 to 5.54) than that found in other earlier investigations on the goat milk composition (34; 36). Due to the high content of SFA, the atherogenic index of milk is about 3-5 times higher compared to other food products of animal origin. The atherogenic index values are higher than those recommended by Bobe et al. (37), due to the higher relative share of saturated fatty acids compared to unsaturated.

The index of thrombogenicity (IT) was from 1.13 in the milk of Toggenburg breed to 2.47 in the milk of the local breeds, which is lower than the values reported by Pittau et al. (38). The lower levels of IT for Toggenburg and Bulgarian White Dairy Goat are similar to those, found by Ulbrich and Southgate (16) and lower values indicate a healthier product.

The hypo/hypercholesterol (h/H) ratio is an index that takes into account the functional activity of FAs in the metabolism of plasma cholesterol lipoproteins, whose types and quantities are associated with higher or lower risk of cardiovascular disease (39). Here we found an average h/H of 0.71 for BWDG, 0.70 for Toggenburg and 0.40 for local breeds. The h/H values in present study (except local breed) are according to Osmari et al. (40) who found an h/H mean value of 0.75 in goat milk. There are no recommended h/H values for dairy products. However, the value of 2.0 used for meats can be taken as a reference. From a nutritional aspect, values lower than 2.0 provide a better fatty acid profile and reduce the risk of cardiovascular disease (41).

## CONCLUSIONS

The obtained results show that in the pasture rearing of the goats, the monounsaturated fatty acid content in the milk is relatively higher. Among breeds investigated, Bulgarian White Dairy Goat showed a better profile with lower saturated fatty acids than Toggenburg and local goats. The ratio of n-6/n-3 fats is in the recommended levels of 1.58 - 2.44. Thrombogenic index values are low, which characterizes the milk of the studied breeds as a healthy food product for the human body.

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