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Small Ruminant Research 47 (2003) 51–61

Small Ruminant Research

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Effect of hygiene-sanitary management on goat milk quality in semi-extensive systems in Spain

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Accepted 22 October 2002

Abstract

Milk samples were collected from 28 farms, at monthly intervals during the production period (December to September). At the same time, each farmer was surveyed about specific conditions of hygiene-sanitary management at the farm. When management improvements were made, there was improvement ($P < 0.05$) in both bacteria count (165,000 bacteria/ml versus 379,000 bacteria/ml in the samples taken from the tank) and somatic cell count (SCC; 1,564,000 cells/ml versus 2,354,000 cells/ml). A source ($P < 0.001$) of microbial milk contamination was its handling in the time from leaving the udder (65,000 bacteria/ml) until reaching the refrigeration farm tank (in the case of machine-milking, with 362,000 bacteria/ml) or the bulk tank of the cooperative (in the case of hand-milking, with 262,000 bacteria/ml). The two study areas, characterized by the milking method, presented differences ($P < 0.001$) in bacteria count and SCC (2,534,000 cells/ml with machine-milking versus 1,785,000 cells/ml with hand-milking). Farms with fewer animals (<100 animals) that practised hand-milking had a better hygiene-sanitary quality. Month also affected SCC, with concentration lowest in December and March (1,510,000 cells/ml), and highest in August and September (3,379,000 cells/ml). This was also part of the change in SCC with stage of lactation, increasing towards its end. SCC showed a positive correlation ($P < 0.01$) with % fat ($r = 0.21$) and % protein ($r = 0.49$). No correlation was observed between the number of bacteria and SCC. It is concluded that the establishment of appropriate conditions of hygiene-sanitary management on the farms improved the bacteriological quality and enabled SCC to fall below recommended limits.

Keywords: Goat milk; Somatic cell count (SCC); Bacteriological quality; Hygiene-sanitary management; Milking method

1. Introduction

The European Union (EU-15) has 17% of the world goat population, with a goat milk production of 12% of the total milk produced from all dairy species. Dairy goats are traditional farm animals in the Mediterranean basin, with five countries (Greece, Spain, France, Italy and Portugal) concentrating 97% of the EU goat population and 97% of its goat milk production. Spain is second in goat population (with 2,873,000 head in the year 2000) (FAO, 2000), and third in goat milk production (320,000 t). Southern Spain (Andalusia) has 42% of the Spanish goat population, with a high number of females for milking (72% of the population, CAP,

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PII: S0921-4488(02)00239-0

2000) and a production of around 250,000 t. Milk production has increased by 18% in this Spanish region since 1995. About 95% of this goat milk is transformed into typical cheeses that have regional or local connotation of origin and quality.

Criteria of hygienic and bacteriological quality of ewe and goat milk are outlined in the European Union (EU) directives 92/46 and 94/71, which regulate different aspects of production and transformation of milk of various animal species. At the end of 1999, these rules became Spanish law (RD 1679/94 and RD 402/96). No threshold was defined for somatic cell count (SCC), but minimum requirements are specified regarding bacteria count. Their compliance is of vital importance for the survival of commercial dairy goat farmers (Boyazoglu and Morand-Fehr, 2001).

In southern Spain, a system of semi-extensive farming is practised, characterized by zones of pasture and shrubbery (supplemented from the manger at times of greater nutritive need), the existence of agricultural cooperatives that support the animal-farming sector in the commercialization of its products, joint farming of several species on a single farm, and the existence of mixed herds of various goat breeds. From a viewpoint of hygiene-sanitary management, although all the farms observe general sanitary norms, most do not follow the general dairy herd recommendations for milking routine (Mena et al., 1999a). Despite this, there are very few studies on the characterization and effect of management practices for the hygiene-sanitary quality of milk on dairy goat farms in Spain.

The aims of the present work were to study the current situation of goat farms with respect to the hygiene-sanitary quality of the milk under different forms of management, and to examine the degree of appropriateness of and compliance with legal requirements. Also the study was to verify the degree of improvement that appropriate hygiene management practices achieved in the bacteriological and somatic cell levels in milk quality.

