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Considerations on goat milk biochemical composition

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Abstract. The benefits of human consumption of goat's milk are given by the presence in this milk of short-chain fatty acids (approximately 20% are short-chain fatty acids) and medium-chain fatty acids (55%), this milk being easier to digest. An important qualitative indicator of goat's milk with technological, nutritional and dietary impact is the fat content. Our data show that the percentage of milk fat increases immediately after parturition, then decreases for most of the lactation. This is due to two factors: a diluting effect, by increasing the volume of milk to the maximum level of lactation and a decreasing effect of lipid mobilization, which leads to a decrease in the plasma level of unesterified fatty acids (especially C18:0 and C18:1), with a role in lipid synthesis in the mammary gland. From the third month of lactation, the average daily amount of milking milk undergoes only slight variations. Also, the fat and protein percentage remain relatively constant during June-August. In summer there was an increase in the levels of monounsaturated, polyunsaturated fatty acids and of conjugated linoleic acids in milk, compared to spring. Our results indicate that multiparous Carpathian breed females, whose food comes mostly from grazing, produce milk during the summer with a ratio between omega-6 and omega-3 below 4.

***Keywords*:** goat milk; fatty acids; omega 6/omega 3 ratio; conjugated linoleic acid

1. Introduction

Goat's milk is a very well tolerated by people allergic to cow's milk, thus representing an alternative to consumption. In addition to their contribution in attributing the specific smell of goat to dairy products, short chain fatty acids and medium chain fatty acids in high proportion have either other properties, as: antibacterial, antiviral, inhibit the development of cholesterol deposits and have a rapid absorption in the intestine [1].

By modulating food rations, it is also possible to increase in milk the content of polyunsaturated fatty acids, thus improving its nutritional value. Polyunsaturated fatty acids are associated with a reduced risk of cardiovascular diseases [2]. Many researches have focused on the antioxidant and anticarcinogenic characteristics of conjugated linoleic acid (CLA), coming from ruminal biohydrogenation of linoleic acid and of linolenic acid. It has been shown that the presence of these acids in drinking milk can decrease oxidative stress and atherosclerosis and can improve the profile of blood lipid, while reducing the risk of developing skin and mammary gland tumors in humans [3].

There is evidence that certain forage species, especially leguminous, can significantly influence the composition of bioactive fatty acids and lipids in the milk of ruminants. Thus, the additional health benefits of lipids from goat's milk can be attributed to the specific feeding behavior of goats, namely a selective one, but also to the interaction between the components of the ratio and the specific digestion of goats [4, 5]. A study conducted in France showed that rations in which grazing has a high share, compared to hay-based rations, were associated with increased levels of xanthophyll, retinol and α-tocopherol in Rocamadour cheese and a high percentage of concentrates in the ratio resulted in a lower content of xanthophyll and of α-tocopherol [6].

The aim of our experiments was to test the effect of nutrition on the quantity and quality of milk in multiparous goats, grown in the same conditions (semi-intensive system), of different breeds: local Carpathian, crossbreed goats R1 Saanen × Carpathian and crossbreed goats R1 French Alpine × Carpathian, from a farm in Constanţa county, Romania.

2. Experimental

2.1. Animal feeding

Starting with April, the animals grazed and received as food supplement alfalfa hay and corn and barley middling. They had free access on a permanent pasture with the following floristic structure: 30% legumes and 70% grasses.

2.2. The method of collecting milk samples

Milk samples were collected individually from all the animals included in the experiment, monthly, twice a day for a period of 5 months. For this purpose, the milk that was milked in the morning and in the evening were weighed individually. Individual milk samples were also taken for performing the qualitative analysis.

2.3. Materials and reagents

Methanol (99.9%), chloroform (99.9%), hexane, sulfuric acid (99.9%), sodium hydroxide, petroleum

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ether for analysis were purchased from Fisher Scientific UK. The forage (alfalfa hay, barley, maize) was purchased from the local market.

2.4. Methods

Fats, proteins and lactose from milk were analyzed by electrochemical method in a standardized Funke Gerber Lactostar analyzer for goat's milk.

In parallel, the profile of milk fatty acids (FA) was determined in the form of methyl esters of fatty acids (FAME) by gas chromatographic method by using a Perkin Elmer-Clarus 500 Chromatograph with capillary column and high polarity stationary phase (0.25 mm inner diameter and 0.25 μm thick film). Analyzes were carried out The National Research - Development Institute for Animal Biology and Nutrition (INCDBNA-IBNA Balotești) [7, 8].

3. Results and discussion

The results on the quantity and quality of milk at Carpathian breed females are presented in Table 1.

