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Somatic Cell Counts and Quality of Goat Milk Produced in the Central Region of Mexico

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Abstract: Although, Mexico is the main goat milk producer of the American continent, there are no published data regarding the quality of its milk. This is the first study on quality assessment of goat milk realized in Mexico, in terms of the percentage of fat, protein and lactose, as well as for fat contents, total solids and Somatic Cell Count (SCC). Samples were taken from 1st to 7th lactation clinically healthy goats yielding in 6 Mexican farms with high level of management, with an average lactation length of 318 days. The mean percentage of fat, protein, lactose and total solids in the analyzed milk were 3.7, 2.7, 4.5 and 11.9, respectively. The mean daily production was 3.7 kg and the average SCC was 493,000 mL^{-1}. The effects of farm, lactation number, sampling month, interaction between farm and sampling month and the random effect of goat nested in farm on milk constituents and SCC were analyzed using mixed models for repeated measurements. SCC was affected by all the study effects ($p<0.01$). Relationship between SCC and milk production was analyzed and results showed that high milk production was accompanied by low SCC, which might be associated to a dilution effect.

Key words: Goat milk, milk quality, somatic cell count (SCC), Mexico

INTRODUCTION

Mexico is the main goat milk producer country in the American Continent, with 42.8% of its total production (FAOSTAT, 2005), equivalent to 161,000,000 L (SIAP-SAGARPA, 2005). Nevertheless and according to a worldwide situation (Dubeuf *et al*., 2004), this production might be higher than what official statistics indicate due to local consumption that is not recorded. Quantitatively, goat milk yield represents only about 1.6% of Mexican cow's milk production, but plays an important social and economic role in some rural areas of Mexico.

From the social perspective, in many poor rural areas, goat production constitutes the only economic resource as it is the main local supplier for dairy and meat products. From the economic perspective, its relevance is based on its mean price which in Mexico is 19% above the cow's milk mean price (SIAP-SAGARPA, 2005). Also, the increasing trend of dairy goat products consumption by higher economic strata of the population, as gourmet products (Haenlein, 2004), turns it into an alternative export for Mexico within the North America Free Trade Agreement (NAFTA).

There is scarce information and no specific legislation on the quality of Mexican goat milk and Mexican standards for milk or dairy products are based on cow's milk (NOM-155-SCFI, 2003). Curiously, goat cheese is the only dairy product that is in the process of being certified with the official Mexican quality certification agency accredited internationally by recognized organizations such as EUREPGAP (México Calidad Suprema, 2006). However, since there are no specific official standards for goat cheese, the quality conditions that Mexican goat cheese must fulfill (PC-031, 2005), are based on physical, chemical and micro biological specifications for cow's milk. Therefore, it is necessary

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to evaluate the quality of goat milk as well as to advance in the knowledge of the factors affecting it and its dairy products, to yield valid quality standards (Raynal *et al*., 2005).

Milk quality is based on its milk constituents such as percentages of fat, protein and lactose, bacteriological quality and on SCC (Contreras *et al*., 1997). Regarding sanitary quality measures, in Mexico there is no official maximum threshold admissible for SCC for goat milk, although, the conditions list (PC-031, 2005) sets a maximum of 400,000 cells mL^{-1}. This SCC limit, based on cow's milk parameters, does not apply to pasteurized goat milk and goat cheese produced with pasteurized milk.

In any case, it should be mentioned that milk from healthy goats has a higher cell count than milk from healthy cows (Paape *et al*., 2001). Mean SCC in cow's milk without intra-mammary infection varies between 40,000 and 80,000 cells mL^{-1} (Paape and Contreras, 2000) and the National Mastitis Council (2001) considers a cow's udder to be healthy when SCC is below 200,000, while the average SCC in US herds has been estimated from 74,742 (Weigel *et al*., 1997) to 117,280 (Schutz, 1994) and in 82,932 for first calving cows (Castillo-Juarez *et al*., 2002) while in goat milk we can find variations from 165,000 (Dulin *et al*., 1983) up to 1,920,000 cells mL^{-1} (Rota *et al*., 1993) and values even higher. It is worthy to note that these estimates change depending on management practices and consumer expectations across markets.