2. Material and methods

2.1. Experimental sites

Two study areas were chosen. In one, situated in the Sierra Norte of Seville (Mena et al., 1999b), hand-milking is practised in 80% of cases, and the autochthonous breeds Florida Sevillana and Blanca Andaluza predominate. In the other area in the Sierra Norte of Cádiz (Castel et al., 1999), machine-milking is used on 47% of the farms. The autochthonous breed Payoya predominates and there is a better infrastructure than in the former area.

2.2. Goats

A total of 28 dairy goat farms were examined. On 14 located in the Sierra Norte of Seville, milking was by hand, and on the other 14, in the Sierra Norte of Cádiz, by machine.

In each set of the 14 farms, 10 on which the management typical of the area was carried out, were denominated “non-improved”, and the other four were denominated “improved”. On these improved farms, the farmers had to follow a more appropriate hygiene-sanitary management regime, based on the following measures: the use by the milker of special clothing when milking, the sealing-off of udders, the non-inclusion in the tank of milk from animals under treatment (also respecting the periods of suppression of such animals), and a high level of cleanliness in the area and of the milking equipment, of the animals, and of the farm in general. Additional measures on farms using hand-milking were the washing of hands, the presence of a specific milking site, and the establishment of a maximum period of 2 h from the end of milking until the milk entered the refrigeration tank common to all the farmers of the cooperative. On farms using machine-milking, the milking equipment was checked for pulsations and vacuum pressure.

2.3. Sample collection

On each farm, milk samples were taken once a month throughout the lactation period of 9 months (from December to September). Sampling was as follows.

In the Sierra Norte of Seville, three milk samples were taken: the first directly from the udder (after discarding the first few strippings of foremilk) from 15% of the goats milked on the farm chosen at random; the second sample was taken from the herd tank, after all animals had been milked (about 1.5–3 h from the beginning); and the third sample was taken from the bulk refrigeration tank of the cooperative (about 1–4 h from the end).

In the Sierra Norte of Cádiz, two milk samples were collected: the first was the same as in the former case, and the second from the refrigeration tank of each farm immediately at the end of milking the whole herd (about 1.5–2.5 h from the beginning).

At each sampling, the farmer was surveyed to discover the effect of possible variations in the hygiene-sanitary management and of the farm conditions on the results. The factors considered were the: state of cleanliness of the milking parlour and equipment, and of the farm, animals and clothing, and the carrying out of postmilking dipping. In the case of machine-milking, additional specific factors were state of cleanliness of the dairy and whether the milking equipment was checked. In the case of hand-milking, farms were checked for transporting the milk from the farm to the bulk tank of the cooperative in <2 h after milking.

The milk samples were collected aseptically into sterile vials with preservative (Azidiol), and kept immediately at 4 °C. Laboratory analysis was always within 24 h from sampling, so that results were unaltered (Zeng et al., 1999).

2.4. Laboratory analyses

Analyses for composition in milk fat and protein used an infrared spectrophotometer (Milko Skan in a Combi-Foss 5000, Foss Electric, Hillerod, Denmark); for number of bacteria/ml, a Bacto Scan 8000 S; and somatic cell counts/ml, were measured by flow cytometry, using a Fossomatic Electronic Cell Counter in a Combi-Foss 5000.

In all cases as recommended by Zeng (1996), Zeng et al. (1997, 1999), instruments were calibrated with goat milk standards for more reliable and accurate analyses.

2.5. Statistical analyses

For variance analysis to be valid, the variable analyzed must meet the conditions of normality. However, if these are not met, they can be attained by an appropriate data transformation (Ali and Shook, 1980; María and Migueltorena, 1996). To this end, and after testing the variables for normality using the descriptive statistics of asymmetry and kurtosis, the logarithmically transformed somatic cell and bacteria counts were used to normalize the frequency distribution. The normally distributed data were analyzed by ANOVA, using the general linear model (GLM) of SPSS software statistical package (SPSS, 1999). The general statistical model for the analysis of SCC and bacteria count included fixed effects due to month of sampling (December to September), area-milking method (machine-milking and hand-milking), type of farm (improved and non-improved with hygiene-sanitary measures), herd size (<75 goats; 76–150; 151–225; >225) type of sample (udder, churn, and refrigeration tank of the farm or bulk tank of the cooperative), double interactions, and residual error. For significant differences between means, the Scheffe test was applied (SPSS, 1999).

