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Comparison of goat milk standards with cow milk standards for analyses of somatic cell count, fat and protein in goat milk

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Abstract

Goat milk standards and cow milk standards were used to calibrate a Fossomatic-300 fluorescent cell counter and Dairylab II infrared milk analyzer for analyses of goat milk samples. Somatic cell counts (SCC) of goat milk were 27% lower (5.5×10^5 ml $-$ 1 versus 7.0×10^5 ml $-$ 1) when the Fossomatic-300 was calibrated with goat milk SCC standards than with cow milk SCC standards ($P < 0.001$). When the Dairylab II was calibrated with goat milk component standards, the levels of fat and protein in milk samples were 0.04% and 0.27% higher, respectively, than with cow milk component standards ($P < 0.001$). The data indicated that Fossomatic instruments and infrared milk analyzers must be calibrated with goat milk standards for more reliable and accurate analysis of goat milk.

Keywords: Somatic cell count; Fat; Protein; Goat milk standard

1. Introduction

Goat milk and its products are popular among health conscious consumers and certain ethnic groups in the United States (Park, 1990). To ensure high standards of quality and product safety, raw goat milk must conform to the regulatory standards of sanitation and quality. There are approximately 1.5 million dairy goats in the United States, which generate an estimated revenue of 500 million dollars (Haenlein and Hinckley, 1995). However, only 12 000 dairy goats are enrolled in the Dairy Herd Improvement Association (DHIA) testing program nationwide (National DHIA, Columbus, OH, unpublished data, 1995). The methodology of goat milk sample analysis is the same as that of cow milk sample analysis in all DHIA laboratories. Somatic cell counts (SCC) are commonly determined using an automated electronic means such as Fossomatic machines. Chemical components (fat, protein, lactose and solids–non-fat) are analyzed using infrared milk analyzers. All DHIA laboratories participate in the mandatory submission of unknown sample test results for both instruments on a monthly basis. Results are verified against standard references at the National DHIA. Weekly routine tests, such as calibration, repeatability, zero reading, homogenization efficiency and purging efficiency, are performed and records are kept according to the guidelines of the DHIA Laboratory Quality Certification Manual (DHIA, 1994).

Significant differences exist in secretory systems and milk composition between cows and goats. Thus,

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the methodologies for cow milk testing and the instruments calibrated with cow milk standards may not be reliable and accurate for analyzing goat milk (Poutrel and Lerondelle, 1983; Maisi, 1990; Atherton, 1992). Haenlein and Hinckley (1995) reviewed the status of SCC in goat milk in the United States and urged that the current methods and testing instruments for cow milk be modified and re-calibrated for goat milk.

The objective of the present investigation was to compare the results for SCC and chemical composition of goat milk using Fossomatic-300 and Dairylab II that were calibrated with either cow milk standards or goat milk standards.

2. Materials and methods

2.1. Standard preparation

Two sets of cow and goat milk standards, one for SCC and another for milk components, were made by the Dairy Quality Control Institute (DQCI) Services, Inc., St. Paul, MN. Cow milk standards were regular commercial standards used by DHIA laboratories. Goat milk standards were specifically made for this study. Fourteen samples of fresh goat milk (approximately 250 ml each), collected from the Alpine herd in the E. (Kika) de la Garza Institute for Goat Research at Langston University, were provided to DQCI for goat milk standard preparation. Four of these samples with different ranges of SCC were used for preparing SCC standards, following the official pyronine Y-methyl green direct microscopic method of Packard et al. (1992). The other ten samples, each pooled from two to three different individual goats, were used for component standards preparation. The standard reference for fat content standard was obtained using the Mojonnier method (Bradley et al., 1992), while the standard reference for protein content was determined by the Kjeldahl method (Bradley et al., 1992).

2.2. Sample collection

Teats of all milking does were washed with iodine solution and dried with single service paper towels prior to milking. Duplicate milk samples of all healthy milking goats from the Alpine herd at the E. (Kika) de la Garza Institute for Goat Research were collected into plastic milk sample vials (Capital Vials, Fultonville, NY) after the first three to four strippings were discarded. Samples were preserved with Microtabs (Control Systems, Inc., San Ramon, CA), stored at 4°C, and analyzed within 24 h. The SCC experiment was conducted at four different stages of lactation (approximately 45, 90, 120 and 155 days in lactation) while the component comparison was carried out at three stages of lactation (approximately 90, 120 and 155 days after parturition).