The aim of this study, was to elaborate an initial assessment of goat milk quality for Mexican herds with high level of management and to evaluate the influence of some environmental factors on SCC and on the content of the main milk constituents.

MATERIALS AND METHODS

Study site: Milk samples were taken from 6 commercial farms that are brucellosis free, have a mechanical milking parlor and belong to the Caprinocultores Unidos de Guanajuato Association. All of the farms are located in Apaseo el Grande, Guanajuato, Mexico (the central region of the country), at 1,767 m above mean sea level, the region has a temperate climate with a minimum temperature of 1°C and maximum of 37°C. The average total annual precipitation is 606 mm with the rainy season from June to September. Farm average lactation length is 318 days, with a dry period length between 2 and 3 months, one parity per year and age at first lactation between 9 and 11 months.

Goats: Twelve goats from 1st to 6th lactation were randomly selected in each farm, two from each lactation number. As a result of the duration of this study at the end of it we also had data corresponding to the seventh lactation. In total, the study included 72 goats, 65 were Saanen, 5 were Toggenburg and 2 were Alpine breeds. All goats were required to be healthy, particularly with no clinical mastitis and were managed in an intensive production system where nutrition was based on alfalfa, corn silage and concentrate containing 18% protein.

Sampling: Monthly samples were taken from the mix of morning and afternoon milking, always from the same goats. The sampling period began in July 2004, ended in July 2005 and included 329 samples. The data obtained during the months of August, September, October and November of 2004, as well as during April and May of 2005 could not be included in the analysis because of technical calibration problems with the measuring instruments. The samples consisted of approximately 50 mL of milk kept in screw cap flasks at 4°C. The milk produced at each milking was recorded and the physical and chemical analyses were practiced the following day. SCC evaluation was also performed the next day as reported by Kroger (1985) and Gonzalo *et al*. (1998).

Laboratory analysis: The physical and chemical components of the milk (fat, protein, lactose and total solids) were determined with an automatic infrared spectroscope (Milko-Scan®) calibrated for goat milk. SCC of milk samples were performed with a fluorescent microscope (Fossomatic®), after preheating the samples at 40°C in water bath and homogenizing them.

Statistical analysis: Fat (F), Protein (P), Lactose (L), total solids (S), milk yield and somatic cells count (SCC) were analyzed using mixed models for repeated measures as recommended by Littell *et al*. (1998) (with SAS software, version 9.1., 2004. SAS Institute Inc., NC, USA). The models included the fixed effects of farm, lactation number, month of sampling, interaction between farm and month of sampling, as well as the random effects of goat nested in farm and the residual. The percentages of F, P and L were log-transformed and S was square-root-transformed in order to normalize their distribution. SCC variables were transformed using base 10 logarithm for the same reason.

RESULTS AND DISCUSSION

The mean percentages of fat, protein, lactose and total solids in the milk analyzed per lactation are shown in Table 1. The general mean for each of these traits were 3.7, 2.7, 4.5 and 11.9%, respectively. The mean values of SCC for each lactation and the amounts of produced milk per day are also shown in Table1. Overall averages were 493,000 cells mL^{-1} and 3.7 L day^{-1}.

Table 1: Descriptive statistics of the studied traits by lactation number

Trait		Lactation number 1	2	3	4	5	6	7	Total
	N	23	40	48	38	52	39	24	264
Fat%	Mean	3.26	3.78	3.87	3.78	3.51	3.70	4.07	3.71
	SD	0.59	1.44	1.36	1.22	1.03	1.00	1.12	1.17
Protein%	Mean	2.8	2.84	2.73	2.79	2.73	2.65	2.63	2.74
	SD	0.31	0.39	0.34	0.38	0.27	0.25	0.21	0.32
Lactose%	Mean	4.58	4.45	4.49	4.40	4.45	4.50	4.54	4.48
	SD	0.19	0.24	0.26	0.19	0.27	0.28	0.29	0.25
Total solids%	Mean	11.57	12.02	12.08	11.93	11.64	11.80	12.20	11.89
	SD	0.83	1.69	1.35	1.27	1.16	1.05	1.20	1.27
SCC	Mean	388	351	391	556	437	585	380	445
($\times10^3$ mL^{-1})	SD	375	474	431	732	509	1188	677	675
Milk yield (L d^{-1})	Mean	3.0	4.0	4.0	4.0	4.0	3.7	4.0	3.9
	SD	0.9	1.5	1.3	1.7	1.7	1.3	0.9	1.4

The highest milk production level was observed in the month of March, although this production level was relatively maintained until the end of July. Lowest SCC in all lactations was also observed during the month of March.

