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Physical-chemical composition of in natura goat milk from cross Saanen throughout lactation period

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SUMMARY. The analyzed milk samples were collected from cross Saanen goats of different ages and different cross breeding types, throughout the lactation period, from September 1996 to December 1997. For the physical-chemical characteristics measured in this experiment, the following average values were obtained, followed by their respective standard deviations: pH (6.69±0.20); acidity (12.96±3.64°D); density (1.030±0.009mg.cm^{-3}); fat (3.83±1.04%); crude protein (3.34±0.73%) and total solids (12.25±1.94g.100g^{-1}). The lactation period influenced the values of acidity, fat, crude protein and total solids; these values decreased during the initial months and increased at the end of the lactation. The correlations were analyzed among the studied characteristics during the lactation, resulting in positive ($p<0.05$) acidity/density correlation ($r=0.2115$), stand out also the positive correlations ($p<0.01$) among fat/total solids ($r=0.7715$) and crude protein/total solids ($r=0.6228$).
Key words: Goat milk, physical-chemical composition, cross Saanen.

RESUMEN. Composición físico-química de leche in natura de cabra cruzada Saanen durante el período de lactación. Las muestras de leche analizadas fueron colectadas de cabras cruzada Saanen de diferentes edades y diferentes grados de cruzamientos sanguíneos, durante el período de lactación, desde Septiembre de 1996 a Diciembre de 1997. Para las medidas de las características físico-químicas en esta experiencia, fueron obtenidas las siguientes medias, seguidas de sus respectivos desvios patrones: pH (6,69±0,20); acidez (12,96±3,64°D); densidad (1,030±0,009mg.cm^{-3}); grasas (3,83±1,04%); proteína bruta (3,34±0,73%) y solidos totales (12,25±1,94g.100g^{-1}). El período de lactación influyó en los valores de acidez, grasas, proteína bruta y sólidos totales; estos valores disminuyeron durante los meses iniciales y aumentaron hasta el final de la lactación. Las correlaciones fueron analizadas entre las características estudiadas durante la lactación, resultando una correlación positiva ($p<0,05$) entre acidez/densidad ($r=0,2115$), obteniendo también una correlación positiva ($p<0,01$) entre grasas/sólidos totales ($r=0,7715$) y proteína bruta/sólidos totales ($r=0,6228$).
Palabras clave: Leche de cabra; composición físico-química; cruzada Saanen.

INTRODUCTION

Milk is a natural system made up of a complex mixture of lipids, proteins, carbohydrates, vitamins and minerals (1,2), which composition varies according to the race, age, food, environmental conditions, stage of lactation, etc. (3). During a long time, it is the only food source for the newborn mammals (2). The goat milk, in particular, is recommended for its high nutritional value and also because it is an important source to those individuals who are allergic to cow milk (4). Concerning nutritional values, goat, cow and human milk are, approximately, isocaloric; each provides about 750 kcal/L of energy, goat and cow milk lipids provide 50% of energy and human milk lipids 55% (5).

The composition of goat milk varies within the same race and among different races. Many values have been obtained for each one of the nutrients that make up the goat milk. These values do not necessarily reflect the composition of one individual sample, but the average composition for one specie (6). The Saanen goats are considered of high potential and widely used, they produce high quality milk with low fat levels (7,6).

The physical-chemical, medical, nutritional, biological, microbiological immunological aspects and heat treatment effect, comparing goat and sheep milk are reported by Jandal (8). Concerning physical-chemical aspects, the acidity test in the milk samples, is of great importance during the elaboration of many dairy products, for the process control. All the microbiological phenomenons that occur during the butter formation and the protein precipitation, like the pasteurization efficiency, depend on the nature and the acid degree (9). The milk components that contribute to its acidity are salts, milk proteins and dissolved CO_2 (10).

Milk fat is a source of certain essential fatty acids, being useful in the transportation of liposoluble vitamins (10). It is predominantly triacylglycerol (98%) with phospholipids and sterols accounting for less than 1% and 0.5% respectively, of the total lipid (3,11).

