Vol.47, n. 6 : pp. 903-909, November 2004
ISSN 1516-8913 Printed in Brazil

BRAZILIAN ARCHIVES OF
BIOLOGY AND TECHNOLOGY
AN INTERNATIONAL JOURNAL

Physical-Chemical Characteristics and Fatty Acids Composition in Dairy Goat Milk in Response to Roughage Diet

Marcelo Shizuo Torii[1], Júlio César Damasceno[1*], Luciano da Rocha Ribeiro[1], Eduardo Shiguero Sakaguti[1], Geraldo Tadeu dos Santos[1], Makoto Matsushita[2] and Nelson Massaru Fukumoto[1]

[1] Animal Science Department, Universidade Estadual de Maringá, [2] Chemistry Department, Universidade Estadual de Maringá, Av. Colombo, 5790, 87020-900, Maringá – Paraná, Brazil.

ABSTRACT

The objective of the present work was to evaluate the physical-chemical characteristics (density, pH, acidity, fat, protein, lactose and total of solids contents) and milk fatty acids composition (C: 4 to C: 20) in response to roughage sources (alfalfa hay T1; oat hay T2 and maize silage T3). Nine Saanen lactating goats were used, in a triple Youden square design (3 animals x 2 periods). There was no treatment effects in the physical-chemical variables in the univariate analyses; by multivariate analyses three distinct patterns of fatty acids could be defined: milk with greater quantity of short chain fatty acids and acids C17:1ω7 e C18:2ω6 (T1); milk with equivalent amounts of short, medium and long chain fatty acids (T2); and milk with greater amounts of acids C16:1ω7, C17:0, C18:1ω9 and C20:0 (T3). These results indicated that the roughage sources used in the diet of lactating dairy goats affected the fatty acids composition, without altering the milk physical-chemical characteristics. The acids more sensitive to the treatment effects were: C10:0, C12:0, C14:0, C16:0, C16:1ω7, C18:0 and C18:3ω6.

Key words: Alfafa hay, maize silage, milk quality, milk composition, oat hay, Saanen

INTRODUCTION

The milk quality is greatly determined by its chemical composition: protein, lactose and fat contents. Recently, special attention has been given to the fatty acids in the milk fat being directly related to human health, and the organolieptic characteristic. The composition of milk fatty acids is dependant on several factors, such as lactation stage, breed, genetic variation, age, health and feed composition (Grummer, 1991; Jensen et al., 1991; Palmquist et al., 1993; Kaylegian, 1995; Murphy et al., 1995). Some experiments have been carried out to study the dietary influence in the production and composition of the milk fat (Spain & Polan., 1995). Utilizing favorable results, European countries are already exploring commercially the milk fat or portions of it; as components in the food industry in a clear attempt to reduce the effects of saturated fats in human health (Kaylegian, 1995; Spain et al., 1995). Sampeyalo et al. (1998) utilized different protein sources in concentrate plus alfalfa hay as roughage and reported the importance of the diet in the production and composition of milk.

[*]Author for correspondence

Studies comparing good and bad roughage used as dairy goat feed showed negative influence of bad quality silage over the body weight gain and milk production. The animals, which received low quality roughage, had greater values in the somatic cells count (SCC), showing greater impairment than those which received silage and hay of good quality (Hussain et al., 1996). The food consumed by the dairy goats can have an effect over the milk organoleptic qualities. Badly kept silage and other feeds may harm these qualities of the dairy goat milk. This is important as it may alter the quality and techniques of preparing the milk products, which makes many researchers seek information about quality variation of this product.

The objective of this work was to evaluate the effects of the diet composed by different roughage (alfalfa hay, oat hay and maize silage) in the physical-chemical characteristics and fatty acids composition in Saanen dairy goat milk.

MATERIALS AND METHODS

Animals and treatments

Nine lactating Saanen dairy goats were used with average live weight of 50kg. They were maintained in individual stalls containing troughs for water, food and mineral salts, and with an area of $3.75m^2$ per animal. The treatments consisted of three diets composed of different roughages: alfalfa hay, oat hay and maize silage, as indicated on Table 1.

