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Quality Indices for Goat Milk

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***Abstract*— The parameters that allow us to decide acceptance or rejection of raw milk for cheese processing must be systematically evaluated. That´s the reason for what the objectives of this study were the following 1) to determine quality indices based on statistical analysis of interrelation of physical and chemical parameters, representative of the quality of goat milk from Jujuy Province: Creole (from Quebrada de Humahuaca) and Saanen (from Valleys) and 2) to determine acceptance limits, based on selected parameters. We took milk samples for chemical analysis: Saanen milk (n = 15) and Creole milk (n = 24). We analyzed: total protein, total lipids, ash, dry extract, casein, calcium, density, titratable acidity and pH. The obtained results were subjected to exploration multivariate analysis, using principal components (PC). We found one PC in both milks, for all variables. Variables extracted were: lipid, casein and milk acidity for both breeds and pH as an additional variable to Creole goats. The intervals of variation of the quality parameters that allow us to accept the milk for process were: for lipids, g/100g: [6.33, 7.75] and [3.74, 5.88], acidity, °D: [15.33, 18.07] and [13.44, 16.64], caseins, g/100g: [3.78, 4.08] and [2.93, 4.29], for Creole and Saanen, respectively. Major differences were found in lipid and acidity indices, showing the great dissimilar behavior between goat breeds and zones.**

***Keywords*— composition parameters, quality, principal component analysis, confidence limits.**

I. INTRODUCTION

The Northwest Argentinean (NOA) is part of the central Andean region of South America. The Andean and Sub-Andean valleys, located in the central sector of the Provinces of Jujuy, Salta and Tucumán west, are mountain areas with unfavorable socioeconomic conditions, primarily engaged in intensive irrigated agriculture practiced by small-farmers in their most indigenous descent. Jujuy has great climatic diversity and varied ecosystems: Yungas, Quebrada, Puna and Valleys. The Quebrada region has the largest part of the goat flock in the province.

The goat cheese making for personal consumption or for sale at tourist sites is a usual activity in the province. This production is carried out in the Valley using milk of Saanen and Anglo Nubian breeds. However, the breeding goat in the Quebrada region is the Creole.

In the rugged geography of the Quebrada de Humahuaca, inaccessible to other animals, these Creoles goats are bred because is a breed that characterized by its hardy and easy adaptation to the environment. The goat cheese is the most important milk derivative in this region. It is made in traditional way with characteristics and presentations that vary according to the process and customs of each place.

Goat milk is a traditional product of the Quebrada de Humahuaca with good acceptance for his nutritional value and digestibility, which are related to the low content of lactose, the small size of the fat globule and the absence of agglutinin (naturally homogenized). These characteristics allow goat milk be incorporated into the diets of people with lactose intolerance [1].

The milk to be used in cheese production must satisfy requirements of sanity and quality, both from the standpoint of chemical and microbiological. The milk must be free of antibiotics, disinfectants and generally inhibitors of the development of the lactic bacteria useful in cheese. In cheese production the colostrum or milk from sick animals cannot be used [2].

The chemical composition and some physical parameters as pH, acidity, density, influencing milk nutritional value, its properties and its value as a raw material for dairy products development. This set of variables is commonly called “milk quality” [3].

The composition of milk varies considerably with breed, stage of lactation, feed type, food a, season and many other factors. However some of the relationships between the components are very stable and can be used to indicate adulteration of milk and to infer its quality [2].

Some authors have determined the chemical composition of goat milk (protein, carbohydrates, lipids, minerals, vitamins) from different biotypes ([4], [5], [6], [7], [8], [9], [10]) and it is observed that there are differences between the races and regions. Furthermore only present comparisons between the results, without establishing optimal values of each parameter in composition or quality and mostly suggest similarity working with dairy cattle.

The knowledge of milk quality and its variations with time is important in for development of local dairy goats industry.

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It implies the systematic measurement of physical and chemical parameters, which allow us to decide the acceptance or rejection of milk or could influence the payment to producers [11].

Therefore it is necessary to develop knowledge that contributes to the generation of quality standards that take into account the particularities of this milk and also serve to identify and promote the growth of industrialization in total agreement with the views expressed by Cordiviola [12] and Chacón Villalobos [7].