The minerals are part of the buffer solution and contribute to the pH, ionic strenght and osmotic pressure maintenance in liquids and body tissues.

The purpose of this paper is to report some characteristics of goat milk composition, justified upon the analysis of samples collected from different animals of different cross breeding types, throughout the lactation period (average 7.5 months).

MATERIAL AND METHODS

The milk samples were obtained from twenty two Saanen goats, randomly selected, representative of Maringá State University's flock of goats (60 animals) and kept at the Iguatemi Experimental Farm in a semi-confinement system. To simulate the characteristic of milk commercialized in the region, animals of different ages (1 to 4 years old) and different cross breeding types (1/2 to 31/32 Saanen x native Brazilian goats), with production between 0.6 and 2.2 average daily liters were selected. The animals had access to African star grass pasture (*Cynodon nilenfuensis*) during the day and received corn silage and concentrate during the nocturnal period. The concentrate consisted of 83% of corn cracked and 17% of soybean meal and it was fed in differents amounts according to the milk production (1 kg concentrate for each 3.5 liters of milk produced). The milking was manual and daily made during dawn.

The analysis of the *in natura* milk followed the AOAC (12) standards and were made immediately after the milking, once a week during the first nine weeks of lactation and, after the tenth week, every fifteen days. The pH levels, acidity, density, fat, crude protein (CP) and total solids (TS) were determined, in triplicates, in the samples collected from September 1996 to December 1997. The colostrum was disposed.

The pH levels were obtained with a combined glass electrode, previously calibrated at 20°C, under a constant agitation for three minutes. The acidity was determined by titration with Dornic solution. The density, measured by the Quévenne thermolactometer, had all its values corrected at a temperature of 15°C. The milk fat amount was determined by the Gerber butyrometer, at 65°C. The TS content was determined by dropping milk in a previously treated sand, and then the sample was heated in an oven at 105°C until constant weight. For the CP, the values were found by the application of the Kjeldahl method. Digestion and distillation were carried out in Büchi Digestion Unit 435 and Büchi Distillation Unit B-323 equipments (Switzerland).

The behaviour of variables measured in the milk, throughout lactation, was studied by averages of the Polynomial Regression analysis (13). The linear correlation coefficients between the variables measured were studied. In the statistic analysis of the results, the Statistica software (release 4.3, 1993) for Windows of the StatSoft (USA) was used.

RESULTS AND DISCUSSION

Averages for each physical-chemical characteristic of the goat milk, followed by their respective standard deviations and maximum and minimum values, are found in Table 1. González-Crespo et al. (14) found for the Verata goats averages of pH around 6.68±0.073, acidity Dornic 15.63±0.818, TS 13.61±1.378%, fat 4.47±1.097% and CP 3.58±0.325%. Le Mens (15), measuring the pH of the alpine race Chamoisée and Saanen goat milk, throughout the lactation period, shows variations between 6.5 and 6.8; also affirms that the acidity, associated with the goat milk richness in casein, in the end of the lactation is of 16 to 18°D and that the density oscillates between 1.026 and 1.042 $mg.cm^{-3}$. Hadjipanayiotou (16) took samples from Damascus goat and found 4.26±0.43%; 4.09±0.18%; and 13.21±0.50$g.100g^{-1}$, for fat, CP and TS, respectively, a considerable variation in the milk fat during the lactation (1). Such variations are related to the temperature variations, genetic and individual factors, stage of lactation, quantity of milk produced and food type (17).