Table 1 - Experimental Dietary Compositions (based on dry matter).

	Treatments (%)		
Ingredients	**Alfafa hay**	**Oat hay**	**Maize Silage**
Alfalfa Hay	48. 11	-	-
Oat hay	-	50.00	-
Maize silage	-		50.00
Soya bran	20.74	25.75	28.00
Ground corn grain	29.26	18.41	16.30
Urea	-	-	0.97
Soya Bean Oil	0.30	3.00	-
Calcitic Calcareous	0.14	1.65	2.83
Bi-calcic phosphate	1.44	1.20	1.90
Nutrients			
Digestible protein (%)	18.00	18.00	18.00
Digestible energy (Kcal)	3.100	3.100	3.100
Calcium (%)	1.150	1.150	1.150
Phosphor (%)	0.600	0.600	0.600

Feeding and Management

Hay was chopped and sieved (5mm mesh). The roughages were fed mixed with the ingredients of the respective concentrate. The animals were fed twice a day, 8:00 and 16:00 hrs, receiving a corresponding quantity of approximately 5% of the animals live weight (LW), based on the dry matter (DM).

The experiment comprised of three periods of 21 days each. The adaptation period was 14 days, followed by 7 days for collection on alternate days (with 4 collection days, 15^{th}, 17^{th}, 19^{th} and 21^{st} days). On the day following the last collection, 22^{nd} day, the animals received the new treatment, thus initiating the next period. The animals were milked twice a day, 8:00 and 14:00 hrs.

Milk Samples

Milk samples were collected during each milking from each animal on previously determined days, and afterwards part of the milk was stored at room temperature and another part in a freezer, for the purpose of physical-chemical analyses and fatty acids composition.

Milk physical-chemical analyses

For the analyses of the crude protein, fat, lactose and total solids the milk samples were stored at room temperature in a plastic recipient of approximately 40mL, containing preservatives, and afterwards were analysed. These analyses were carried out with a Bentley 2000 analyzer, where infrared radiation from the sample constituents were transformed into electrical impulses detected by a photomultiplier. After the milk samples were homogenized, the aliquots were assayed according to the norms stipulated by the Instituto Adolfo Lutz (1985).

Fatty acids composition

Milk samples were centrifuged at 3000 rpm for a duration of 10 minutes, afterwards the floaters were collected. This portion consisted of fat matter appropriate for obtaining ester methylic from fatty acids: the methylic esters from fatty acids were obtained by the lipids transesterification in heptane KHO/MeOH 2 mol/L, preconised ISSO 5509 (1978), and analyzed in a chromatographer in Shimadzu 14 gas with a silica cast capillary column (50m x 0.25mm and 0.20µm of Carbon-wax 20M) using a flame ionization detector. The temperatures in the injector and detector were 220 e 245ºC, respectively. The column was operated with initial temperature of 40ºC per 3 minutes, with a ratio of increase of 10ºC/minute up to 240ºC. The peaks were identified by comparing the Sigma pattern and respective areas obtained through the integrator-processor CG-300.

Statistical analyses

Initially, a triple latin square design (3x3) was predicted, but as there was loss of material already collected from one of the periods, the data were analysed as being a triple Youden square design (Cochran and Cox, 1957), with 3 animals x 2 periods.

The results were studied through univariate and multivariate analyses; the GLM procedures and the PRINCOMP were used, from the SAS computational program (SAS, 1985). The Tukey test was used to compare the treatments means.

RESULTS AND DISCUSSION

The values for the physical-chemical properties: acidity, density, fat, pH, protein, lactose and total solids are given in Table 2. For acidity (ºD), no differences between treatments were observed (P>0.05), thus the values being around 16.23ºD. These results agreed with the ones obtained by González-Crespo (1995) and Le Mens (1991), who studying the milk chemical composition from Saanen and Chamoisée, suggested that the associated acidity to the milk contents in casein was between 16 to 18ºD.