2.3. Determination of somatic cell count

One set of milk samples was analyzed for SCC using the Fossomatic-300 instrument (Foss Electric, Hillerod, Denmark) calibrated with goat milk SCC standards according to the instruction manual. The instrument was re-calibrated with cow milk SCC

Table 1
Ranges of somatic cell counts (SCC × 10^3 ml^{-1}), fat (%) and protein (%) in goat and cow milk standards used for calibration in this study

Sample No.		1	2	3	4	5	6	7	8	9	10
SCC	Goat std [a]	125	317	925	1500						
	Cow std [b]	151	374	891	1127						
Fat	Goat std [c]	2.14	2.30	2.47	2.55	2.74	2.89	3.11	3.23	3.61	4.50
	Cow std [c]	2.09	3.03	3.43	3.99	4.65	3.22	3.55	3.68	3.89	4.68
Protein	Goat std [d]	2.85	2.62	3.06	2.58	2.82	3.05	2.84	2.57	2.91	3.12
	Cow std [d]	3.13	3.25	3.07	3.12	3.11	3.87	3.16	3.10	3.05	3.36

[a] By pyronine Y-methyl green direct microscopic method (Packard et al., 1992).
[b] By conventional direct microscopic method (Packard et al., 1992).
[c] By Mojonnier method (Bradley et al., 1992).
[d] By Kjeldahl method (Bradley et al., 1992).

Table 2
Comparisons of somatic cell counts (SCC, ln), fat% and protein% using instruments calibrated with either goat milk standards or cow milk standards

Variable	Obs.	Mean		Mean difference	SE [a]
		Goat STD	Cow STD		
Overall					
SCC	205	5.7390	5.8432	−0.1042 ***	0.0092
Samples of $> 10^6$ SCC ml^{-1}	77	6.3040	6.4119	−0.1079 ***	0.0113
Samples of $< 10^6$ SCC ml^{-1}	128	5.4115	5.5169	−0.1053 ***	0.0150
Fat (%)	177	3.14	3.09	0.0424***	0.0049
Protein (%)	177	2.66	2.39	0.2673***	0.0063

[a] Standard error.
*** $P < 0.001$.

standards and the same set of goat milk samples was re-analyzed.

2.4. Analyses of fat and protein

A duplicate set of goat milk samples was analyzed for fat and protein using the Dairylab II (Multispec Ltd., Weldrake, York, UK). The milk analyzer was first calibrated with goat milk component standards following the method described in the instruction manual. Fat and protein contents of goat milk samples were determined. The instrument was then re-calibrated with cow milk component standards, and the same set of goat milk samples was re-analyzed.

2.5. Statistical analysis

The paired comparison t-test of the SAS Institute Inc. (1989) was used to determine the differences between variables (SCC, fat% and protein%) of goat milk obtained by instruments calibrated with either cow or goat milk standards. Stages of lactation were considered as blocks. SCC data were transformed into natural logarithms for statistical analysis.

3. Results and discussion

The ranges of SCC ($n = 4$) and milk components ($n = 10$) in goat and cow milk standards are shown in Table 1. SCC of goat milk standards ranged from 1.25×10^5 to 1.5×10^6 ml − 1 while SCC of cow milk standards were between 1.51×10^5 and 1.13×10^6 ml − 1. The ranges of fat% in goat and cow milk standards were 2.14–4.50% and 2.09–4.68%, respectively. Protein references were from 2.57 to 3.12% for goat milk standards and from 3.05 to 3.87% for cow milk standards. After each calibration, the Fossomatic-300 was checked for zeroing and repeatability and Dairylab II for zeroing, repeatability, purging efficiency and homogenization efficiency. Both instruments met the quality specifications of the National DHIA (1994) before samples were analyzed.

Means of SCC (ln) in goat milk are shown in Table 2. Mean SCC of all samples tested were 5.5×10^5 ml − 1 (ln = 5.739) and 7.0×10^5 ml − 1 (ln = 5.8432) when Fossomatic-300 was calibrated with goat milk SCC standards and cow milk standards, respectively. The estimation of SCC in goat milk obtained by the machine calibrated with cow milk standards was 27.3% higher than the result obtained by the same machine but calibrated with goat milk standards ($P < 0.001$). Among the samples tested ($n = 205$), 37.6% ($n = 77$) exceeded the one million legal limit established by the FDA in the Pasteurized Milk Ordinance (PMO) for Grade A raw goat milk (PMO, 1993). When all goat milk samples were classified into two groups based on the SCC limit, i.e. those with $< 1.0 \times 10^6$ ml − 1 and those with $> 1.0 \times 10^6$ ml − 1, similar findings existed in both the low SCC group and the high SCC group (20.8% and 29.1% higher, respectively).

