Seasonal quality of milk from Creole grazing goats, stabled Saanen and French-Alpine goats

Calidad estacional de leche de cabras Criollas en pastoreo vs cabras estabuladas Saanen y Alpina-Francesa

Qualidade sazonal do leite de cabras Crioulas em pastagem vs cabras estábuladas Saanen e Franco-alpina

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Abstract

Background: Goat milk production has been increasing in northern Mexico; however, there is little information available about its quality. **Objective:** To compare goat milk quality during three seasons among creole goats in a traditional grazing system and stabled Saanen and French-Alpine goats. **Methods:** An experiment was performed in a completely randomized nested design with seasonality factor (fixed effects) with three levels (rain, transition, and drought) and breed factor (fixed effect with three levels (Creole, Saanen and French-Alpine)) nested within the season-of-the-year factor. Fifteen goats were randomly selected: five Creole in the extensive grazing system, five stabled Saanen, and five stabled French-Alpine. The factors assessed in milk were fat content, non-fat solids, protein, lactose, salts, density, freezing point, conductivity, and pH (using a Lactoscan® device). **Results:** With respect to season for all the breeds: fat, non-fat solids, protein, lactose, and salt contents were higher ($p \leq 0.05$) for goats sampled in the rainy season, followed by drought and transition seasons, respectively. The variables related to milk quality by breed and season showed that milk fat content of creole goats was greater ($p \leq 0.05$) in the drought season; salt and non-fat content ($p \leq 0.05$) in the three seasons of the year;

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density and protein increased (p≤0.05) in the transition and rainy seasons, while lactose was greater (p≤0.05) in drought and rainy seasons; protein was greater (p≤0.05) in transition and rainy seasons; and the freezing point was lower (p≤0.05) in the transition season. Regarding conductivity, French-Alpine milk was greater (p≤0.05) in the drought season. **Conclusion:** Season of the year significantly affects milk quality, with increased quality during the rainy season in creole grazing goats.

Keywords: *caprines; creole; French-Alpine goats; goats; goat milk; grazing goats; lactose; milk quality; milk fat; milk protein; non-fat solids; Saanen; salts; seasonality.*

Resumen

Antecedentes: La producción de leche de cabra se ha venido incrementando en el norte de México,; sin embargo, existe poca información sobre su calidad. **Objetivo:** Comparar la calidad de la leche de cabra durante tres épocas del año para cabras criollas en pastoreo y cabras puras de dos razas diferentes bajo estabulación. **Métodos:** El experimento se realizó mediante un diseño anidado completamente aleatorizado, con el factor época del año (efecto fijo) con tres niveles (lluvia, transición y sequia) y el factor raza (efecto fijo) con tres niveles (Criolla, Saanen y Alpino-Francesa) anidado dentro del factor época del año. En el sistema de pastoreo extensivo se eligieron al azar cinco cabras de raza Criolla, en el sistema estabulado se eligieron al azar cinco cabras de la raza Saanen y cinco de la raza Alpino-Francesa. La variables medidas fueron: contenido de grasa, sólidos no grasos, proteína, lactosa, sales, densidad, punto de congelación, conductividad y pH (utilizando el dispositivo Lactoscan®). **Resultados:** Respecto a la temporada del año para las tres razas se encontró que los contenidos en leche de grasa, sólidos no grasos, proteína, lactosa y sales fueron mayores (p≤0,05) en la época de lluvias, seguido por la leche muestreada en sequía y transición. Las variables por raza y temporada del año arrojaron que la grasa fue mayor (p≤0,05) en cabras criollas en sequía, solidos no grasos fue mayor (p≤0,05) en las tres temporadas del año en cabras criollas, la densidad aumentó (p≤0,05) en cabras criollas en transición y lluvia. La proteína fue mayor (p≤0,05) en cabras criollas en transición y lluvia, mientras que la lactosa fue mayor (p≤0,05) en cabras criollas en sequía y lluvia. El menor punto de congelación (p≤0,05) se presentó en cabras criollas en transición, la conductividad fue mayor (p≤0,05) en cabras Alpina-Francesa en sequía y la concentración de sales fue mayor (p ≤0,05) en cabras criollas durante las tres temporadas. **Conclusión:** Existe un marcado efecto de la temporada sobre la calidad de la leche, siendo la epoca de lluvias cuando se presenta mejor calidad en cabras criollas en pastoreo.