Table 1. Milk quantity (g) and composition (%) variation in Carpathian breed females (mean ± standard deviation)

Lactation period	Quantity (g)	Fat (%)	Protein (%)	Lactose (%)
Month 1	1439.65± 38.00	3.71± 0.0224	3.17± 0.0102	4.59± 0.0178
Month 2	1636.85± 53.44	3.61± 0.0221	3.11± 0.0091	4.58± 0.0171
Month 3	1607.50± 30.84	3.63± 0.0216	3.15± 0.0085	4.62± 0.0162
Month 4	1566.45± 48.52	3.66± 0.0220	3.14± 0.0086	4.60± 0.0156
Month 5	1543.60± 48.32	3.67±0. 0229	3.16± 0.0094	4.59± 0.0172

According to Table 1, the corn middlings and barley middlings supplements increase the amount of energy ingested. There is a significant increase in the amount of milk milked in the second month of lactation compared to the first month of lactation, from the daily value of 1.4 kg milk to 1.6 kg milk, an increase associated with the decrease of fat and protein percentages. The fat content of milk increases rapidly after parturition, then has showed a decrease for most of the lactation.

This phenomenon is due to an increase of milk volume until the peak of lactation and a reducing of a lipid mobilization that leads to a decrease of non-esterified fatty acids in the plasma level, involved in lipid synthesis in the mammary gland [9]. From the third month of lactation, the daily average amount of milk undergoes only slight variations. In addition, the percentage of protein and fat remains constant during the period June-August.

Lactose, the principal carbohydrate in milk is synthesis from glucose in the mammary gland. It promotes absorption of calcium, phosphorus, and magnesium at intestinal level and the use of vitamin D, also. It maintains the osmotic balance blood flow - alveolar cells in the mammary gland. Smaller quantities of lactose are found in colostrum at the beginning and at the end of lactation [10], as in our studies, in all females groups. For French Alpine × Carpathian crossbreed females (Table 2) and the Saanen × Carpathian crossbreeds (Table 3) there is an increase of milk quantity starting with the second month of lactation, when the largest amount of milk is made.

Table 2. Milk quantity (g) and composition (%) variation in French Alpine × Carpathian crossbreed females (mean ± standard deviation)

Lactation period	Quantity (g)	Fat (%)	Protein (%)	Lactose (%)
Month 1	2341.30± 36.70	3.43± 0.0224	2.92± 0.0078	4.61± 0.0096
Month 2	2571.80± 70.00	2.78± 0.0217	3.12± 0.0057	4.59± 0.0098
Month 3	2514.95± 58.04	3.93± 0.0220	3.69± 0.0065	4.62± 0.0097
Month 4	2467.85± 60.87	4.58± 0.0225	3.71± 0.0063	4.63± 0.0097
Month 5	2405.85± 39.34	4.40± 0.0222	3.72± 0.0082	4.61± 0.0091

Table 3. Milk quantity (g) and composition (%) variation in Saanen × Carpathian crossbreed females (mean ± standard deviation)

Lactation period	Quantity (g)	Fat (%)	Protein (%)	Lactose (%)
Month 1	2400.75± 75.40	4.00± 0.0283	3.81± 0.0086	4.62± 0.0116
Month 2	2603.45± 84.46	3.17± 0.0268	3.08± 0.0082	4.65± 0.0108
Month 3	2543.65± 40.65	3.81± 0.0273	3.21± 0.0073	4.64± 0.0104
Month 4	2487.25± 63.72	3.82± 0.0272	3.61± 0.0064	4.65± 0.0114
Month 5	2417.15± 56.65	3.83± 0.0275	3.64± 0.0087	4.63± 0.0123

The percentage of milk fat is significantly higher in both categories of crossbreeds compared to the Carpathian breed, although during the lactation months it suffers the same variation: a decrease in the second month, due to quantitative increase, followed by an increase during the summer months.

Generally, milk from animals farmed on pastures with optimum nutritional quality have a high fat content, due to high-fiber feed [9]. Moreover, studies have shown that goats' milk is rich in micro components (fatty acids and vitamins), volatile compounds, phenolic compounds, favorable to human nutrition and health. The grazing positively influences the fat in milk, an aspect highlighted by other researchers as well. Soryal *et al.* [11] recorded a higher percentage of milk fat at grazed Alpine breed, compared to those maintained in the shelter and fed with alfalfa hay. Some dietary fatty acids are involved as factors influencing human health [12, 13]. Dietary sources from ruminants (milk, cheese and meat) contain more conjugated linoleic acid (CLA) than foods obtained of non-ruminant origin. Ruminant dairy products are the major dietary source of CLA, principally represented by the cis-9, trans-11 isomer (rumenic acid), but also by the trans-10, cis-12 isomer [14]. The profile of fatty acids and the content of conjugated linoleic acids are different depending on the calendar month, similar results being obtained in other experiments of this kind, performed on animals in which grazing is the main feeding system [15]. Tsiplakou *et al.* showed that CLA content of grazing goat milk fat increased significantly in April – May (early growth

stage of grass) and then declined, while that of indoors husbandry was constant during the same period [16].