To demonstrate association between the results of the survey on conditions of hygiene-sanitary management, made at the time of milk sampling, and different sources of variation (type of farm, area-milking method, herd size, and month), we performed Chi-square (χ^2) distribution tests on contingency tables. Pearson correlation coefficients among different variables of goat milk were also determined.

3. Results

The number of bacteria in the milk samples, showed differences for sampling month ($P < 0.001$), with July presenting the lowest count, and January and April the highest. Also significant were the factor farm type ($P < 0.05$) and its interaction with month ($P < 0.01$). Farms with improved hygiene-sanitary conditions showed a lower bacteria count throughout almost all the months of study, although the differences were significant only in the first months (December to February) and in September (Table 1 and Fig. 1).

The type of sample was an important factor in the variability of the data ($P < 0.001$). Milk was found to be contaminated and with an increase in bacteria after leaving the udder (65,000 bacteria/ml) until arriving at its destination—the farm refrigeration tank (in the case of farms using machine-milking, 362,000 bacteria/ml) or bulk tank of the cooperative (for farms using hand-milking, 262,000 bacteria/ml). The milking method was an important factor ($P < 0.001$);

Table 1
Mean values (±S.E.) of bacteria/ml in goat milk samples by month and type of farm (improved or non-improved with hygiene-sanitary measures)

Months	Improved		Non-improved	
	A.m.[a,b]	$\log_{10}$ bacteria	A.m.[a,b]	$\log_{10}$ bacteria
December	48 ± 5.7 (47)	4.63 ± 0.05 a	246 ± 127.8 (431)	4.94 ± 0.11 b
January	108 ± 52.8 (97)	4.60 ± 0.12 a	308 ± 73.1 (512)	5.09 ± 0.09 b
February	51 ± 8.9 (69)	4.57 ± 0.09 a	280 ± 102.9 (617)	4.92 ± 0.09 b
March	43 ± 8.1 (50)	4.53 ± 0.07 a	62 ± 11.0 (104)	4.59 ± 0.06 a
April	282 ± 148.5 (640)	4.84 ± 0.16 a	236 ± 75.4 (465)	4.87 ± 0.10 a
May	192 ± 83.7 (279)	4.72 ± 0.17 a	210 ± 56.2 (389)	4.84 ± 0.10 a
June	63 ± 35.0 (122)	4.32 ± 0.12 a	256 ± 103.5 (561)	4.68 ± 0.10 a
July	55 ± 21.4 (60)	4.44 ± 0.11 a	126 ± 71.0 (278)	4.46 ± 0.09 a
August	105 ± 25.8 (124)	4.90 ± 0.10 a	94 ± 18.7 (145)	4.77 ± 0.09 a
September	30 ± 7.4 (36)	4.38 ± 0.09 a	65 ± 12.1 (90)	4.71 ± 0.09 b
December to September	103 ± 21.6 (165)	4.59 ± 0.04 a	198 ± 24.7 (379)	4.78 ± 0.03 b

Means within a row with different letters are different ($P < 0.05$).
[a] Arithmetic means ($\times 10^3$).
[b] Values in parenthesis are the number of bacteria in bulk tank.

