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Quality of raw milk for human consumption in two locations in Sucre, Colombia

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ABSTRACT

Objective. To determine the physicochemical, microbiological and somatic cell count of raw milks marketed for human consumption in neighborhoods of Sincelejo and Corozal (Sucre). **Materials and methods**. A cross-sectional study was carried out in 97 samples of raw milk marketed for human consumption in different neighborhoods of Sincelejo and Corozal (Sucre). Physical-chemical, microbiological and somatic cell count parameters were determined. The data obtained were analyzed according to the regulations in normative measures in Colombia. **Results.** Most of the physical-chemical parameters of the raw milk samples analyzed were found within the normal range according to Colombian legislation. Mesophilic count and somatic cells count was found to be above what is allowed by the legislation. The presence of total and fecal coliforms, antibiotics and adulterants such as sucrose and starches were determined. **Conclusions.** Raw milks distributed for human consumption in Sincelejo and Corozal presents good physical-chemical quality but poor microbiological quality; it becomes necessary to increase surveillance and to demand the production of excellent quality milk in the primary sector in the dairy chain.

Keywords: Antibiotics, foods, risk, trade, zoonoses (*Source: NAL USDA*).

RESUMEN

Objetivo. Determinar la calidad fisicoquímica, microbiológica y recuento de células somáticas de leches crudas que se distribuyen para consumo humano en diferentes barrios de Sincelejo y Corozal (Sucre). **Materiales y métodos.** Mediante un estudio descriptivo de corte transversal, se tomaron 97 muestras de leche cruda; se determinaron algunos parámetros fisicoquímicos, microbiológicos y recuento de células somáticas. Los datos obtenidos se analizaron de acuerdo a la normatividad vigente en Colombia. **Resultados.** La mayoría de los parámetros fisicoquímicos de las muestras de leche cruda evaluadas se encontraron dentro de los parámetros normales de la legislación colombina. El recuento estándar en placa y el recuento de células somáticas se encontraron por encima de lo permitido por la legislación. Se demostró la presencia de coliformes totales, coliformes fecales, antibióticos y adulterantes como sacarosa y almidones. **Conclusiones.** La leche cruda que se distribuye para consumo humano en Sincelejo y Corozal presenta buena calidad fisicoquímica pero deficiente calidad microbiológica; se hace necesario incrementar la vigilancia y exigir al eslabón primario de la cadena láctea la producción de leche de excelente calidad.

Palabras clave: Alimentos, antibióticos, economía, riesgo, zoonosis (*Fuente: NAL USDA*).

INTRODUCTION

Milk provides essential nutrients such as calcium, magnesium, selenium, riboflavin, cyanocobalamin and pantothenic acid and is an essential source of energy and high quality proteins. Milk and its dairy products make diets that are composed of only vegetables more varied. Milk with an animal origin plays a significant role in the diet of infants, especially in populations with restricted access to other foods with an animal origin, such as meat (1).

The production of food of optimum quality for human consumption is a global concern and must ensure the production of raw materials with optimum quality under varying scenarios. In excellent quality milk, the highest percentages should be: protein> 3.2%, fat> 3.5%, and total solids> 12.2% and the counts should be mesophilic < 50000 CFU/mL and somatic cell< 100000 SC/mL (2). Furthermore, Colombian law provides that milk for human consumption must not have inhibitors, antibiotics, or adulterants and must be harmless (3).

The factors that influence the consumption of raw milk in Colombia include low levels of schooling and lower costs (4), along with the belief that raw milk has a high nutritional value compared to pasteurized milk. But, the consumption of raw milk as a complete food, together with its liquid state and poor handling, make for an excellent means for bacterial proliferation, with a direct impact on the transmission of foodborne diseases or FBD (5,6).

In Colombia, during 2013, 702,827 liters/day of raw milk were sold, which represented 4% of the national production, with local production; 5,078 people earned their livelihood from this trade (4). In Sincelejo, there is a large number of people who earn their living from the commercialization of raw milk (7).