In relation to density, there were no effect to the roughage used and the values were near the ones found by Chornobai (1998), who analyzing the milk "in natura" from Saanen goats, obtained a value around 1.031 kg.m^{-3}. According to Le Mens (1991), the milk density oscillated between 1.026 to 1.042 kg.m^{-3}, according to the results obtained in individual milks, from herds or milk mixture, being related to the season of the year, the physiological state and breed.

For the fat content (%), the results were similar (P>0.05) between the treatments. These values were near to the ones obtained by Damasceno *et al.* (1997), which evaluated the response of dairy goats to different levels of concentrate, and inferior to the ones found by Carvalho Neto *et al.* (1993) and Chornobai (1998), who obtained values around 4.0 and 3.81%, respectively. Palmquist *et al.* (1993) reported that the variations in fat content were related to various factors, such as lactation stages, temperature, quantity of milk produced, breed and feed type.

The pH values were around 6.48, also not having any differences (P>0.05) among treatments. However, Chornobai (1998), analyzing the milk "in natura", found average values of 6.7. Le Mens (1991), when measuring the dairy goat milk pH from the Saanen and Chamoisée breeds, throughout the lactation period, found variations between 6.5 and 6.8.

As for the protein content (%), the values were similar for all the treatments. Bonassi *et al.* (1996), studying protein content of the Saanen and Parda dairy goat milk, found average values of 3.11 (g/100g), and Sung *et al.* (1999), studying the milk chemical composition of Alpine, Nubian, Toggenburg and Saanen breeds, found average values of protein around 3.25%.

The lactose content average was 4.17% and it did not present any differences (P>0,05) among the treatments, the values being close to the ones found by Damasceno *et al.* (1997), and inferior to the ones obtained by Sung *et al.* (1999).

For the total solids, no dietary effect was observed; the values of the current work being around 10.13%, contrary to Chornobai (1998), who obtained average values of 12.40%.

Table 2 - Average Values for acidity(ºD), density(kg.m^{-3}), fat(%), pH, protein(%), lactose(%) and total solids(%) of goat's milk in response to the type of roughage diet.

Parameters	Treatment[1]			
	T1	T2	T3	VC*
Acidity,(ºD)	15.95	16.45	16.29	4.72
Density,(kg.m^{-3})	1.029	1.030	1.029	0.27
Fat, (%)	2.65	2.88	2.71	19.20
pH	6.49	6.47	6.48	0.52
Protein, (%)	2.84	2.97	2.88	10.16
Lactose, (%)	4.28	4.09	4.13	4.60
Total Solids, (%)	10.13	10.22	10.04	10.00

[1] T1 = alfalfa hay; T2 = oat hay; T3 = maize silage
*variation coefficient

Table 3 shows the fatty acids composition values (g/kg). For the decanoic (C10:0) and dodecanoic (C12:0) acids, the diets containing alfalfa hay and oat hay resulted in similar concentration, both superior to the values found in animals fed by maize silage. However, for the tetradecanoic (C14:0), hexadecanoic (C16:0) and 9-hexadecenoic (C16:1ω7) acids, animals fed with oat hay exhibited superior values to those fed with maize silage, whereas both did not differ from animals fed with alfalfa hay. The concentration of octadecanoic (C18:0) and 6,9,12-octadecatrienoic (C18:3ω6) acids, were superior for animals fed with maize silage, compared to those fed with alfalfa hay or oat hay, which did not differ between each other. For the remaining fatty acids, butanoic (C4:0), hexanoic (C6:0), octanoic (C8:0), pentadecanoic (C15:0), heptadecanoic (C17:0), 10-heptadecanoic (C17:1ω7), 9-octadecenoic (C18:1ω9), 9, 12-octadecadienoic (C18:2ω6) and eicosanoic (C20:0), no differences were found (P≤0.05) among the treatments.

These results agreed with those obtained by Chornobai (1998), who analyzing the fatty acids composition of the milk "in natura" of Saanen goats during the whole lactation period found the following concentrations for the same fatty acids (g/kg): C4:0 – 0.6022; C6:0 – 0.1356; C8:0 – 0.4335; C10:0 – 2.4465; C12:0 – 1.4592; C14:0 – 3.4788; C15:0 – 0.1738; C16:0 – 8.9569; C16:1ω7 – 0.5073; C17:0 – 0.2094; C17:1ω7 – 0.0766; C18:0 – 4.0893; C18:2ω6 – 0.7020; C18:3ω6 – 0.0935; C20:0 – 0.0910, respectively.