Considering the diverse information on physicochemical parameters of suitability of goat milk for cheese making, the objectives were: 1) to determine quality indices based on statistical analysis of interrelation of physical and chemical parameters, representative of the quality of Criollo goats milk and Saanen, in the Province of Jujuy and 2) to determine acceptance limits, based on the selected parameters.

II. Materials And Methods

It was worked with goat milk of two breeds: Creole and Saanen, fed by grazing local herbs and bush, preselected for their ability to pasteurization, total microbial content (determined by the methylene blue test) and cheese yield.

The Creole goat milk producers studied was obtained from the Quebrada Jujuy (Aboriginal Community - Tumbaya Department - Jujuy) during a lactation cycle between the months of October to March. Milk samples were taken in each month of the cycle.

The Saanen goat milk came from a dairy farm located in the General Belgrano Department, Jujuy. Its lactation cycle is from May to February and is divided into four periods, according to the inflection points detected in the yield curve, during the execution of previous studies [13]. Samples were taken in the months of July, October, December and February, corresponding to the inflection points mentioned.

The producers were selected to be representative of the establishments in the region with little infrastructure for both milking and for development. Milk was collected by milking, performed once a day. For each period of lactation were taken three replicates (10 L) and each was evaluated in triplicate, with respect to composition and production of cheese. They were moved under refrigeration (5 ° C) to the laboratory, where they were submitted to tests immediately. They were homogenized by gentle mechanical agitation for about 30 seconds and filtered to remove impurities.

The physicochemical characterization of goat milk through composition determination was performed according to AOAC [14]: Total Protein: by the Kjeldahl method, AOAC 955.04 c. Ash: method A.O.A.C. 968.08. Fat: Acid Hydrolysis AOAC method, 922.06. Dry Extract: by FIL-21 [15]. Casein: by FIL-20 [16]. Calcium: by FIL-36 [17]. Acceptance parameters were determined: acidity by titration, expressed in Dornic degrees (° D) AOAC Method 947.05; Density Method through A.O.A.C. 925.22 and pH: a team HANNA, accuracy 0.01 pH.

Data obtained from the analysis of composition and acceptance of goat milks were analyzed using test Tukey Multiple ranges with a confidence level of 95%. Analysis of variance was performed using Statgraphics Centurion XV software. This analysis also allowed us to observe the presence of abnormal or atypical data.

The results were arranged in matrix form, composing n rows (average value of each replicate for each time) and p columns (variables or quality parameters). We took samples of each breed: fifteen samples for Saanen (n=15) and twenty four samples for Criollas (n=24). This matrix was subjected to multivariate exploration by principal component analysis (PCA). It was performed to check if the variables studied generated separation or clustering of the samples according to their quality and to determine which of these variables affected it.

The PCA consists of four characteristic stages: calculating the correlation matrix (R) between pairs of variables and analysis, extraction of the factors, the rotation of the solution to facilitate the interpretation of data and the estimation of scores samples in the new dimensions [18].

The correlation matrix to the extraction of the factors was selected, it standardizes the variables to average value of zero and standard deviation equal to one, which is indicated when the variables have different measurement scales [18], as in this work. The factorial model used (principal components) directly decomposes the correlation matrix re- climbing eigenvalues and eigenvectors. The number of factors was extracted according to the Kaiser rule, but also took into account the communalities obtained with this extraction. Thus, it was observed that the number of factors obtained would be sufficient to explain the largest proportion of variance of each variable included in the analysis.

Statistical analysis was performed using Statgraphics Centurion XV software.

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TABLE I
COMPOSITION OF SAANEN GOAT MILK