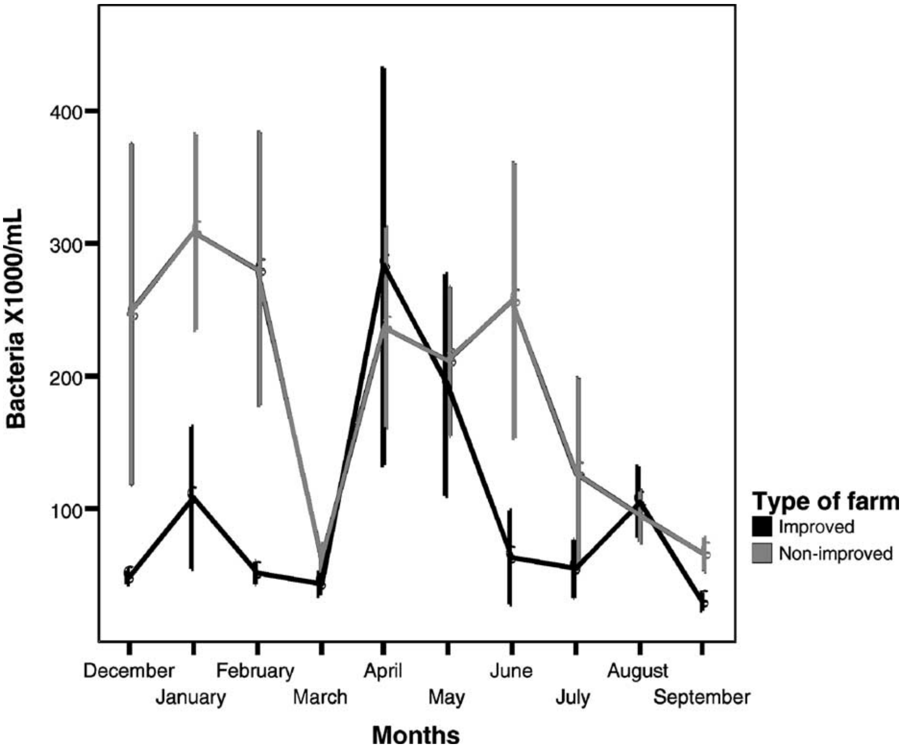

Fig. 1. Change during the months of study in the number of bacteria (±S.E.) in goat milk samples from the tank on farms improved or not-improved with hygiene-sanitary measures.

Table 2
Mean values (±S.E.) of bacteria/ml in goat milk samples from farms using hand-milking or machine-milking and according to sample type and herd size

	Hand-milking		Machine-milking	
	A.m.[a]	$\log_{10}$ bacteria	A.m.[a]	$\log_{10}$ bacteria
Sample type				
From udder	46 ± 6.5	4.39 ± 0.04 a, A	85 ± 12.2	4.68 ± 0.04 b, A
Churn	84 ± 15.9	4.53 ± 0.05 A		
Bulk or collective tank[b]	262 ± 53.6	4.89 ± 0.06 a, B	362 ± 66.1	5.12 ± 0.05 b, B
Herd size (number of goats)				
<75	55 ± 12.8 (91)	4.39 ± 0.05 A	–	–
76–150	112 ± 30.0 (217)	4.64 ± 0.05 a, AB	200 ± 61.2 (338)	4.82 ± 0.05 b
151–225	140 ± 37.0 (231)	4.70 ± 0.10 a, B	191 ± 29.4 (236)	4.98 ± 0.08 b
225	211 ± 53.5 (477)	4.71 ± 0.07 B	206 ± 57.7 (338)	4.89 ± 0.06

Means within a row (a, b) or column (A, B) with different letters are different ($P < 0.05$). The values in parenthesis, the number of bacteria in bulk tank.
[a] Arithmetic means ($\times 10^3$).
[b] Collective tank refers to the tank of the cooperative, in the case of farms using hand-milking.

farms using machine-milking presented a greater bacteriological contamination. Interaction between the two factors ($P < 0.05$) showed that in the case of the area using hand-milking, milk was contaminated significantly in the period from the end of milking at the farm until its arrival at the bulk tank of the cooperative (Table 2).

Regarding herd size, its interaction with area and milking method was significant ($P < 0.05$): in the area using hand-milking, the farms with fewer animals (<75) presented a lower number of bacteria (55,000 bacteria/ml) than did the larger farms (>150 goats and >140,000 bacteria/ml), whereas no significant differences were observed between the farms using machine-milking (Table 2).

The SCC showed no significant differences with respect to type of sample, but there was an effect for the sampling month ($P < 0.001$; Table 3 and Fig. 2): December and March presented the lowest concentration, and August and September the highest.

Differences were observed for the type of farm ($P < 0.01$) and area-milking method ($P < 0.01$): the farms with improved hygiene-sanitary measures (1,564,000 cells/ml versus 2,354,000 cells/ml for the non-improved farms) and those using hand-milking (1,785,000 cells/ml versus 2,534,000 cells/ml for those using machine-milking) presented the lowest SCC. Differences were also significant for herd size ($P < 0.01$) and its interactions (Table 4) with area-milking method ($P < 0.01$) and type of farm ($P < 0.05$), so that no significant differences were observed for these two factors when the herd size was small (<150 goats), though they were when it was large.