The results of multivariate analyses are shown in Table 4, which showed the greater the value of the first main component (MC1), the greater was the participation of the short length chain fatty acids (< 16 carbons) and of the acids C17:1ω7 and C18:2ω6; the greater the values of the second main component (MC2), the greater was the participation of the fatty acids C16:1ω7, C17:0, C18:1ω9 and C20:0. Thus, the diets resulted into three distinct patterns of milk fatty acids: alfafa hay presented milk fat with greater amounts of short length chain fatty acids and of the acids C17:1ω7 and C18:2ω6; oat hay with equivalent quantities of short, medium and long length chain fatty acids and maize silage presented fat with greater amounts of acids C16:1ω7, C17:0, C18:1ω9 and C20:0.l.

Table 5 presents the correlation on values among the milk fatty acids. High positive correlation values were seen mainly between the fatty acids C4:0 to C16:1ω7. The acids C17:1ω7 and C18:2ω6 also exhibited high values of positive correlation (r>0.80) with the remaining acids, mainly C4:0 to C16:0. Negative correlation (r < -0.80) was observed for the acids C18:0 and C18:3ω6. These acids correlated negatively with the majority of the milk fatty acids, independent of the chain length.

Although the correlation analyzes did not indicate directly a cause and effect relationship among the variables, the present study has the following considerations: positive correlation between acids would indicate that probably one of the acids, possibly one of the smaller length chain, would be precursor of one of a longer length chain or that both beneficiate of the same precursor, but without competing among themselves; negative correlation would indicate that fatty acids would compete among themselves for the same precursor or that the presence of one would inhibit the other syntheses; or the absence of correlation would indicate not having any of the processes previously described.

Table 3 - Milk fatty acids composition in response to different types of roughage in the diet.

Fatty acids(g/kg)	Treatments[1]		
	T1	T2	T3
C4:0	0.3742 [a]	0.4480 [a]	0.2253 [a]
C6:0	0.4453 [a]	0.4744 [a]	0.4054 [a]
C8:0	0.5980 [a]	0.5850 [a]	0.4899 [a]
C10:0	2.4109 [a]	2.3414 [a]	1.8017 [b]
C12:0	1.1600 [a]	1.0824 [a]	0.7276 [b]
C14:0	2.5183 [ab]	2.7070 [a]	2.1432 [b]
C15:0	0.2135 [a]	0.2136 [a]	0.1984 [a]
C16:0	6.7832 [ab]	7.4336 [a]	5.7506 [b]
C16:1ω7	0.1727 [ab]	0.2253 [a]	0.1438 [b]
C17:0	0.1294 [a]	0.1720 [a]	0.1550 [a]
C17:1ω7	0.1481 [a]	0.1446 [a]	0.1006 [a]
C18:0	1.6091 [b]	1.7687 [b]	2.7886 [a]
C18:1ω9	5.1325 [a]	6.4788 [a]	6.4469 [a]
C18:2ω6	0.7309 [a]	0.7109 [a]	0.6400 [a]
C18:3ω6	0.2067 [b]	0.1954 [b]	0.3453 [a]
C20:0	0.0600 [a]	0.0925 [a]	0.1050 [a]

Similar letters in the same row do not differ statically between each other according to the Tukey test ($P \leq 0.05$)
[1] T1 = alfalfa hay; T2 = oat hay; T3 = maize silage

Table 4 - Auto-values, auto-vectores, relative importance and accumulated percentage of the two first main components