Table 4. The profile of fatty acid and conjugated linoleic acid (CLA) content in milk, at Carpathine breed females (mean ± standard deviation)

Characteristics (g/100 g fatty acids)	April	May	June	July	August
Saturated fatty acids	70.36± 1.4141	71.23± 0.7071	68.43± 2.1211	67.33± 2.5351	67.46± 3.8284
Monounsaturated fatty acids	23.36± 1.2613	22.32± 1.0113	24.16± 0.9447	25.00± 1.2023	25.88± 1.1533
Polyunsaturated fatty acids	4.51± 1.0233	4.77± 0.5687	6.03± 0.2523	6.16± 0.6523	5.06± 0.7264
Ω6/Ω3 Ratio	9.51± 0.3413	5.91± 0.6674	2.84± 0.2214	3.09± 0.1115	3.91± 0.6743
CLA	0.40± 0.0284	0.38± 0.02632	0.85± 0.0365	0.77± 0.0321	0.54± 0.0544

Table 5. Fatty acid profile and conjugated linoleic acid (CLA) content in milk, at French Alpine × Carpathian crossbreed females (mean ± standard deviation)

Characteristics (g/100 g fatty acids)	April	May	June	July	August
Saturated fatty acids	73.35± 1.1141	71.93± 1.2893	66.94± 1.6745	66.43± 2.1098	67.49± 2.1441
Monounsaturated fatty acids	20.48± 2.0935	21.96± 1.8734	25.26± 1.8562	25.35± 2.1342	25.87± 2.3851
Polyunsaturated fatty acids	4.87± 1.0811	4.46± 0.8841	5.95± 0.9082	6.56± 0.7212	5.09± 1.0324
Ω6/Ω3 Ratio	8.04± 0.3342	5.40± 0.2212	5.20± 0.4301	3.67± 0.3763	3.90± 0.4917
CLA	0.63± 0.0183	0.38± 0.0201	0.71± 0.0139	0.87± 0.0187	0.53± 0.0122

Table 6. Fatty acid profile and conjugated linoleic acid (CLA) content) in milk, at Saanen × Carpathian crossbreed females during the experiment (mean ± standard deviation)

Characteristics (g/100 g fatty acids)	April	May	June	July	August
Saturated fatty acids	71.60± 2.0149	70.65± 1.8743	61.46± 1.9823	66.81± 1.7843	67.77± 2.0199
Monounsaturated fatty acids	22.02± 1.0621	23.87± 1.2021	30.42± 0.8780	25.09± 1.1793	25.83± 1.1141
Polyunsaturated fatty acids	5.13± 1.1011	3.92± 0.6811	6.56± 0.3524	6.44± 0.298	4.94± 1.0112
Ω6/Ω3 Ratio	8.32± 0.3524	6.16± 0.2132	5.46± 0.2019	3.62± 0.5273	4.16± 0.4253
CLA	0.63± 0.0213	0.35± 0.0119	0.71± 0.0098	0.80± 0.0283	0.52± 0.0413

The monounsaturated, polyunsaturated fatty acids and conjugated linoleic acids levels in milk increased in summer months compared to the levels registered in spring months, and the saturated fatty acids level decreased during the summer months. Results that are considered similar were obtained in other experiments performed on grazing animals [17].

A diet rich in omega 6 acids results in an increased ratio of omega-6/omega-3. This increased ratio is associated with chronic low-grade inflammation, which favors Alzheimer's, heart disease, cancer, obesity [18]. By reducing this ratio, the inflammatory reaction of the body decreases and the risk of chronic diseases is reduced. The recommended optimum ratio is less than 5, but in animal products this ratio is different, between 10 and 15 [19, 20]. Our data indicate that Carpathian females, whose food comes mostly from grazing, produce milk with a ratio below 4 during the summer. Results that are considered similar have been obtained on primiparous goats grown under similar conditions [21].

4. Conclusions

Our results confirm that by modulating the ration we can improve animal productivity, within the limits of genetic potential. Also, the biochemical analyzes carried out to assess the quality of the milk are in line with those of numerous other studies, which have shown that the milk from goats fed on pasture is richer in fat-soluble vitamins, in unsaturated fatty acids and in conjugated linoleic acid, besides the high content of fatty acids with medium chain. Moreover, goats farmed on pastures have a medium chain fatty acid profile that is improved, compared to those fed conventionally with concentrated feed.

Conflict of interest

No conflict of interest declared.

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