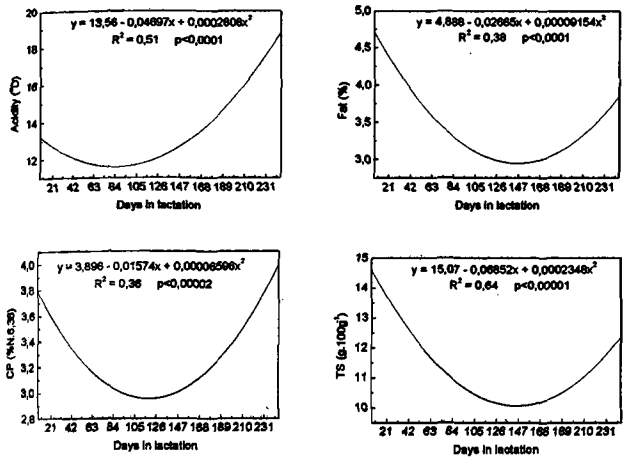
TABLE 1
Physical-chemical characteristics of goat milk

Characteristics	Minimum	Maximum	Average	Standard deviation
pH	6.26	7.85	6.69	0.20
Acidity (°D)	4.52	21.01	12.96	3.64
Density ($mg.cm^{-3}$)	1.013	1.045	1.030	0.009
Fat (%)	1.60	8.30	3.83	1.04
CP (%N x 6.38)	2.24	8.91	3.34	0.73
TS ($g.100g^{-1}$)	8.05	19.08	12.25	1.94

Averages of the samples in triplicates; CP = crude protein; TS = total solids.

The Figure 1 illustrates the behaviour of the acidity, fat, CP and TS of the samples analyzed throughout the lactation period. It is possible to notice that the acidity decreases until the 3rd month, when it maintains for a few weeks in a low index. Approximately from the 5th month on, it exceeds the initial lactation values. The TS portray a similar behaviour to the fat, which reduces until around the 5th month, reaching the minimum value. At the end of lactation some points are recovered in their index, but are still lower than the initial index of lactation. The CP reaches the lowest index in the lactation before the fat, around the 4th month. At the end of lactation their values are higher than the initial ones. According to Mahieu (18), because of mammalian gland's involutionn at the end of lactation, an alteration in the relative proportion among the different nitrogen compounds occurs, which is verified by a reduction of the synthesized proteins in the mamma and by an increase of the infiltrations of blood proteins.

FIGURE 1
Behaviour of the acidity, fat, crude protein (CP) and total solids (TS) of the cross Saanen goat milk, throughout the lactation period



The statistical analysis based upon the linear correlation coefficients (r) between studied characteristics (Table 2), shows a more accentuate positive correlation ($p<0.01$) for fat/TS ($r=0.7715$) and CP/TS ($r=0.6228$). Fat and CP constitute about 57.5% of the TS milk samples in question. It may also be observed that the acidity/density correlation ($r=0.2115$) is positive ($p<0.05$) and there are no significant ($p>0.05$) correlations between pH/CP and acidity/fat. It is possible that for the acidity/CP correlation ($r=0.3624$), the major influence comes from the casein attributed by Le Mens (15), to be the principal fraction of goat milk proteins and also the responsible, along with the mineral salts and the ions, for its natural acidity. If the physiological factors are considered for the positive ($p<0.01$) CP/fat correlation ($r=0.3178$), when animals with a higher grade of fat milk are selected, a higher protein content will then be obtained, probably. However, it has been demonstrated for cows, according to Walstra and Jenness (10), that the genetic factors that determines both variables are not the same. It means that the selection of a CP/fat proportion is possible. From the density/fat correlation ($r=0.3007$), significant in $p<0.01$, a negative value for r was expected, since the density value decreases when the fat concentration is increased (15). It may be affirmed that the so-called ìpoor milkî presents low density and from the industrial point of view, the higher the percentage of TS in the milk, associated positively to the calcium grade, the better the milk will be, resulting in a better technologic efficiency in the cheese (14); so, because of the dependence degree between density and TS, the positive density/TS correlation appears ($r=0.3750$).