days	g/100g					mg/100g	g/ml	°D	pH
time	Dry Extract	Protein	fat	ash	casein	calcium	density	titratable acidity	
90	14.40	3.66	4.24	0.84	2.93	134	1.034	13.32	6.59
90	14.58	3.67	4.31	0.85	2.94	137	1.035	13.33	6.60
90	14.22	3.65	4.17	0.83	2.92	139	1.033	13.31	6.58
90	14.40	3.66	4.24	0.84	2.93	134	1.034	13.32	6.59
90	14.48	4.26	3.27	0.87	3.41	142	1.022	12.96	6.79
90	13.71	4.52	3.3	0.94	2.64	149	1.032	13.55	6.73
180	13.64	4.26	3.58	0.97	2.86	150	1.0325	13.60	6.65
180	13.80	3.66	4.34	0.99	3.47	158	1.033	13.50	6.71
180	13.43	4.55	3.37	1.01	2.70	153	1.031	14.5	6.69
180	13.28	3.76	4.42	0.75	3.01	142	1.021	13.68	6.71
180	13.29	3.77	4.56	0.76	3.02	159	1.022	13.69	6.72
180	13.27	3.75	4.28	0.74	3.00	151	1.020	13.67	6.70
240	13.27	6.31	7.36	1.02	5.11	159	1.032	19.98	6.75
240	13.22	4.65	5.71	0.86	3.72	139	1.022	14.04	6.60
240	13.22	4.65	5.71	0.86	3.72	148	1.022	14.04	6.60
240	13.33	4.66	6.20	0.87	3.73	153	1.023	14.22	6.61
240	13.26	6.44	7.40	1.01	5.26	148	1.030	19.13	6.60
300	13.13	6.18	7.32	1.02	5.5	151	1.031	18.27	6.61
300	12.39	4.59	3.39	0.92	2.71	157	1.030	14.00	6.70
300	13.11	4.64	5.22	0.85	3.71	157	1.021	13.86	6.59
300	11.48	4.26	3.27	0.87	3.41	149	1.022	12.96	6.79
300	11.61	4.25	3.36	0.88	3.40	150	1.023	13.14	6.80
300	11.35	4.27	3.18	0.86	3.42	158	1.021	12.78	6.78
Media	13	4.1	4.4	0.83	3.3	148	1.025	13.5	6.67
DS	1	0.4	0.9	0.05	0.3	8	0.005	0.4	0.08

III. RESULTS AND DISCUSSION

The composition and the acceptance physicochemical parameters for the studied milks are shown in Tables I and II.

The statistical analysis of data showed significant differences between the months studied, for both milks.

Therefore the registered average values were only indicative for the studied and observed group and cannot be considered as indicators for the entire cycle of production.

The principal component analysis verified that the variables were highly correlated. With a decisive 0.058 and 0.013, respectively lipids, casein and milk acidity for both races and also the pH, for Creole: Significant Pearson correlations (> 0.5) were observed between the variables.

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TABLE II
COMPOSITION OF CREOLE GOAT MILK

days	g/100g					mg/100g	g/ml	°D	pH
time	Dry Extract	protein	fat	ash	casein	calcium	density	titratable acidity	
30	14.50	5.20	6.1	0.81	4.11	132	1.028	14.0	6.77
30	14.53	5.30	6.3	0.82	4.16	139	1.031	14.0	6.80
30	14.47	5.10	5.9	0.8	4.06	125	1.025	14.0	6.74
60	16.20	5.34	6.9	0.84	4.18	126	1.030	14.2	6.71
60	16.60	5.37	7.1	0.85	4.21	128	1.031	14.2	6.74
60	15.80	5.31	6.7	0.83	4.15	124	1.029	14.2	6.69
90	17.40	5.75	5.4	0.94	4.12	146	1.029	16.7	6.63
90	17.10	5.76	5.9	0.95	4.13	150	1.030	16.7	6.60
90	17.70	5.74	4.9	0.96	4.11	142	1.028	16.6	6.66
120	17.19	4.80	8.2	1.11	3.53	137	1.030	18.8	6.50
120	17.15	4.90	8.4	1.07	3.57	132	1.031	18.2	6.51
120	17.21	4.70	8.1	1.03	3.49	135	1.029	18.5	6.49
150	18.43	5.05	8.5	1.02	3.74	139	1.031	20.5	6.52
150	18.45	5.11	8.1	1.04	3.75	134	1.030	20.2	6.54
150	18.77	4.99	8.9	1.01	3.73	143	1.033	19.7	6.56
Media	17	5.2	7	0.9	3.9	135	1.029	17	6.6
D S	1	0.3	1	0.1	0.3	7	0.001	2	0.1

The Bartlett tests of sphericity were: 60.13 and 51.75, for Saanen and Creole goats' milk respectively. The index KMO Kaiser-Meyer-Olkin were 0.77 and 0.73, respectively, so that we found the association degree between the variables.

According to the Kaiser rule we extracted a single factor or CP and the communalities obtained were> 0.85 in both milks. This component explained the 90.13% of variance of all the variables (in case of Saanen milk) and explains the 84.66% of the variance (for Creole milk). In Table III we show the quality representative variables on both studied milk.