The consumption of raw milk is a custom throughout Colombia, and this trade has been reported in 623 municipalities. It is a differentiated product in many regions, with its own marketing channels and a final captive consumer (4). The consumption of raw milk was recognized as one of the main causes of FBD in the USA and, between 1993 and 2006, produced 46 outbreaks that caused 930 reported illnesses and 71 hospitalizations in people under 20 years of age (8). In Colombia, there is no clear evidence on the impact of FBD, but there is evidence of the circulation of different pathogens such as *B. abortus*, *L. monocytogenes*, and *Salmonella* spp in raw milk (9,10,11).

Because of public health risks, Decree 616 of 2006 prohibited the trade of raw milk for human consumption (12), but Decree 2838 of the same year provided a transitory modification for the sale, marketing and cooling of raw milk for direct human consumption (13). Finally, Decree 1880 of 2011 established the minimum requirements for direct human consumption of raw milk in Colombia. The general objective was to establish the physicochemical quality, microbiological parameters and somatic cell counts in raw milks marketed for human consumption in neighborhoods from Sincelejo and Corozal (Sucre).

MATERIALS AND METHODS

Type of study. Descriptive cross-section.

Place of study. The sampling was carried out in the municipalities of Sincelejo located in the subregion Montes de María and Corozal located in the subregion Sabanas, municipalities that are located in the Department of Sucre, northwest Colombia, within the Caribbean region where tropical dry forests (TDF) predominate, cattle ranching prevails and milk production is one of the basic components of the economy (14,15).

In total, 97 samples of raw milk that marketed for direct human consumption in different neighborhoods of Sincelejo and Corozal (Sucre) were taken. Each sample was homogenized with a sterile, stainless steel hand stirrer for three or four minutes, then with a sterile stainless steel spoon. Two 200 mL samples were placed in two previously labeled sterile containers. All of the samples were collected in sterile blue cap bottles, previously labeled, which were preserved in iodine containers, ensuring a temperature between 4 and 7°C, until they were sent to the laboratory within 12 hours after collection, where the temperature of the containers and samples was checked with a thermometer, ensuring that a cold temperature was maintained in the chain.

In the first sample, the percentage of fat (% of fat), percentage of protein (% of protein), percentage of non-fatty solids (% of NFS), percentage of total solids (% of TS), mesophilic count with infrared spectroscopy and somatic cells count (SCC) with flow cytometry were determined. In the second sample, the Laboratorio del Instituto de Investigaciones Biológicas del Trópico (IIBT) of the Universidad de Córdoba analyzed the density (thermolactodensimeter), pH (pH meter), acidity (titration with sodium hydroxide 0.1N), adulterants (sucrose, ox bile solution), neutralizers (potassium

oxalate), starches (lugol), non-fatty solids (Bertuzzi index refractometer), total coliforms, fecal coliforms with a commercial method and antibiotic residues with a qualitative commercial technique. The samples were processed in less than 24 hours after collection.

Analysis of results. The data were tabulated in an Excel, and descriptive statistics were utilized with SAS. The indices were compared with Decree 616 of February 28, 2016 and Decree 1880 of May 27, 2011 from the Ministry of Social Protection, which regulates the requirements that raw milk must meet for human consumption in Colombia.

RESULTS

80.41% (78/97) of the raw milk samples were collected in Sincelejo, and 19.59% (19/97) marketed in Corozal (Sucre). Table 1 show the averages of the physicochemical, microbiological and somatic cell parameters in the raw milk marketed for human consumption in different neighborhoods of Sincelejo and Corozal. Informal traders sold 8,434 liters/day, with an average of 87 liters/day each.

Table 1. Physico-chemical, microbiological and somatic cells parameters in raw milks marketed for human consumption in neighborhoods from Sincelejo and Corozal (Sucre).

