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CHANGES IN FATTY ACID COMPOSITION AND CHOLESTEROL CONTENT OF GOAT COLOSTRUM

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Abstract: The purpose of this paper is to detect any changes in fatty acid and cholesterol content of goat colostrum in the period of 0-72 hours after kidding. For that purpose, samples of colostrum from 16 goats, belonging to local populations in north-eastern Romania where collected. Samples were preserved by freezing and then subjected to chemical analysis. Preparation of solutions for fatty acids analysis was based on the principle of methylation, by combining alkaline methylation (NaOCH3/MeOH) with acid (BF3/MeOH). For cholesterol we used the principle of fat saponification, using potassium hydroxide, followed by filtration and separation of cholesterol with hexane. Detection of cholesterol and fatty acids content was performed by gas chromatography device. Caprinic acid (C10:0), myristic acid (C14:0), palmitic acid (C16: 0), stearic acid (C18:0) and oleic acid (C18:1) quantified more than 75% of the total fatty acids determined 72 hours after birth. Among short-medium-chain fatty acids, capronic acid (C6:0) was found in highest proportion (average concentration of 5.7% of total fatty acids), but at the same time, presented the most obvious oscillation range from 0 to 72 hours (6.56% at birth, 2.45% and 7.59% from 12 hours to 72 hours), with the differences between mean values being significant ($p<0.05$). In the case of polyunsaturated fatty acids, the ratio between omega 3 and omega 6 was 1/4.64 at kidding and 1/4.23 at 72 hours after birth, the differences being insignificant. In goat colostrum, the mean concentration of cholesterol was 9.43 mg per 100 g.

Key words: goat colostrum, fatty acids, cholesterol.

Introduction

Fatty acids are organic substances with weak acidic character which is part of most lipids. Humans, like all other creatures, synthesize their own lipids mostly from the fat in food, but also from other nutrients such as carbohydrates and

proteins. However, by metabolic means that man has, the body cannot create double bonds beyond carbon 9. Therefore, polyunsaturated fatty acids cannot be assured only through food. On this point, these fatty acids are also called essential fatty acids. Of all internal and external factors affecting milk fatty acid composition, the most important is food (by adding additional fat in feed), as shown in recent studies done on cows *(Jensen, 2002)*, on goat *(Chilliard et al., 2003)* or sheep *(Bocquier and Caja, 2001)*. Changes the fatty acid profile of sheep and goat milk do not differ too much from the experimental model for cows. If we talk about how ruminants respond to changing profile of these fatty acids in food and later in milk, the goats are those that respond best *(Chilliard and Feraly, 2004)*. On the other hand, sterols are a small fraction of the total milk lipids, with cholesterol being the main sterol (95%), quantifying about 300 mg/100g of fat, or 10 mg/100 ml of cow's milk *(Talpur et al, 2009; Park et al., 2007)*. Sterol fraction of milk is of particular importance for human nutrition because its high level in blood plasma is associated with increased cardiovascular disease risk.

Materials and Methods

Analyzed material was the colostrum and milk collected from 16 goats belonging to native populations in north-eastern Romania. From each goat a total of six samples of colostrum, from kiding up to 72 hours (0, 6, 12, 24, 48 and 72) and milk. Samples were preserved by freezing and stored in appropriate conditions until the time of analysis (two weeks).

Determination of fatty acids was performed by combining alkaline methylation (NaOCH3/MeOH) with acid methylation (BF3/MeOH) *(Molto-Puigmartí et al., 2010)*. After centrifugation, the upper phase of the sample was extracted, placed in an Eppendorf-type tube containing anhydrous sodium sulfate, then was taken, and was injected into a gas chromatograph 1 µl of solution. Standard for fatty acid methyl ester: "Supelco 37 component FAME Mix" was purchased from Sigma-Aldrich. Gas chromatographic condition: Instrument: Varian CP 3380 gas chromatograph, column: 100 x 0.25 mm CP-Sil 88 (FAME) phase; Detector: FID 270°C; Injector: separator at 270°C; Carrier gas: H2, 235 kPa, temperature program: 140°C for 10 min at 10°C/min to 235°C, isothermal for 26 minutes.