Milk constituents: The mean percentage of fat, protein, lactose and total solids were within the wide ranges referenced in the literature. Fat percentage in goat milk has been reported as 3.9 % (Leitner *et al*., 2004), in the range of 4.6-5.1 % (Salama *et al*., 2003) as 5.4 % (Analla *et al*., 1996) and even above 6% (Ramos *et al*., 2002). Protein values have been estimated in the range of 2.6-4.3% (Zeng, 1996; Analla *et al*., 1996; Alsina *et al*., 2002; Salama *et al*., 2003; Leitner *et al*., 2004) and lactose, the most stable component, oscillates between 4.4 and 4.7% (Buxadé and Caballero, 1996). Regarding total solids, our estimate (11.9%) was low, but within the range (10.6-17.8%) found in the previously published studies for goat milk (Salama *et al*., 2003; Soryal *et al*., 2004; Sánchez *et al*., 2005).

The wide ranges given for the mean fat and protein in goat milk are due to factors such as breed, season of the year, lactation number or duration of lactation, among others. For the Saanen breed, the American Dairy Goat Association records average percentages for fat and protein of 3.3 and 2.9, respectively (ADGA, 2004), which are more in tune with the data obtained in this study. Lactation length range from ADGA data was from 275-305 days, which is close to the lactation length observed in our studied farms. Nevertheless, besides ADGA (2004), we found no other published research with similar lactation length. In the literature reviewed it ranged from 120 days (Petrova *et al*., 2001) to 210 days (Rota *et al*., 1993).

Falagán and Mateos (1996) found that the highest levels of fat, protein and non-fat solids were reached around the 6th lactation. In contrast, our results showed that the levels of fat, protein and non-fat solids were homogenous across the seven lactations.

Production level is a factor that influences milk constituents, especially the percentage of fat, as it has been observed that goats with lower production level have a higher fat percentage, notwithstanding that there are other related factors such as breed or nutrition (Lu *et al*., 2005). In general, fat and protein content is greater at the beginning and at the end of lactation when milk volume decreases (Fekadu *et al*., 2005), but this could not be evaluated in our study because we did not study these constituents across the complete lactation length and instead focused on differences among lactations. Nevertheless, the association between each milk constituent and milk production was studied using regression analysis and we found a relationship only between protein and milk production, albeit with a low determination coefficient (R^2 = 0.11). We consider that the absence of any relationship between milk constituents and milk production could be due to the small variation among observed values for fat (3.2-4.0), protein (2.7- 2.9), lactose (4.5-4.6) and total solids (11.3-12.2) (i.e., to the fact that there is not a large variation in the percentage of these milk constituents in goats due to homeostatic effects).

Climatic conditions have an effect on the concentration of milk constituents. In general, avoiding the extremes, high weather temperature reduce the amount of fat and protein in milk which increases once the temperature decreases (Linzell, 1973). Climate and breed are related, since there are breeds adapting better than others to different climatic conditions; it has been described, for example, that Saanen breed is sensible to sun light, adapting better and offering improved yields in cold areas (Gonzalo and Sánchez, 2002). In our study 90% of the goats were from this breed, which may explain the fact that fat and protein increase in January when the temperature is lower. Lower weather temperature values were registered on December 2004 and January 2005 with a mean of 17.6 and 17.9°C, respectively. Higher weather temperature values were measured in June 2005, with a mean of 25.4 °C.

Somatic cell count: The SCC mean observed (493,000 mL^{-1}) indicates a good sanitary quality and that these livestock enterprises could comply with standards of countries that have legislation in this matter such as the United States, which mandate liquid state marketing of goat milk lower than 1,000,000 cells mL^{-1} (Paape and Contreras, 2000). This observed SCC mean from an average lactation length of 318 days, is below than what is usually found in literature, including those referring to Saanen breed in intensive production systems. For example, Sung *et al.* (1999) observed a SCC mean value of 549,541 cells mL^{-1} in the 2nd and 3rd lactations and Gomes *et al.* (2006) reported a SCC mean value of 582,000 cells mL^{-1} for the first eight lactations.