Parameters	Results	Decret 616/1880
Density (g/mL)	1.029	1.030 - 1.030
Acidity (% lactic acid)	0.17	0.13 – 0.17
pH	6.96	
Fat (%)	4.95	Above 3.0
Protein (%)	3.45	Above 2.9
Non-fat solids (%)	8.79	8.7 - 8.4
Total Solid (%m/v)	13.84	Above 11.3
Mesophilic (Cfu/mL)	1461866	700000
Somatic cells (CS/mL)	1002382	

The distribution by rank for the standard plate count (SPC) or mesophilic count, an indicator of the processes of obtaining and storing milk, is shown in Table 2, and the distribution of the somatic cells count (SCC), an indicator of udder health (mastitis) can be seen in Table 3.

The determination of adulterants, such as sucrose, was 4.10%, with 1.03% starches. Only 7.21 of the raw milk samples had inhibitors or antibiotics detected.

Table 2. Distribution of mesophilic counts in raw milk marketed for human consumption in neighborhoods from Sincelejo and Corozal (Sucre).

Range (Cfu/mL)	n	Frequency	Cumulative frequency
< de 25.000	3	3.09	3.09
25.001 to 50.000	0	0.00	3.09
50.001 to 100.000	3	3.09	6.18
100.001 to 150.000	8	8.25	14.43
150.001 to 200.000	7	7.22	21.65
200.001 to 300.000	11	11.34	32.99
300.001 to 500.000	6	6.19	39.18
500.001 to 700.000	1	1.03	40.21
> 700.001	58	59.79	**100.00**
TOTAL	**97**	**100.00**	

Table 3. Distribution of somatic cells in raw milk marketed for human consumption in neighborhoods from Sincelejo and Corozal (Sucre).

Range (CS/mL)	n	%
< 100.000	0	0
100.000 to 200.000	5	5.15
200.000 to 300.000	10	10.31
300.000 to 500.000	26	26.80
500.000 to 700.000	11	11.34
700.000 to 1.000.000	6	15.47
>1.000.000	30	30.93
TOTAL	**97**	**100.00**

DISCUSSION

It was determined that the average density of the milk samples (Table 1) was below the range established by Colombian law. Values below the range established in Colombia may be associated with several factors, including adulteration with solutes (16), nutritional deficiencies of cows (17), high mesophilic count and somatic cells (18,19).

In 32.96% of the samples, the density was outside that established by Decree 616, but normal density values for raw milk have been reported in Sucre (20,21).

The acidity had an average of 0.17% lactic acid, a high average, and, in order to decrease this increased acidity resulting from a lack of refrigeration and high environmental temperatures, the vendors rely on fixed customers and distribute their products in the early morning hours to inhibit bacterial proliferation, which converts lactose into lactic acid and increases acidity (22). Greater values of acidity have been determined in milk in Sucre, where factors such as high environmental temperatures (dry, warm climate), prolonged

transport times and commercial deliveries have been established as determinants of increased acidity (21). 54.59% of the samples were within the range established by Decree 616 for acidity; the increase in acidity was indicative of inadequate, hygienic quality and poor preservation of raw milk (2,21,22).

The acidity or pH potential of excellent quality milk is between 6.60 and 6.80 (23). In the present study, the pH was 6.96, with a minimum value of 6.30 and a maximum of 10.01; only 30.92% of the samples were within the normal range established by Colombian law. The increase in the pH value may have been due to the lack of refrigeration and storing the milk in plastic jugs, which favor bacterial proliferation that degrades lactose (2,21,22).

The average fat % was 4.95%; a value that is within Colombian standards. Lower percentages have been reported for different herds in Sucre (20.21). 6.18% of the samples were below the standard established by Colombian law, which may have been due to adulteration with solutes, nutritional deficiencies of the cows (17), and high mesophilic count and somatic cells (18,19) .