	Main components (MC)	
	MC1	MC2
Auto-values (variance)	12.69	3.31
Auto-vectors		
C4:0	0.2664	0.1730
C6:0	0.2560	0.2255
C8:0	0.2786	-0.0671
C10:0	0.2788	-0.0634
C12:0	0.2761	-0.0986
C14:0	0.2661	0.1750
C15:0	0.2807	-0.0036
C16:0	0.2604	0.2050
C16:1ω7	0.2183	0.3457
C17:0	-0.0295	0.5470
C17:1ω7	0.2798	-0.0424
C18:0	-0.2781	0.0747
C18:1ω9	-0.1325	0.4849
C18:2ω6	0.2738	-0.1212
C18:3ω6	-0.2802	-0.0313
C20:0	-0.1983	0.3892
Relative importance (%)	79.34	20.66
Accumulated percentage	79.34	1.00

Lanna et al. (2001) reported that long length chain fatty acids, mainly specific isomers of conjugated linoleic acids (CLA), inhibited the milk fat synthesis, mainly short and medium length chain fatty acids (<16 carbons), such as C14:0 e C16:0. These acids, according to Williams (2000), were related to major incidence of arteriosclerosis. Thus, the conjugated linoleic acids (CLA) have important roles, because they confer to the product greater nutritional quality.

The presence in the diets of finely milled forages were resulted in more elevated values of isomers of CLA (Baumgard et al., 2000), that they formed naturally in the rumen by the incomplete bio-hydrogenation of the polyunsaturated fatty acids present in the diet (Griinari & Bauman, 1999) or even endogenously through the des-saturation of the acid C18:1 trans 11, an enzyme present in the mammary gland (Corl et al., 2000).

Table 5 - Correlation matrix of the goat's milk fatty acids (FA).

Fat Acids	C4:0	C6:0	C8:0	C10:0	C12:0	C14:0	C15:0	C16:0	Cl6:1 ω 7	C17:0	C17:1ω7	C18:0	C18:1ω9	C18:2ω6	C18:3ω6
C6:0	**0.99**														
C8:0	**0.90**	**0.86**													
C10:0	**0.91**	**0.86**	**1.00**												
C12:0	**0.88**	**0.82**	**1.00**	**1.00**											
C14:0	**1.00**	**1.00**	**0.90**	**0.91**	**0.88**										
C15:0	**0.95**	**0.91**	**0.99**	**0.99**	**0.99**	**0.95**									
C16:0	**1.00**	**1.00**	**0.88**	**0.88**	**0.85**	**1.00**	**0.93**								
Cl6:1ω7	**0.94**	**0.97**	**0.70**	**0.70**	**0.65**	**0.94**	**0.77**	**0.96**							
C17:0	**0.21**	**0.31**	-0.23	-0.22	-0.28	**0.22**	-0.11	**0.27**	**0.54**						
C17:1ω7	**0.92**	**0.88**	**1.00**	**1.00**	**0.99**	**0.92**	**1.00**	**0.90**	**0.73**	-0..18					
C18:0	-0.90	-0.85	-1.00	-1.00	-1.00	-0.90	-0.99	-0.87	-0.69	**0.24**	-1.00				
C18:1ω9	-0.17	-0.07	-0.58	-0.57	-0.62	-0.17	-0.48	-0.11	**0.19**	**0.93**	-0.54	**0.59**			
C18:2ω6	**0.86**	**0.80**	**1.00**	**0.99**	**1.00**	**0.85,**	**0.98**	**0.82**	**0.62**	-0.32	**0.99**	-1.00	-0.65		
C18:3ω6	-0.97	-0.93	-0.98	-0.99	-0.97	-0.96	-1.00	-0.95	-0.81	**0.05**	-0.99	**0.98**	**0.42**	-0.96	
C20:0	-0.45	-0.35	-0.79	-0.78	-0.82	-0.44	-0.71	-0.39	-0.11	**0.78**	-0.76	**0.80**	**0.96**	-0.85	**0.67**

Thus, supplying finely shredded forages favored the synthesis of isomers in the rumen that besides contributing in the nutritional aspect of the milk, inhibited the development of various tumors (Ip, 1994; Ip et al., 1997), further reinforcing the advantages of using dairy goat milk, which has been considered one of the most complete foods and of easiest digestion (Chornobai, 1998). In the present experiment hay was shredded and silage was composed of small parts (through the ensilage process) before being supplied to the animals.