The wide range that is reflected in the published studies, from 414,000 cells mL^{-1} in lactations of 270 days of length published by Dulin *et al.* (1983) to 1,920,000 cells mL^{-1} found by Rota *et al.* (1993), indicates that SCC is affected also by non-pathological factors. Maybe goats do not differ very much from cows regarding the causes that increase SCC, but are different in the magnitude of their response, especially when the causes are other than mastitis (Wilson *et al.*, 1995; Zeng, 1996).

Regarding non-pathological factors that affect SCC, the linear model used showed that there was significant effect ($p<0.01$) of farm, number of lactation and month of sampling on SCC.

SCC was reduced in all lactations during the month of March. This could be due to milk production level in that month. Milk production was also affected by the month of sampling. March was the month where highest milk production level was reached, although thereafter the milk production level was relatively maintained. This milk production increase could have been due to better feed quality and not to a change in the kind of feeding that was constant all year long. First cuts of alfalfa at the beginning of the spring in this part of Mexico have a higher nutritional value than those obtained during the rest of the year.

The observed effect of lactation number on SCC is in agreement with other author findings, independently from breed or management production system (Dulin *et al.*, 1983; Rota *et al.*, 1993; Wilson *et al.*, 1995; Gomes *et al.*, 2006). Some authors have found that as the number of lactation increases there is a higher SCC, following an inversely proportional curve in relation to the lactation curve and it is hypothesized that this increment could be due to a concentration effect produced by the decrease of milk production (Dulin *et al.*, 1983; Rota *et al.*, 1993). SCC in goats consistently increases with the stage of lactation (Min *et al.*, 2007).

However, average data in this study do not clearly indicate an increase in SCC nor a reduction of milk production as the number of lactations increased. Representation of data does not show the typical image of a curve inversely proportional to milk production, perhaps because lactation curves are normally presented in lactation days in relation to milk production and not lactation number in relation to milk production as it occurs in this case. Even so, a similar pattern can be seen, especially in the fourth lactation, where the reduction in production is seen to be more clearly coincidental with the increase in SCC. In any case, high milk productions were always accompanied by low values of SCC. The daily production mean obtained in this study (3.7 L) is higher than that reported for the Saanen breed (Gonzalo and Sánchez, 2002).

It could be said that the reduction in SCC values associated to high milk production might be due to a dilution effect. Nevertheless, in the case of goats, SCC increase is not always associated with a milk production reduction. Low milk production, together with high SCC may be due more to the effect of advanced lactation than to a high SCC per se (Wilson *et al.*, 1995) as has been observed in the partial SCC analysis during this study, where the amount of milk depended on lactation number and was not related to SCC. Luengo *et al.* (2004) found that in healthy udders SCC was higher in old goats. Multiple birth and short lactation were factors associated with elevated SCC. In any case, total data showed that lactation number as well as the amount of milk produced was related to SCC.

CONCLUSION

This study describes, at the farm level, the milk constituents' percentage and SCC patterns for goat milk in a sample of animals that are clinically healthy, in an intensive production system with an average lactation length of 318 days, in a temperate region of Mexico.

Mean milk production of 3.7 L day^{-1} was observed, which is a higher value than those previously described for Mexican farms. The mean percentages for fat, protein, lactose and total solids in the analyzed milk were 3.7, 2.7, 4.5 and 11.9, respectively, which are in agreement with the standards of the American Dairy Goat Association. The observed SCC mean (493,000 mL^{-1}), shows a good sanitary status of the farms and complies with the limits set by those countries that have legislation in this matter. SCC and milk constituents were affected by non-pathological factors. Higher milk production was associated to lower SCC, but production level was not associated to variations in milk constituents' percentage.

In Mexico, the maximum admissible threshold for SCC has not been set for goat milk. Nevertheless, a maximum limit could not be suggested based on our findings, since it would be necessary to study other breeds and other production systems to establish a more representative threshold for the national conditions.

Although, all the studied farms have relatively similar management practices and feeding regime, SCC differed among farms. There were also important individual differences among goats. Regarding milk constituents, there were significant differences depending on the month of sampling with higher levels of protein and total solids observed in January, when temperatures were lower.

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