Cholesterol determination was performed using gas chromatography apparatus described above, and solution preparation for analysis was based on the principle of fat saponification with potassium hydroxide, followed by filtration and separation of cholesterol with hexane. Organic phase was diluted in 10 ml hexane, and from this solution 5 ml was taken, then injected into the gas chromatograph. Temperature, in this case was 210°C, working time was 35 minutes per sample.

To test the statistical significance of differences between values studied, and correlations between the main characters of milk production, we used ANOVA Single Factor algorithm, included in the software package Ms Excel.

Results and Discussion

1. Fatty acids. Of the total fatty acids determined in the goat colostrum, caprinic acid (C10:0), myristic acid (C14:0), palmitic acid (C16:0), stearic acid (C18:0) and oleic acid (C18:1) quantified more than 75% (79% at 72 hours after birth). Among these, saturated fatty acids such as myristic acid (C14:0), palmitic acid (C16:0) and stearic acid (C18:0) have the highest proportion (9.7%, 28.1% and 10.9%, respectively), with minor oscillations on the interval 0 - 72 hours. In the goat colostrum, some fatty acids with high metabolic value, such as capronic acid (C6:0), caprylic (C8:0), caprynic (C10:0) and lauric (C12:0) have been identified in high concentration. According to some authors *(Alonso et al., 1999; Goudjil et al., 2004)*, above mentioned fatty acids are found in significantly higher concentrations in sheep and goat milk compared to cow milk. These fatty acids print specific taste and flavor of goat milk and are used to identify possible blends with milk from other species. Data on saturated fatty acids and dynamics on the changes of their content in goat colostrum depending on the time elapsed since their birth, are presented in Table 1.

Table 1. Saturated fatty acids content in goat colostrum sampled at different time intervals after birth (g/100g)

Fatty acids	Sampling time (hours)					
	0	6	12	24	48	72
C6:0	6,56^{ab}	6,490^{ab}	2,450^{a}	3,540^{ab}	7,577^{b}	7,590^{b}
C8:0	0,22^{a}	0,257^{a}	0,307^{a}	0,766^{ad}	0,487^{bd}	0,560^{d}
C10:0	2,67^{a}	2,263^{a}	3,090^{a}	5,893^{a}	4,010^{a}	4,203^{a}
C11:0	0,05^{a}	0,213^{a}	0,063^{a}	0,133^{a}	0,083^{a}	0,080^{a}
C12:0	2,18^{a}	1,787^{a}	2,217^{a}	2,837^{a}	2,533^{a}	2,707^{a}
C13:0	0,06^{a}	0,067^{a}	0,053^{a}	0,077^{a}	0,073^{a}	0,077^{a}
C14:0	11,55^{a}	10,677^{a}	11,693^{a}	9,157^{a}	7,977^{a}	7,200^{a}
C15:0	0,83^{a}	0,900^{a}	0,950^{a}	0,840^{a}	0,950^{a}	0,853^{a}
C16:0	26,59^{a}	29,257^{a}	32,363^{a}	26,607^{a}	28,103^{a}	25,670^{a}
C17:0	1,42^{a}	1,463^{a}	1,390^{a}	1,330^{a}	1,193^{a}	1,343^{a}
C18:0	10,52^{a}	10,653^{a}	9,457^{a}	10,690^{a}	11,327^{a}	12,867^{a}
C20:0	0,30^{a}	0,327^{a}	0,273^{a}	0,207^{a}	0,233^{a}	0,257^{a}
C21:0	0,06^{a}	0,163^{a}	0,047^{a}	0,027^{a}	0,030^{a}	0,037^{a}
C22:0	0,08^{a}	0,106^{a}	0,100^{a}	0,009^{a}	0,077^{a}	0,087^{a}
C23:0	0,180^{a}	0,147^{a}	0,150^{a}	0,103^{a}	0,133^{a}	0,103^{a}
C24:0	0,06^{a}	0,070^{a}	0,057^{a}	0,043^{a}	0,037^{a}	0,037^{a}
Total	63,33^{a}	64,84^{a}	64,66^{a}	62,259^{a}	64,823^{a}	63,671^{a}

Values in the same row marked with different superscript differ significantly (ab: p<0.05; ad: p<0.001)

Among short-medium-chain fatty acids, capronic acid (C6:0) was found in highest proportion (average concentration of 5.70% of total fatty acids), but at the same time, presented the most obvious oscillation from birth to 72 hours (6.56% at birth, 2.45% and 7.59% at 12 hours to 72 hours), with the differences between mean values being significant (*p<0.05*).