Another aspect to consider could be the importance of quantifying the fatty acids, which compose the milk fat, as well as determining the total fat content in the milk, to better evaluate the treatments effects. In the current experiment no differences were detected between treatments in the milk fat content, although the diets resulted in the milks with distinct fatty acids profiles.

Based on these results, it was possible to conclude that the roughage source in the lactating dairy goat diets affected the fatty acids composition without altering the physical-chemical characteristics of the milk, where each diet resulted in a profile particular to the fatty acids. The most sensitive acids to the effects of the treatments were: C10:0, C12:0, C14:0, C16;0, C16:1ω7, C18:0 and C18:3ω6.

RESUMO

O presente trabalho teve por objetivo avaliar o efeito de fontes de volumosos (feno de alfafa T1; feno de aveia T2 e silagem de milho T3) nas características físico-químicas (densidade, pH, acidez, teores de gordura, proteína, lactose e sólidos totais) e composição em ácidos graxos (C:4 a C:20) do leite. Foram utilizadas 9 cabras Saanen em lactação, em delineamento experimental triplo quadrado de Youden (3 animais x 2 períodos). Não houve efeito (P>0,05) dos tratamentos nas variáveis físico-químicas. Através de análise multivariada, verificou-se três padrões distintos de ácidos graxos: leite com maior quantidade de ácidos graxos de cadeia curta e dos ácidos C17:1ω7 e C18:2ω6 (T1); leite com quantidades equivalentes de ácidos graxos de cadeia curta, média e longa (T2) e leite com maiores quantidades dos ácidos C16:1ω7, C17:0, C18:1ω9 e C20:0 (T3). Estes resultados indicaram que a fonte de volumoso em dietas de cabras em lactação afeta a composição em ácidos graxos, sem alterar as características físico-químicas do leite. Os ácidos mais sensíveis aos efeitos dos tratamentos foram: C10:0, C12:0, C14:0, C16;0, C16:1ω7, C18:0 e C18:3ω6.

REFERENCES

Baumgard, L. H.; Corl, B. A.; Dwyer, D. A.; Saebo, A. and Bauman, D. E. (2000), Identification of the conjugated linoleic acid isomer that inhibits milk fat synthesis. *Am. J. Physiol Regul. Integr. Comp. Physiol.*, **278** : (1), 179.

Bonassi, I. A.; Kroll, L. B. and Vieites, R. L. (1996), Composição protéica do leite de cabra. *Cienc. Tecnol. Aliment.*, **16** : (3), 218-222.

Carvalho Neto, F. A.; Pereira, M. M. G. and Muratori, M. C. S. (1993), *Caracterização físico-química do leite cru de cabra do Centro de Ciências Agrárias da Universidade Federal do Piauí*. Teresina, Piauí.

Chornobai, C. A. M. (1998), *Avaliação físico-química de leite in natura de cabras cruza Saanen, ao longo do período de lactação*. Dissertação (Mestrado), Universidade Estadual de Maringá, Maringá, PR.

Cochran, W. G. and Cox, G. M. (1957), *Experimental Design*. 2. ed. New York : John Willey & Sons, Inc. 611 pp.

Corl, B. A.; Baumgard, L. H.; Dwyer, D. A.; Griinari, J. M.; Philips, B. S. and Bauman, D. E. (2000), The role of delta-9-desaturase in the production of cis-9, trans-11 CLA and other delta-9 desaturated fatty acids in milk fat. *J. Dairy Science*, **83** : (1), 164.

Damasceno, J. C.; Ferreira, A. C. D. and Geahl, S. E. et al. (1997), Responses of the dairy goats supplemented with different levels of concentrate. *J. Dairy Science*, **80** : (1), 462.

González-Crespo, J.; Lozano, M. and Mas, M. et al. (1995), *Produción y composición quimica de la leche de cabra verata*. Alimentaria. pp. 53-58.