Ideally, SCC is the number of leukocytes in milk. Unfortunately, epithelial cells are also counted by the Fossomatic instrument. Epithelial cells come from organic tissues during milk synthesis and secretion.

They account for a small but relatively constant part of the milk. It has been reported that goat milk contains more epithelial cells than cow milk (Park and Humphrey, 1986). Scanning electron microscopy and flow cytometry demonstrated marked differences in the granulation and density of somatic cells in goat and cow milk, resulting in different competency and functionality of the cells (Dulin et al., 1982, Dulin et al., 1983; Droke et al., 1993). In goat milk, there are also large numbers of cytoplasmic particles from the apocrine secretory system of dairy goats (Dulin et al., 1982, Dulin et al., 1983). Cytoplasmic particles are not classified as cells because they do not contain nuclei and DNA. Therefore, somatic cell counting methods specific for DNA binding will not count them as SCC. These distinguishing characteristics of goat and cow milk can create errors when cow milk SCC standards are used for goat milk SCC determination. The pyronine Y-methyl green stain method used for goat milk standard preparation differentiates between leukocytes and cytoplasmic particles, excluding cytoplasmic particles from total SCC (Packard et al., 1992). Therefore, it is recognized by the FDA as the official confirmative method for goat milk SCC determination.

The comparison of fat and protein contents obtained by cow and goat milk standards is also shown in Table 2. The fat and protein percentages of goat milk samples ($n = 177$) analyzed with the Dairylab II calibrated with goat milk component standards were 0.04 and 0.27 higher ($P < 0.001$), respectively, than those with the milk analyzer calibrated with cow milk standards. Although the difference in fat content was significant, it was within the acceptance of DHIA quality certification (± 0.04). The difference in protein content due to the different standards used was above the DHIA maximum allowance (± 0.04). When the milk analyzer was calibrated with the conventional cow milk standards it underestimated fat and protein contents in goat milk. These results indicate that a tremendous economic loss could be suffered by producers if a multiple component price incentive program is implemented.

According to Bradley et al. (1992), analyses of milk components by IR instruments depend on calibrations against suitable reference standards. A study in the UK reported that infrared milk analyzers calibrated with cow milk standards generated incorrect results for sheep milk analysis (Harris, 1986). Using eight sheep milk samples, this researcher observed 0.39% and 0.34% higher fat and protein contents, respectively, by official chemical methods than by an infrared instrument calibrated with cow milk standards. Barbosa and Miranda (1984) compared an infrared milk analyzer calibrated with cow milk standards with official chemical methods for fat and protein analyses of goat milk. Significant differences of fat and protein contents were found, where higher fat% and lower protein% were obtained by the instrument calibrated for cow milk than by the official chemical methods.

Fat and protein of goat milk are different from those of cow milk in many ways. Goat milk consists of a higher proportion of small fat globules than cow milk and is more homogeneous than cow milk because the smaller sizes of fat globules in goat milk provide a better dispersion (Haenlein, 1984). Although fat globules of goat and cow milk are similar in composition and properties (Jenness, 1980), goat milk does not contain a substance called agglutinin in fat globule membranes. Agglutinin causes fat globules of cow milk to cluster more easily. Goat milk fat contains a higher concentration of short-chain fatty acids (C_4–C_{14}) than cow milk (Jenness, 1980; Loewenstein, 1982). Basic fractions of proteins in goat and cow milk are similar in κ-casein, β-casein, α_{s2}-casein, α-lactalbumin and β-lactoglobulin (Jenness, 1980). However, the content of α_{s1}-casein in goat milk varies markedly, as compared with that in cow milk. Martin and Addeo (1995) observed a complex and diverse polymorphism of α_{s1}-casein in goat milk, which was partly responsible for the individual variability of casein content. Also, goat milk consists of a lower percentage of casein in total protein than does cow milk, i.e. 71–78% versus 75–85% (Loewenstein, 1982). It is apparent that variations in the components of fat and protein as well as in the composition of individual fatty acids and amino acids in goat milk versus cow milk make it inadequate and unreliable to use cow milk standards for goat milk analysis.