TABLE III
PHYSICOCHEMICAL VARIABLES AND PARAMETERS OF ACCEPTANCE

Creole goat milk	Saanen goat milk
fats, caseins, titratable acidity and pH	fats, caseins and titratable acidity

Table IV shows the coefficients of each variable involved in the main component. The factorial solution obtained initially presented a simple structure with only one factor in both cases, so it was no necessary to obtain a rotated factorial solution.

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TABLE IV
COEFFICIENTS OF THE PRINCIPAL COMPONENT

Variables	Component 1 Creole goat milk	Component 1 Saanen goat milk
pH	0.947	-
Casein	0.947	0.956
Acidity	-0.930	0.946
Fat	-0.853	0.946

The summary statistics for the milk of both breeds do present standardized statistical bias and standardized kurtosis into the expected range (-2 to +2) bias, which determines that each of the variables fit a normal distribution. Values of these statistics outside the range indicate significant deviations from normality, which would invalidate the statistical procedures applied to the data.

In Table V we show the intervals of confidence for means and standard deviations of each of the variables, with 95.0 % of significances. These intervals delimit the sampling error in estimating of the parameters of the populations from which the data come. They can be used to determinate the accuracy in estimating population means and their standard deviations. These intervals assume that the populations from which the samples come from can be represented by normal distributions.

TABLE V
QUALITY PARAMETERS FOR MILK ACCEPTANCE

Quality variables	Creole goat milk	Saanen goat milk	Goat milk Argentine Food Code
Fat (g/100g)	[6.33,7.75]	[3.74,5.88]	≥ 3
Casein (g/100g)	[3.78,4.08]	[2.93,4.29]	*
Acidity (°D)	[15.33,18.07]	[13.44,16.64]	[14-22]
pH	[6.57,6.69]	-	[6.57-6.96]

* The law does not contemplate the caprine casein but if the total protein ≥ 2.8.

As we can see there are differences between the acceptance ranges for milk goat breeds studied. Creole goat milk had higher intervals compared to Saanen goat milk. The main differences were found in fat and acidity levels.

These results denote the different behavior between production areas and races, considering that Saanen goats typically produce milk with low fat content [10]. The ranges of acidity in the milk of Saanen goats were lower than those obtained for Creole goats. Although many samples of goat's milk presented acidity values about 20 °D, they allowed us obtain cheese of adequate quality for consumption and with appropriate textural features.

Parameters for acceptance of goat milk for process and commercialization were included recently in the Argentine legislation, although the content of casein is not contemplated in the Code, the total protein is. Considering that approximately 80% of the proteins in milk are caseins, the lower value of protein statutory results inferior to the one obtained in this study for goat milk of both breeds. The remainder parameters were within acceptable ranges in legislation.

The quality of milk for cheese making is related to cheese yield [19] and this in turn to the composition, so the intervals of variation of the compositional variables found in this work, became important. The cheese yields, according to previous studies, were: 22.96 ± 0.03 % for Creole goat cheese and 15.3 ± 0.5 % for Saanen goats [13].

The analyses established by the Argentine Food Code for quality control of goat milk (to consumption or to dairy processing) are: density, fat, non -fat dry matter, acidity, freezing-point depression and proteins. From the results of statistical analysis in the goat milk studied, is sufficient to assess the variables: lipid, caseins, acidity and pH to explain 95% of the variance, simplifying the number of studies to assess the quality of milk for cheese making goat.

The use of main component analysis was effective in identifying the mainly variables of composition and physicochemical parameters to assess the quality of goat milk of the both breeds studied. The values of these variables are among those covered in the legislation, for goat milk. However, the limits differ from those found in this work, which is the reason for what its applicability would not ensure the aptitude of milk for process.

IV. CONCLUSIONS

The statistical tools employed (principal component analysis) were suitable for identifying the main variables of composition and physicochemical parameters for assessing the quality of the goat Creole's milk and goat Saanen's milk from Jujuy.

According to statistical analysis, it is sufficient to evaluate the lipid content, casein, acidity and pH to determine the acceptance of goat milk for cheese making.

This work represents an important advance in the knowledge of goat milk in the region and a specific contribution to determine easily the quality of goat milk for processing.