Regarding caprylic acid (C8:0), from the statistically point of view, the differences between the concentration in the first 12 hours after birth and 48 - 72 hours after birth, where significant at p<0.05 and p<0.001, respectively. Also, it appears that in the colostral milk analyzed, all saturated fatty acids where found in the average concentration over 63% in the period 0-72 hours after birth, but the differences between the average values of the samples were not significant.

Analyses made on colostrums of native goats from north-eastern Romania, collected at different time intervals after birth, showed an average concentration of monounsaturated fatty acids of about 30% (Table 2).

Table 2. Monounsaturated fatty acids content in goat colostrum sampled at different times after birth (g/100g)

Fatty acids	Sampling time (hours)					
	0	6	12	24	48	72
C14:1	0,10[a]	0,123[a]	0,053[a]	0,050[a]	0,073[a]	0,233[a]
C15:1	0,24[a]	0,100[a]	0,223[a]	0,170[a]	0,090[a]	0,079[a]
C16:1	0,36[a]	0,247[a]	0,317[a]	0,293[a]	0,333[a]	0,333[a]
C17:1	0,67[a]	0,593[a]	0,790[a]	0,780[a]	0,633[a]	0,667[a]
C18:1ωc	29,21[a]	28,127[a]	27,587[a]	30,577[a]	27,847[a]	29,053[a]
C20:1	0,44[a]	0,883[a]	0,490[a]	0,447[a]	0,450[a]	0,423[a]
C22:1ω9	0,10[a]	0,087[a]	0,037[a]	0,223[a]	0,123[a]	0,093[a]
C24:1	0,15[a]	0,173[a]	0,160[a]	0,113[a]	0,083[a]	0,107[a]
Total	31,27[a]	30,333[a]	29,657[a]	32,653[a]	29,632[a]	30,988[a]

aa – differences are not significant

Oleic acid (C18:1ωc) was found in concentrations exceeding 28%, representing 93.42% of the total monounsaturated fatty acids. Monounsaturated fatty acid content of colostrum, except oleic acid, has an average similar to the results obtained by *Park et al. (2007)*.

Among polyunsaturated fatty acids, linoleic acid (C18:2ω6c) was found in highest concentration (mean 2.93%), representing over 54% of this group of fatty acids. The concentration of over 1% of gamma linolenic acid was also found (C18:3ω6), followed by eicosapentaeonic acid (C20:5ω3) with an average concentration of 0.75%.

CLA concentration determined in goat colostrum analyzed was on average 0.01%, being lower compared to the data presented by *Alonso et al. (1999)*. As shown by other authors *(Jahries et al. 1999)*, this could be explained by the fact that conjugated linoleic acid content of milk varies according to season, being lower in the winter (when colostrum was collected), compared with the summer season (1.28% in summer, and 0.58% in winter, in the sheep's milk).

Polyunsaturated fatty acids comprised on average 5.36% of total fatty acids in the goat colostrums examined (Table 3).

Table 3. Polyunsaturated fatty acids content of goat colostrum sampled at different hours after birth (g/100g)

Fatty acids	Sampling time (hours)					
	0	6	12	24	48	72
C18:2ω6t	0,04[a]	0,043[a]	0,033[a]	0,053[a]	0,040[a]	0,036[a]
C18:2ω6c	2,79[a]	2,643[a]	3,263[a]	2,863[a]	3,067[a]	2,930[a]
C18:3ω6	1,14[a]	1,080[a]	1,003[a]	1,320[a]	1,020[a]	1,053[a]
C18:3ω3	0,05[a]	0,123[a]	0,057[a]	0,040[a]	0,026[a]	0,053[a]
C20:2	0,03[a]	0,043[a]	0,193[a]	0,023[a]	0,023[a]	0,030[a]
C20:3ω6	0,19[a]	0,480[a]	0,237[a]	0,113[a]	0,176[a]	0,183[a]
C20:3ω3	0,08[a]	0,017[a]	0,147[a]	0,023[a]	0,033[a]	0,017[a]
C20:4ω6	0,06[a]	0,063[a]	0,090[a]	0,023[a]	0,027[a]	0,030[a]
C22:2	0,09[a]	0,083[a]	0,103[a]	0,070[a]	0,067[a]	0,070[a]
C20:5ω3	0,78[a]	0,548[a]	0,767[a]	0,437[a]	1,063[a]	0,930[a]
CLA	0,02[a]	0,007[a]	0,013[a]	0,010[a]	0,009[a]	0,007[a]
Total	5,27[a]	5,13[a]	5,906[a]	4,975[a]	5,551[a]	5,339[a]