Table 5 shows the relationship between the main aspects of farm hygiene-sanitary management and some of the factors found to be significant. It can be seen that the improved farms and those having fewer animals present the highest percentages for compli-

Table 3
Mean values (±S.E.) of somatic cells/ml in goat milk samples by month

Months	A.m.[a]	$\log_{10}$ cells
December	1681 ± 168	6.10 ± 0.05 a
January	2295 ± 367	6.22 ± 0.04 ab
February	2132 ± 225	6.18 ± 0.05 ab
March	1382 ± 114	6.04 ± 0.04 a
April	1738 ± 170	6.17 ± 0.04 ab
May	1896 ± 140	6.20 ± 0.03 ab
June	1824 ± 131	6.20 ± 0.03 ab
July	2307 ± 183	6.30 ± 0.04 ab
August	3023 ± 204	6.43 ± 0.04 b
September	3809 ± 736	6.39 ± 0.08 b
December–September	2121 ± 83	6.21 ± 0.01

Means within a column with different letters are different ($P < 0.05$).
[a] Arithmetic means ($\times 10^3$).

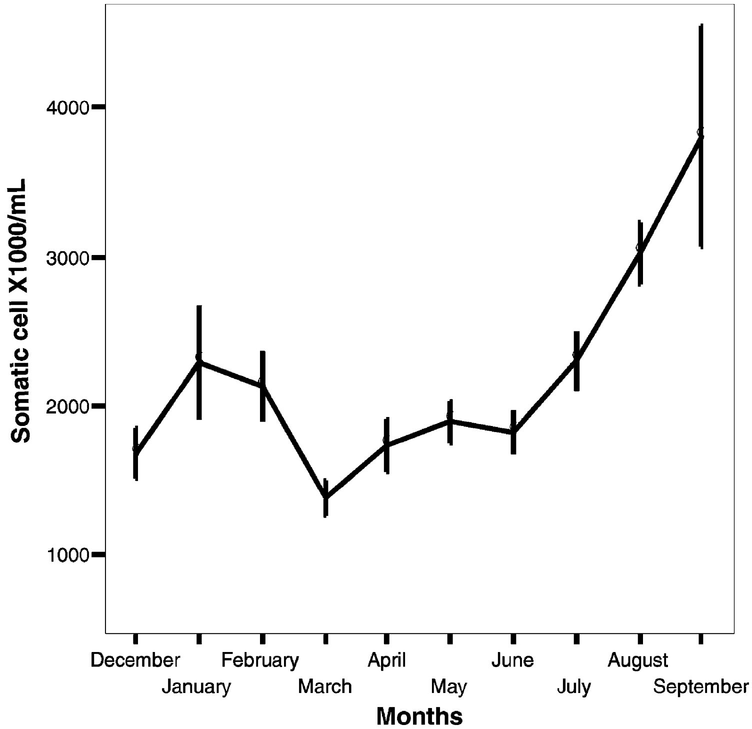

Fig. 2. Somatic cell counts (SCC) in goat milk samples (±S.E.) during the months of study.

ance with most of the hygiene-sanitary measures. However, and despite the lower bacteria and somatic cell counts for the farms using hand-milking, those using machine-milking presented a slight superiority in certain measures. Also analyzed was the association between those aspects of management and of other environmental, factors (presence of rainfall, mean temperature) and month, ranked by bacteria count. There was an association with the factor rainfall ($\chi^2 = 8.8$, $P < 0.05$) and, consequently, animals being somewhat more dirty ($\chi^2 = 6.1$, $P < 0.05$). Similarly, a relationship was found between season and months ranked by cell count ($\chi^2 = 220$, $P < 0.001$): the months of highest values were those towards summer.

With respect to the biochemical composition of the milk, the mean for the samples analyzed ($n = 555$) was 3.62% for protein and 4.97% for fat. The correlation of these variables with SCC and number of bacteria was positive ($P < 0.01$) only for SCC and the percentages of fat ($r = 0.21$) and protein ($r = 0.49$).