Griinari, J. M. and Bauman, D. E. (1999), Biosynthesis of conjugated linoleic acid and its incorporation into meat and milk in ruminants. In: *Conjugated Linoleic Acid: Biochemical and Nutrition Clinical, Cancer, and Methodological Aspects*. AOCS Press, Champaign.

Grummer, R. R. (1991), Effect of feed on the composition of milk fat. *J. Dairy Science*, **74**, 3228-3243.

Hussain, Q.; Havrevoll, Ø. and Eik, L. O. (1996), Effect of type roughage on feed intake, milk yield and body condition of pregnant goats. *Small Ruminant Research*, **22**, 131-139.

Instituto Adolfo Lutz (1985), Normas Analíticas do Instituto Adolfo Lutz. Vol.1 - *Métodos químicos e físicos para análise de alimentos*. 3. ed. Secretaria do Estado da Saúde. Coordenadoria dos Serviços Técnicos Especializados, São Paulo. 533 pp.

Ip, C.; Jiang, C. and Thompson, H. J. et al.(1997), Retention of conjugated linoleic acid in the mammary gland is associated with tumor inhibition during the post-initiation phase of carcinogenesis. *Carcinogenesis*, **18**, 755-759.

Ip, C. (1994), Conjugated linoleic acid in cancer prevention research: A report of current status and issues. Research report n. 100-4; *The National Livestock and Meat Board*, Chicago, IL.

ISO 5509. International Standard (1978), (E)/ Erratum, published, 1981. Animal and vegetable fats and oils – *Preparation of methyl esters of fatty acids*. International Organization for Standardization, Switzerland.

Jensen, R. G.; Ferris, A. M. and Lammi-Keefe, C. J. (1991), Milk fat – composition, function and potential for change. *J. Dairy Science*, **74**, 3228-3243.

Kaylegian, K. E. (1995), Functional characteristics and nontraditional applications of milk lipid components in food and nonfood systems. *J. Dairy Science*, **78**, 2524-2540.

Lanna, D. P. D.; Delgado, E. F. and Gama, M. S. et al. (2001), Nutrientes, hormônios e genes na regulação da síntese de gordura em bovinos em crescimento e lactação. In: Mattos, W. R. S. (Ed.). *A produção animal na visão dos brasileiros*. Piracicaba : Sociedade Brasileira de Zootecnia. pp. 658-685.

Le Mens, P. (1991), *La leche de cabra. Propriedades físico-químicas, nutricionales y químicas*. In: Luquet, F. M. (Coordinador). *Leche y productos lacteos. Vaca – oveja – cabra*. Volumen 1: La leche. De mama a la lecheria. Editorial Acribia, S.A., Zaragoza, Espanã. pp. 343-360.

Murphy, J. J.; Connolly, J. F. and Mcneill, G. P. (1995), Effects on cow perfomace and milk fat composition of feeding full fat soyabeans and rapessed to dairy cows at pasture. *Livest. Prod. Science*, **44**, 13-25.

Palmquist, D. L.; Beaulieu, A. D. and Barbano, D. M. (1993), Milk fat synthesis and modification. *Journal of Dairy Science*, **76**, 1753-1771.

Sampelayo, M. R.; Amigo, L. and Ares, J. L. et al. (1998), The use of diets with different protein sources in lactating goats: composition of milk and its suitability for cheese production. *Small Ruminant Research*, **31**, 37-43.

SAS, Institute Inc. (1985), *Users guide: Statistics*. Version 5 Edition. Cary NC: SAS Institute Inc. 955 pp.

Spain, J. N. and Polan, C. E. (1995), Evaluating effects of fich meal on milk fat yield of dairy cows. *J. Dairy Science*, **78**, 1142-1153.

Sung, Y. Y.; Wu, T. I. and Wang, P. H. (1999), Evaluation of milk quality of Alpine, Nubian, Saanen and Toggenburg breeds in Taiwan. *Small Ruminant Research*, **33**, 17-23.

Willians, C. M. (2000), Dietary fatty acids and human health. *Ann. Zootechnia*, **49**, 165-180.

Received: August 27, 2003;
Revised: January 08, 2004;
Accepted: July 07, 2004.