aa – differences are not significant
CLA - conjugated linoleic acid

Fatty acids with the highest concentration detected in goat colostrum were saturated fatty acids (62%), followed by monounsaturated fatty acids with a concentration above 30%, and polyunsaturated fatty acids, found in a proportion of 5.36%. Also, in the three groups of fatty acids throughout the period studied, there were no significant changes.

2. Cholesterol. Values of the concentration of cholesterol in goat milk varies considerably by race, or analytical techniques used. Cholesterol concentration in goat milk and colostrum of north-eastern Romania is presented in Table 4.

Table 4. Dynamics of changes of fat content and cholesterol content in colostrum and milk

Specification	Unit	Sampling time (hours after kiding)						
		0	6	12	24	48	72	7 days
Fat	%	4,20	8,08	5,14	6,02	4,80	3,50	2,30
Cholesterol	mg/100g	2,50^{a}	19,88^{d}	21,13^{d}	7,86^{d}	9,24^{d}	10,87^{d}	9,43^{d}
Cholesterol in fat	mg/100g	59,4	245,8	411,5	130,6	192,7	310,4	411,0
Cholesterol in fat	%	0,06^{a}	0,25^{c}	0,41^{bc}	0,13^{ab}	0,19^{b}	0,31^{bc}	0,41^{c}

Values in the same row marked with different superscript differ significantly (ab: $p<0.05$; ac: $p<0.01$; ad: $p<0.001$)

Following changes in the fat content of colostrum and milk from goats studied, it appears that it varied in very wide limits, depending on the time that has elapsed after the birth. Thus, at birth, the colostrum fat was 4.2%, then increased to 8.08% after 6 hours, decreased after 12 hours (5.14%) and increased again 24 hours (6,02%), followed by a continuous decrease until the average value of 2.3% recorded in 7th day.

Cholesterol levels in colostrum had a similar change as the fat content, except that the maximum concentration was recorded 12 hours after birth (21.13 mg/100 g colostrum). In goat milk studied, cholesterol concentration was on average 9.43 mg/100 g milk.

It should be noted that high significant differences were observed only between the mean value of samples collected at birth and the remaining samples. Cholesterol concentration in fat varied significantly, the lowest being at birth (0.06%) and highest (0.41%) was recorded in samples collected 12 hours and 7 days after kidding. These variations are considerable, but comparable with those reported by other authors *(Fraga et al., 2000; Goudjil et al., 2003)* for goat and cow milk.

Conclusion

In the goat colostrum, of short and medium-chain fatty acids, capronic acid is found in highest proportion, but at the same time, has the highest oscillation in the range 0-72 hours after kidding.

Both the dominant saturated fatty acids, and monounsaturated and polyunsaturated fatty acids in goat colostrums, saw minor changes of concentration on interval 0 to 72 hours after kidding.

In goat colostrum analyzed, cholesterol concentrations averaged 9.43 mg/100 g colostrum, with significant changes from 0 to 7 days after birth.