4. Discussion

In contrast to cow milk, the limit for SCC in ewe and goat milk has not yet been definitely established (Boyazoglu and Morand-Fehr, 2001). Nevertheless, for Europe and for fresh milk, some experts (unpublished data) have advised a threshold of 1,500,000 cells/ml. For the case of number of bacteria, Spanish legislation (Real Decreto 402/96, modifying 1679/94), following the directives of the European Union (92/46 and 94/71), set the limit at 500,000 bacteria/ml for fresh milk. In the present work, 20% of the farms under the habitual local hygiene-sanitary management presented a mean bacteria count above 500,000 bacteria/ml in the samples taken from the refrigeration tank. These data are better than those obtained by the Laboratorio Interprofesional Lácteo (Interprofessional Dairy Laboratory) of Castilla-León in 1997 (unpublished data), in which 44% of the farms were below 500,000 bacteria, 17% between 500,000 and 1 million, and 22% between 1 and 3

Table 4
Mean values (±S.E.) of somatic cells/ml according to area-milking method, type of farm and herd size

	Herd size (number of goats)							
	<75		76–150		151–225		>225	
	A.m.[a]	$\log_{10}$ cells	A.m.[a]	$\log_{10}$ cells	A.m.[a]	$\log_{10}$ cells	A.m.[a]	$\log_{10}$ cells
Type of farm[b]								
Improved	1024 ± 128	5.88 ± 0.05 a	1934 ± 337	6.19 ± 0.06 b	1881 ± 169	6.16 ± 0.05 b, A	1649 ± 128	6.16 ± 0.04 b, A
Non-improved	1072 ± 115	6.12 ± 0.06 a	1985 ± 156	6.19 ± 0.02 b	3389 ± 473	6.40 ± 0.04 c, B	2552 ± 129	6.3 ± 0.02 bc, B
Area								
Hand-milking	1038 ± 97	5.90 ± 0.04 a	1931 ± 103	6.23 ± 0.02 b	1831 ± 182	6.16 ± 0.05 b, A	2209 ± 141	6.27 ± 0.03 b
Machine-milking	–	–	2035 ± 288	6.15 ± 0.04 a	3212 ± 414	6.37 ± 0.04 b, B	2466 ± 162	6.32 ± 0.03 b

Means within a row (a, b, c) or column (A, B) with different letters are different ($P < 0.05$).

[a] Arithmetic means ($\times 10^3$).

[b] Refers to farms improved or not improved with hygiene-sanitary measures.

million. With regard to SCC, 20% of those farms presented a count of between 1 and 1.5 million, 10% between 1.5 and 2 million, and 70% exceeded 2 million, higher values in general than those obtained by other authors. Droke et al. (1993) reported that 62% of 71 farms had an SCC above 1 million cells in the refrigeration tank, while Galina et al. (1996), in 1046 milk samples tested, reported 44% showing an SCC below 250,000, 36% from 250,000 to 1 million, and 20% exceeding 1 million.

A first significant source of microbial contamination of the milk was its handling from leaving the udder (65,000 bacteria/ml) until arriving at its destination for refrigeration (the farm tank in the case of farms using machine-milking, with 362,000 bacteria/ml, or the bulk tank of the cooperative for the farms using hand-milking, with 262,000 bacteria/ml). This could be due to poor hygiene of the milking equipment and milk storage tank, and to an incorrect refrigeration temperature. As expected, for SCC there were no differences depending on type of sample, as also indicated by Zeng and Escobar (1996). In contrast, for both variables, the hygiene-sanitary management and its continuity over time were significant. The farms that since the beginning of this study had improved management by putting into effect a series of measures (the improved farms) presented a lower bacteria count (for the milk sample taken in the refrigeration tank: 165,000 bacteria/ml) and a lower SCC (1,564,000 cells/ml) than the non-improved farms (379,000 bacteria/ml and 2,354,000 cells/ml). However, and with regards to bacteria, the differences were significant only in the first months (December–February), possibly due to a certain improvement from February, as deduced from the surveys, of the hygiene-sanitary norms observed on most of the non-improved farms. On these farms, despite the farmers' initial saying they were not going to make any change in management, they did make some improvements as a response to the coming into effect of the European directives (and consequently the increased payment for hygiene-sanitary quality of the milk) and by imitation of the improved farms.