4. Conclusion

Results from this study indicated that Fossomatic-300 and Dairylab II calibrated with cow milk stan-

dards overestimated somatic cell counts and underestimated protein and fat contents for goat milk, respectively. Goat milk standards (SCC and components) must be used to calibrate the instruments for reliable analysis of goat milk. However, it is not practical to use goat milk standards for instrument calibrations in every DHIA laboratory when a small number of goat milk samples are to be analyzed because of the cost for the standards and the time for calibration. If a central DHIA laboratory is set up to analyze goat milk exclusively, this laboratory could obtain more reliable and accurate results by using goat milk standards for calibration at a cheaper rate.

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References

Atherton, H.V., 1992. Using somatic cells and antibiotic tests for determining the quality of goat milk. In: T.A. Gipson S. Hart and L.T. Trong (Editors), Proc. National Symposium on Dairy Goat Production and Marketing. Langston University, OK, pp. 128–135.

Barbosa, M. and Miranda, R., 1984. Addendum to Special Publication No. 49. Changes to Contemporary Dairy Analytical Techniques. Royal Society of Chemistry, London, UK.

Bradley, R.L., Arnold, E., Barbano, D.M., Semerad, R.G., Smith, D.E. and Vines, B.K., 1992. Chemical and physical methods. In: R.T. Marshall (Editor), Standard Methods for the Examination of Dairy Products. American Public Health Association, Washington, DC, pp. 433–531.

DHIA, 1994. Quality Certification Manual. National Dairy Herd Improvement Association, Columbus, OH. pp. 1–32.

Droke, E.A., Paape, M.J. and Di Carlo, A.L., 1993. Prevalence of high somatic cell counts in bulk tank goat milk. J. Dairy Sci., 76: 1035–1039.

Dulin, A.M., Paape, M.J. and Weinland, B.T., 1982. Differentiation and enumeration of somatic cells in goat milk. J. Food Prot., 45: 435–439.

Dulin, A.M., Paape, M.J., Schultze, W.D. and Weinland, B.T., 1983. Effect of parity, stages of lactation, and intramammary infection on concentration of somatic cells and cytoplasmic particles in goat milk. J. Dairy Sci., 66: 2426–2433.

Haenlein, G.F.W., 1984. Goat milk versus cow milk. In: G.F.W. Haenlein and D.L. Ace (Editors), Extension Goat Handbook, USDA Extension Services, Washington, DC, Fact Sheet E-1, pp. 1–4.

Haenlein, G.F.W. and Hinckley, L.S., 1995. Goat milk somatic cell count situation in USA. Internat. J. Anim. Sci., 10: 305–310.

Harris, W.M., 1986. Automated determination of fat, crude protein, and lactose in ewe milk by infrared spectrometry. Analyst, 111: 37–39.

Jenness, R., 1980. Composition and characteristics of goat milk: review 1968–1979. J. Dairy Sci., 63: 1605–1630.

Loewenstein, M., 1982. Dairy goat milk and factors affecting it. In: Proc. 3rd Intern. Conference on Goat Production and Disease, Tucson, AZ, pp. 226–236.

Maisi, P., 1990. Milk NAGase, CMT antitrypsin as indicators of caprine subclinical mastitis infections. Small Rumin. Res., 8: 129–139.

Martin, P., and Addeo, F., 1995. Genetic polymorphism of caseins in the milk of goats and sheep. Proc. Intern. Dairy Federation Seminar on Production and Utilization of Ewes and Goats Milk, Limin-Hersonissos, Crete, Greece, 1 pp.

Packard, V.S., Tatini, S., Fugua, R., Heady, J. and Gilman, C., 1992. Direct microscopic methods for bacterial or somatic cells. In: R.T. Marshall (Editor), Standard Methods for the Examination of Dairy Products. American Public Health Association, Washington, DC, pp. 309–325.

Park, Y.W., 1990. Nutrient profiles of commercial goat milk cheeses manufactured in the United States. J. Dairy Sci., 73: 3059–3067.

Park, Y.W., and Humphrey, R.D., 1986. Bacterial cell counts in goat milk and their relationships with somatic cell counts, percent fat, protein. J. Dairy Sci., 69: 32–37.

PMO, 1993. Grade A Pasteurized Milk Ordinance. US Department of Health and Human Services, Washington, DC, 14 pp.

Poutrel, B. and Lerondelle, C., 1983. Cell content of goat milk: CMT, Coulter Counter and Fossomatic for predicting half infection. J. Dairy Sci., 66: 2575–2579.

SAS Institute Inc., 1989. SAS/STAT User's Guide: Statistics. SAS Institute Inc., Cary, NC, pp. 1633–1639.