Promene u sastavu masnih kiselina i sadržaju holesterola u kolostrumu koza

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Rezime

Cilj ovog rada je da prikaže bilo kakve promene u sadržaju masnih kiselina i holesterola u kolostrumu koza u periodu od 0-72 sata nakon jarenja. Iz tog razloga, kolostrum je prikupljan od 16 koza lokalne populacije iz severo-istočne Rumunije. Uzorci su čuvani tako što su zamrznuti, pa su onda slati na hemijsku analizu. Priprema rastvora za analizu masnih kiselina je urađena kombinovanjem alkalne metilacije (NaOCH3/MeOH) sa kiselom (BF3/MeOH). Za holesterol korišćen je princip saponifikacije, upotrebom kalijum hidroksida, što je praćeno filtracijom i separacijom holesterola heksanom. Kaprinska (C10:0), miristinska kiselina (C14:0), palmitinska kiselina (C16: 0), stearinska kiselina (C18:0) i oleinska kiselina (C18:1) činile su više od 75% ukupnih masnih kiselina koje su determinisane 72 h nakon porođaja. Među masnim kiselina kratkog lanca, kaprinska kiselina (C6:0) je imala najveće učešće (prosečna koncentracija od 5.7% ukupnih masnih kiselina), ali u isto vreme i sa najvećim oscilacijama u periodu od 0 do 72 h (6,56% na porođaju, 2,45% i 7,59% od 12 h do 72 h), sa razlikama između srednjih vrednosti koje su bile značajne na nivou $p<0.05$. U slučaju polinezasićenih masnih kiselina, odnos između omega 3 i omega 6 bio je 1/4,64 na porođaju i 1/4,23, 72 sata nakon porođaja, razlike nisu bile značajne. U kolostrumu koza srednja vrednost holesterola bila je 9,43 mg $100g^{-1}$.

References

ALONSO L., FONTECHA J., LOZADA L., FRAGA M.J., JUAREZ M., (1999): Fatty acids composition of caprine milk: major, branched chain and trans fatty acids. Journal of Dairy Science, 82, 878-884.

BOCQUIER F., CAJA G., (2001): Production et composition du lait de brebis: Effets del'alimentation. INRA Production Animal, 14, 129-140.

CHILLIARD Y., FERLAY A. (2004): Dietary lipids and forages interactions on caw and goat milk fatty acids composition and sensory properties. Advances in Food and Nutrition Research, 44, 467-492.

CHILLIARD Y., FERLAY A., ROUEL J., LAMBERET G. (2003): A review of nutritional and physiological factors affecting goat milk synthesis and lipolysis. Journal of Dairy Science, 86, 1751-1770.

GOUDJIL H., FONTECHA J., LUNA P., FUENTE M.A., ALONSO L., JUAREZ M. (2004): Quantitative characteriztion of unsaturated and trans fatty acids in ewe's milk fat. Lait, 84, 473-482.
GOUDJIL H., TORRADO S., FONTECHA J., FRAGA M.J., JUAREZ M. (2003): Composition of cholesterol and its precursors in ovine milk. Lait, 83, 1-8.
FRAGA M.J., FONTECHA J., LOZADA L., MARTINEZ-CASTRO I., JUAREZ M. (2000): Composition of the sterol fraction of caprine milk fat by gas cromatography and mass spectrometry. Journal of Dairy Research, 67, 437-441.
JAHRIES G., FRITSCHE J., KRAFT J. (1999): Species dependent, seasonal, and dietary variation of conjugated linoleic acid in milk. În: Yurawecz M.P., Mossoba M.M., Kramer J.K.G., Pariza M.W., Nelson G.J. (eds.), Advances in Conjugated Linoleic Acid. American Oil Chemists Society, Champaign, IL.
JENSEN R.G. (2002): The composition of bovine milk lipids: January 1995 to December 2000. Journal of Dairy Science, 85, 295-350.
MOLTÓ-PUIGMARTÍ C., PERMANYER M., CASTELLOTE A.I., LÓPEZ-SABATER M.C. (2010): Effects of pasteurization and high-pressure processing on vitamin C, tocopherols and fatty acids in mature human milk. Food Chemistry, DOI: 10.1016/j. foodchem. 2010.05.079.
PARK Y.W., JUAREZ M., RAMOS M., HAENLEIN G.F.W. (2007): Physico-chemocal characteristics of goat and sheep milk. Small Ruminant Research, 68, 88-13.
TALPUR F.N., BHANGER M.I., MEMON N.N. (2009): Milk fatty acid composition of indigenous goat and ewe breeds from Sindh, Pakistan. Journal of Food Composition and Analysis, 22, 59-64.

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