Table 5
Main aspects of hygiene-sanitary management of the farms and relationship with different sources of variation[a]

Variable of management	Type of farm: improved or not with hygiene-sanitary measures			Area-milking method			Herd size (total number of goats)[b]				
	Improved	Non-improved	χ^2	Hand	Machine	χ^2	<75	76–150	151–225	>225	χ^2
Milking parlour	95.5	69.5	18.1***	58.3	92	35.2***	85.7	42.4	61.5	55.2	10.1*
Cleanliness of milking parlour	87	63.9	12.3***	69.4	72.2	0.2	73.9	60.6	84.6	69	2.8
Cleanliness of milking equipment	89.9	86.5	0.5	73.5	98.4	31.4***	95.7	66.7	53.8	72.4	9.2*
Sealing-off performed	78.3	16.1	80.7***	28.6	40.5	3.4	43.5	3	61.5	31	20.1***
Clean clothing	47.8	9	43.3***	10.2	29.4	12.2***	26.1	9.1	7.7	0	9.8*
Cleanliness of farm	89.9	35.7	56.0***	42.3	60.3	7.2**	73.9	24.2	69.2	25	21.1***
Cleanliness of animals	88.4	70.8	8.2**	71.1	80.2	2.5	91.3	63.9	84.6	57.1	9.3*
Cleanliness of dairy[c]	100	88	4.4*								
Checking of milking equipment[c]	97.1	21.7	57.8***								
Time of milk transport: 2 h[b]	97.1	74.2	8.1**				78.3	72.7	84.6	96.4	6.3

[a] Data express % of farms carrying out or meeting such management condition. For the variables of cleanliness, those having a level of cleanliness from 3 or 4, within a scale from 1 to 4, are included.

[b] Includes only farms using hand-milking. The variable "time of milk transport" refers to the time taken by the farmers to transport it from the farm to the bulk tank of the cooperative.

[c] Includes only farms using machine-milking.

* $P < 0.05$.

** $P < 0.01$.

*** $P < 0.001$.

As observed in Table 5, the greater care in hygiene (cleanliness of the farm, of the animals, and of the milking parlour), sealing-off the udders, checking of the milking equipment on the farms using machine-milking, or non-delay in transporting the milk to the cooperative tank in the case of hand-milking, would explain the better results of the improved farms. Both for these farms and for the non-improved ones, the mean levels of bacteria count were within the limits established by the EU, and only the non-improved farms would exceed the recommended limit for SCC. However, all the farms would be above the limits for somatic cells established in other countries, such as Norway (1,200,000 cells/ml) and the USA (1,000,000 cells/ml) (Contreras et al., 1997). Nevertheless, many studies (Dulin et al., 1983; Droke et al., 1993; Wilson et al., 1995) suggest that the most generally accepted legal limit (1,000,000 cells/ml) may not be appropriate (a high percentage of milk coming from uninfected udders has an SCC that is higher) and could block the development of the goat milk industry.

The study areas, characterized by the milking method among other factors, presented differences both in the bacteria count (362,000 bacteria/ml in the milk samples from the tank on farms using machine-milking versus 262,000 bacteria/ml on those using hand-milking) and in the SCC (hand: 1,785,000 cells/ml; machine: 2,534,000 cells/ml). No Spanish studies analyzing this factor in goats are known, although there are studies in sheep with somatic cells. The results from these few studies are comparable between the two systems (Bergonier et al., 1996; Zeng and Escobar, 1996). In this species, the cell formula of the milk hardly shows differences depending on milking method (Gonzalo and Gaudioso, 1983, 1985; Iturritza and Beltran, 1987), but the work of Gonzalo et al. (1996), studying milk samples from the bulk tank, obtained contrasting results depending on the geographical area of the analysis. According to all these authors, the differences might be attributable more to physiological effects (higher proportion of alveolar milk—and thus of cells—in hand-milking or machine-milking with manual checking), zootechnic effects (different production systems and breed), or hygiene. In our study, as observed in Table 5, no obvious differences have been found between the two areas with regard to the measures of hygiene-sanitary management, since, despite the lower bacteria and somatic cell counts for the farms using hand-milking, those using machine-milking presented slightly higher values for some of these measures, possibly implying the effect of other factors, such as those indicated by the mentioned authors. The high level of somatic cells in this area could be due to a high rate of subclinical mastitis (Sánchez, personal communication). Moreover, part of the difference found between the two areas could be due to a different predominance of breeds (Florida Sevillana and Blanca Andaluza in the area with hand-milking, and Payoya in that with machine-milking), as other authors have already observed, although for other breeds (Park and Humphrey, 1986; Sung et al., 1999). However, other authors (Zeng and Escobar, 1996) found no differences between the breeds studied.