TABLE 2
Linear correlation coefficients (r) between the physical-chemical characteristics of goat milk from cross Saanen throughout the lactation period

Characteristics	pH	Acidity (°D)	Density ($mg.cm^{-3}$)	Fat (%)	CP (%N.6.38)	TS ($g.100g^{-1}$)
pH	1.0	-0.6946**	-0.2445**	-0.3111**	-0.0033	-0.2970**
Acidity (°D)	-0.6946**	1.0	0.2115*	0.1560	0.3624**	0.2635**
Density ($mg.cm^{-3}$)	-0.2445**	0.2115*	1.0	0.3007**	0.2970**	0.3750**
Fat (%)	-0.3111**	0.1560	0.3007**	1.0	0.3178**	0.7715**
CP (%N 6.38)	-0.0033	0.3624**	0.2970**	0.3178**	1.0	0.6228**
TS ($g.100g^{-1}$)	-0.2970**	0.2635**	0.3750**	0.7715**	0.6228**	1.0

CP = crude protein; TS = total solids; *p<0.05; **p<0.01.

Goat milk from different cross breeding types (Saanen x native Brazilian goat) showed the same physical-chemical characteristics when compared to the Saanen breed from Europe, Africa and Australia (5).

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REFERENCES

1. Baer RJ. Alteration on the fatty acid content of milk fat. J Food Protect 1991;54:383-6.
2. Fennema OR. Food Chemistry. 3th ed. New York: Marcel Dekker, 1996.
3. Jensen RG, Ferris AM, Lammi-Keefe CJ. Symposium: Milk fat - composition, function and potential for change. J Dairy Sci 1991;74:3228-43.
4. Gupta N, Mathur MP. Purification and ribonuclease from goat milk. Indian J Dairy Sci 1991;44:529-31.

5. Jenness R. Composition and characteristics of goat milk: Review 1968-1979. J Dairy Sci 1980;63:1605-30.
6. Miller WM. Dairy Goat, in: John S, Glenn Jr. (Revisor) Almanac Cooperative Extension Service. University of California, Youth Dairy Goat Project, 1994.
7. Haenlein GFW, Caccese R, Delaware U. Goat milk versus cow milk, in: Ace DL (Revisor). Collection Goat Handbook. Washington DC: USA Publishers, 1992.
8. Jandal JM. Comparative aspects of goat and sheep milk. Small Rumin Res 1996;22:177-85.
9. Spreer E. Lactologia Industrial. 2nd ed. Zaragoza: Editorial Acribia, 1991.
10. Walstra P, Jenness R. Química y Física Lactológica. Zaragoza: Editorial Acribia, 1987.
11. Kennelly JJ. The fatty acid composition of milk fat as influenced by feeding oilseeds. Anim Feed Sci Technol 1996;60:137-52.
12. Helrich K (Ed). Official Methods of Analysis of the Association of Official Analytical Chemists. 15th ed. Arlington: Association of Official Analytical Chemists, 1990.
13. Montgomery DC. Design and Analysis of Experiments. 4th ed. New York: John Wiley & Sons, 1997.
14. González-Crespo J, Lozano M, Mas M, Serrano A. Producción y composición química de la leche de cabra verata, Alimentaria, junio 1995:53-58.
15. Le Mens P. Propriedades físico-químicas, nutricionales y químicas, in: Luquet (Coord.), Volume 1, Leche y productos lacteos. Vaca - oveja - cabra. La leche. De la mama a la lecheria. Zaragoza: Editorial Acribia, 1991.
16. Hadjipanayiotou M. Composition of ewe, goat and cow milk and of colostrum of ewes and goats. Small Rumin Res 1995;18:255-62.
17. Palmquist DL, Beaulieu AD, Barbano DM. ADSA Foundation Symposium: Milk fat synthesis and modification. J Dairy Sci 1993;76:1753-71.
18. Mahieu H. Factores que influyen en la composición de la leche, in: Luquet (Coord.), Volume 1, Leche y productos lácteos. Vaca - oveja - cabra. La leche. De la mama a la lecheria. Zaragoza: Editorial Acribia, 1991.

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