REFERENCES

[1] Silanikove, N., Leitner, G., Merin, U. and Prosser, C. G. 2010. Recent advances in exploiting goat's milk: quality, safety and production aspects. Small Ruminant Research, 89(2), 110-124.. .

[2] García, V., Rovira, S., Boutoial, K. and López, M. B. 2014. Improvements in goat milk quality: A review. Small Ruminant Research, 121(1), 51-57.

[3] Simonenko, S. V. 2010. Physicochemical and microbiological goat milk quality indices. Russian Agricultural Sciences, 36(6), 473-475.

[4] Goetsch, A., Zeng, S. and Gipson, T. 2011. Factors affecting goat milk production and quality. Small Ruminant Research 101: 55– 63.

[5] Mestawet T.A., Girma A., Ådnøy T., Devold T.G., Narvhus J.A. and Vegarud G.E. 2012. Milk production, composition and variation at different lactation stages of four goat breeds in Ethiopia. Small Ruminant Research 105: 176–181.

[6] Fekadu B., Soryal K., Zeng S., Van Hekken D., Bah B. and Villaquiran M. 2005. Changes in goat milk composition during lactation and their effect on yield and quality of hard and semi-hard cheeses. Small Ruminant Research 59: 55–63.

[7] Chacón Villalobos A. 2005. Aspectos nutricionales de la leche de cabra (Capra hircus) y sus variaciones en el proceso agroindustrial. Agronomía Mesoamericana 16(2): 239-252.

[8] Chiatti F., Caroli A., Chessa S., Bolla P. and Pagnacco G. 2005. Relationships between goat κ-casein (CSN3) polymorphism and milk composition. The role of biotechnology 3: 163-164.

[9] Oliszewski, R., Rabasa A., Fernández J., Poli M. and Núñez M. 2002. Composición química y rendimiento quesero de leche de cabra criolla serrana del noroeste argentino. Zootecnia Tropical 20(2): 179–189.

[10] Salvador A. and Martínez G. 2007. Factores que afectan la producción y composición de la leche de cabra: Revisión Bibliográfica. Revista de la Facultad de Ciencias Veterinarias 48(2), 61-76.

[11] Vega S., Gutiérrez R., Ramírez A., González M., Díaz-González G., Salas J., González C., Coronado M., Schettino B. and Alberti A. 2007. Características físicas y químicas de leche de cabra de razas alpino francesa y saanen en épocas de lluvia y seca. Revista de Salud Animal, 29(3), 160-166.

[12] Cordiviola C., Arias R., Vaamonde G., Lacchini R. and Antonini A. 2007. Calidad Higiénico-Sanitaria de la Leche de Cabra en la Cuenca de Cañuelas, Provincia de Buenos Aires. Vº Congreso de Especialistas en Pequeños Rumiantes y Camélidos Sudamericanos, Mendoza, Argentina.

[13] Maldonado S., Bernal R., Burgos L. and Santapaola J. 2011. Production and Commercialization of Goat Milk and Cheese in Northwest Argentina. In: Goats: Habitat, Breeding and Management, Nova Science Publishers, pp. 1-38. ISBN: 978-1-61942-932-1.

[14] A.O.A.C. Official Methods of Analysis of the Association of Official Analytical Chemist 1995.

[15] International Standard FIL-IDF 21. 1962. Milk and Milk Products – determination of Caseins (Reference Method). Brucelas, Bélgica.

[16] International Standard FIL-IDF 20. 1964. Milk and Milk Products – determination of Total Solids (Reference Method). Brucelas, Bélgica.

[17] International Standard FIL-IDF 36. 1966. Milk and Milk Products – determination of Calcium (Reference Method). Brucelas, Bélgica.

[18] Ramonda M. B. 2009. Desarrollo de un modelo basado en métodos estadísticos para la predicción del tiempo de maduración de Quesos Argentinos. Tesis de post grado de Doctor en Química. Universidad Nacional del Litoral. Disponible en: bibliotecavirtual.unl.edu.ar:8180/tesis.pdf

[19] Frau S., Togo J., Pece N., Paz R. and Font G. 2010. Estudio comparativo de la producción y composición de leche de cabra de dos razas diferentes en la provincia de Santiago del Estero. Revista de la Facultad de Agronomía, La Plata, 109 (1): 9-1.