Another factor with significant effect was herd size. Milk from the farms with fewer animals presented a better hygiene-sanitary quality, above all for the farms using hand-milking (Tables 2 and 4). However, although all the farms would be below the EU limit for the number of bacteria, only those farms with fewer than 100 animals met the recommended limit for SCC. The differences observed between farms could be due to the different hygiene-sanitary management, as reflected in Table 5 in the case of the farms using hand-milking (higher degree of cleanliness of the farm in general and of the animals in particular, and the existence of a separate milking parlour).

Regarding the sampling month, in contrast to what might be expected, the number of bacteria did not increase, and was even lower in the months of highest environmental temperature (significantly, July showed the lowest number). This would mean that the bacteriological quality can be maintained in hot months if the farmer carries out an appropriate management and keeps the refrigeration tank at a correct temperature. The higher counts in certain months (January, April) may be associated with the existence of rainfall (χ^2, $P < 0.05$) and, consequently, to somewhat dirtier animals (χ^2, $P < 0.05$). The month also affected SCC, with December and March presenting the lowest concentration, and August and September the highest. This factor could be affected by the change in number of cells during lactation, with an increase towards its end (Dulin et al., 1983; Rota et al., 1993; Zeng and Escobar, 1996; Galina et al., 1996; Zeng et al., 1997; Fahr et al., 1999), and may be considered the non-infectious factor of greatest effect on somatic cell count (Gonzalo, 1996). At farm level, this could be reflected as a seasonal variation in SCC in milk samples taken from the tank. This was considered to be the case by Hinckley (1991), who, studying this type of sample, obtained the lowest value in April and the highest in September and October, reflecting the number of fresh mid- and late-lactation days. In our study, there was a relationship between the season and the months ranked by cell number (χ^2, $P < 0.001$), in which the months of highest values were those towards summer, when lactation finished in both areas (Mena et al., 1999b; Castel et al., 2000).

In the relationship of biochemical composition with the parameters of hygiene-sanitary quality, a positive correlation was obtained between SCC and the percentages of fat ($r = 0.21$) and protein ($r = 0.49$). Sung et al. (1999) found similar correlation coefficients: 0.23 for fat and 0.38 for protein. Other authors also observed this significant correlation between SCC and fat and protein (Park and Humphrey, 1986; Zeng and Escobar, 1996; Zeng et al., 1997). No correlation was observed between the number of bacteria and the SCC, as reported by Park and Humphrey (1986), nor with biochemical composition.

5. Conclusions

Most of the semi-extensive goat farms studied, under the habitual management of each farmer, obtained a milk of acceptable bacteriological quality, but did not meet the recommended SCC quality level. However, the establishment of appropriate conditions of hygiene-sanitary management on the farms substantially improved the bacteriological quality and enabled SCC to fall below recommended limits. At the same time, giving particular attention to the conditions of hygiene when handling the milk could improve its quality, as a marked bacteria contamination was observed in the period from leaving the udder until arrival at the refrigeration tank. On the farms using hand-milking, a milk of greater hygiene-sanitary quality was obtained, although this result could have been affected by other factors not studied (breed, existence of subclinical mastitis, etc.) and which should be examined. In certain environmental conditions, such as rainfall, the measures of hygiene on a farm should be maximized, as the bacteria count of the milk was highest in the wettest months.

Acknowledgements

The authors thank the Dirección General de Investigación y Formación Agraria of the Consejería de Agricultura y Pesca (Junta de Andalucía) and the Federación Andaluza de Empresas Cooperativas for the provision of funding (Project C-97-078), and the cooperatives Corsevilla and Nuestra Señora de los Remedios for technical help in the gathering of the samples.

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