The average protein % was 3.45%, a high protein index, which may have been due to the crossbreeds, between *Bos taurus* and *Bos indicus*, a characteristic of a double purpose system where there is a smaller volume, but high percentages of protein, fat and total solids, among others (24). Likewise, this average was above values reported for different herds in Sucre (20.21). 96.91% of the samples were above the value established by law for raw cow milk for human consumption. In Colombia, in a national study, it was determined that 99% of raw milk samples were above 2.9% (4). The average NFS% was 8.79%, indicating that the milk had an excellent quality (2). In only 24.74% of the samples, this value was lower than 8.70%.

The average TS% was 13.84%, indicating excellent quality milk (3); lower indices have been reported in Sucre (20.21). This high average in the current study may have been due to the cross between *Bos taurus* and *Bos indicus*, presenting a dual purpose system (24). 4.1% of the samples were below the value determined by Decree 616. In a national study, 44.5% of the samples of raw milk for human consumption were below the standard established by Decree 616 (4).

The aerobic mesophilic count average was 1461866 CFU/mL, which exceeds the level allowed by Colombian law: 700000 CFU/mL (3) and is very high compared with international standards for milk for human consumption. Mesophilic count less than 100000 CFU/mL are ideal (2.25). In Sucre, very high values have been reported in raw milk (20,21), which may be due to the lack of hygiene in the milking processes and poor milk storage and storage practices (2,26).

Only 3.09% of the samples had counts less than 50000 CFU/mL (Table 2), indicating excellent microbiological quality, and the same percentage had counts of 100000 CFU/mL (Table 2), classified as normal milk quality. 93.82% of the mesophilic counts were high. The presence of high mesophilic count may have been due to inadequate milk transport and sales, lack of a cold chain, high environmental temperatures, prolonged sale times and collection of inappropriate materials (2,26).

In Colombia, the law does not establish the count of total coliforms and fecal coliforms as a criterion for evaluating the microbiological quality of raw milk. A high load of contaminating bacteria in milk decreases the useful life of processed products and safety (27). Raw milk cannot have more than 1000 coliforms/mL (2). The total and fecal coliform counts were 838941 coliforms/mL and 182155 coliforms/mL, respectively. The presence of fecal coliforms is an indicator of direct food contamination by fecal matter and implies an indirect risk of adding other pathogens (27,28) or a lack of good practices during milking (26). In eastern Antioquia, it has been suggested that improving milking management variables would increase the bacteriological quality of milk (29).

This study determined a high SCC, which indicates that the milk came from cows with a high prevalence of mastitis. The average SCC was 1002382 SC/mL (Table 1). This demonstrates the absence of programs for the prevention and control of bovine mastitis (30). A study on raw milk in Galeras, Sucre (Colombia), indicated that the mastitis index was greater than 20% (20). Milk from mastitis-free sources has a low SCC, and its increase is directly proportional to increases in the degree of mastitis (18,31).

The result obtained for the presence of antibiotics in the milk samples was 7.21%. The presence of antibiotics or inhibitors in raw milk is an indicator of poor practices in the management of veterinary drugs (32) and is a public health factor because it can cause adverse effects in humans such as: allergies, anaphylactic shock, dysbacteriosis, antibacterial resistance, alteration of intestinal microflora, and reduction of protein synthesis, among others (33). A study conducted in six departments of Colombia with samples of raw milk for human consumption determined that 5.5% of the samples were positive for antibiotics (4).

Another explanation for the presence of antibiotics or inhibitors in milk is commercialization in informal channels where greater controls are not required (34).

The presence of adulterants such as sucrose masks dilution with water in milk, restoring physicochemical properties. In Colombia, 0.5% of samples were positive for starches (4). Colombian law prohibits any type of adulterants in milk for human consumption or its dairy products (3).

The physicochemical quality of raw milk distributed for human consumption in different neighborhoods of Sincelejo and Corozal, Sucre(Colombia) indicates that it is suitable for human consumption, but not from the microbiological or SCC point of view, where there are serious deficiencies that make this milk unsuitable for human consumption. Herds must improve all quality parameters in order to produce high quality milk, and sellers must utilize excellent handling to ensure the milk is harmless.

Conflict of interests.

The authors declare no conflict of interest with publication of this manuscript.

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