Palabras clave: *cabras alpinas francesas; cabras; cabras criollas; cabras en pastoreo; calidad de la leche; caprinos; estacionalidad; grasa de la leche; lactosa; leche de cabra; proteína láctea; Saanen; sales; sólidos no grasos.*

Resumo

Antecedentes: No norte do México a produção de leite de cabra aumentou; no entanto, a qualidade do leite é desconhecida. **Objetivo:** Comparar a qualidade do leite de cabra durante três estações do ano com cabras crioulas em sistema de pastoreio tradicional e cabras Saanen e franco-alpinas em estábulos. **Métodos:** O experimento foi realizado através de um delineamento completamente casualizado com o fator de sazonalidade (efeitos fixos) com três níveis (chuva, transição e seca) e fator de raça (efeito fixo com três níveis (crioulo, Saanen e franco-alpino) aninhados dentro do fator estação do ano quinze cabras foram selecionadas aleatoriamente, cinco no sistema de pastejo extensivo, cinco Saanen e cinco Franco-Alpino no sistema estábulo. Os fatores avaliados no leite foram teor de gordura, sólidos desengordurados, proteína, lactose, sais, densidade, ponto de congelamento, condutividade e pH pelo aparelho Lactoscan®. **Resultados:** Em relação às estações do ano, nas três raças, mostrou que os teores de gordura, sólidos desengordurados, proteínas, lactose e sal foram maiores (p≤0,05) nas cabras cujo leite foi amostrado na ocasião um de chuvas seguido por aquele amostrado nas estações de seca e transição, respectivamente. As variáveis relacionadas à qualidade do leite de cabra por raça e ano, mostraram que nas cabras crioulas o teor de gordura foi maior (p≤0,05) na estação seca; teor de sal e gordura (p≤0,05) nas três estações do ano; a densidade aumentou significativamente e o teor de proteína foi maior (p≤0,05) nas estações de transição e chuvas, enquanto o valor de lactose foi maior (p≤0,05) nas estações seca e chuvosa; o teor de proteína foi maior (p≤0,05) nas estações de transição e chuvas; e o ponto de congelamento foi menor (p≤0,05) na estação de transição. Em relação à condutividade, o leite de cabra franco-alpino apresentou valor significativamente superior (p≤0,05) na seca. **Conclusão:** A qualidade do leite tem um efeito significativo por estação, sendo que a estação chuvosa aumentou a qualidade do leite em cabras crioulas em pastejo.

Palavras-chave: *cabras; cabras crioulas; cabras Franco-Alpinas; cabras en pastoreo; caprinos; gordura de leite; lactose; leite de cabra; proteína do leite; qualidade do leite; Saanen; sazonalidade; sólidos sem gordura.*

Introduction

Goat milk is very important for the economy and survival in diverse regions and populations worldwide (Yangilar, 2013). The increasing demand of consumers for natural products is having a positive effect on the development of organic production systems. Among them, grazing is becoming important in goat production. Nonetheless, a better understanding of the relationship between grazing and production yield is required (Charpentier and Delagarde, 2018). Goat studies have reported that they are efficient in feed conversion and use for milk production (Bedoya, 2012). Goat milk has stood out during the last decades due to its macronutrient contribution (fat, protein and minerals) and its vitamin and fatty acids contents, particularly linoleic acid (Kondyli *et al.*, 2012).

López *et al.* (2011) reported that marginality of small farming production systems, especially goats, is characterized by the absence of products with high added-value. The rationale of those families to increase their income is by increasing their flock size instead of reducing it and obtaining greater productivity.

In arid and semi-arid rangelands, the soil physical-chemical characteristics (mineral, pH, electrical conductivity, organic matter, among others; Debra *et al.*, 2009) and climate variables (temperature, relative humidity, wind speed and precipitation) are interrelated to determine presence, nutrition, and growth of plants (Fernandez-Illescas and Rodríguez-Iturbe, 2004). These factors directly establish the vegetation type and its chemical composition. Additionaly, those variables have a bearing on the available nutrients for grazing goats (Skarpe *et al.*, 2007; Yayneshet *et al.*, 2008). The previous is expressed in physiological processes, such as milk production and composition, determining variability in the biochemical characteristics in the same year and between seasons (Mellado *et al.*, 2006; Richardson and Hahn, 2007; Guevara *et al.*, 2009).

The goat milk industry requires to determine milk quality in the local conditions in which the animals are raised. We hypothesis that milk quality of creole goats under a traditional extensive grazing system differs according to seasonality and is higher compared to milk from Saanen and French-Alpine goats reared in a stabled system. Moreover, this study is of practical importance for goat producers since knowing when protein and fat content is higher throughout the year would allow them to add value to milk and cheese. Therefore, the objective of this study was to compare milk quality between creole goats in a traditional extensive grazing system and stabled Saanen and French-Alpine goats feed alfalfa and commercial concentrate during three seasons of the year (drought, rain, and transition).

Materials and Methods

Study site and management systems

The study was conducted in two sites. Site 1) is located in the buffer zone of Sierra de La Laguna Biosphere Reserve, Mexico, in the plot named El Mezquitillo at 23° 27' 33.264"N and 110° 5' 18.7794"W, and Site 2) at 24° 5' 45.1932"N and 110° 20' 20.3598"W. Both sites are located in the Municipality of La Paz, Baja California Sur, Mexico.

Site 1 consisted of creole goats in an extensive grazing system. Goats were kept confined at night in corrals with no feed, but water *ad-libitum* and set free during the day to graze vegetation (*ad libitum*) in the zone. According to León de la Luz *et al.* (2012), the predominant vegetation in the area is characterized by low deciduous forest with presence of tepeguaje [desert fern] (*Lysiloma microphylla*), lomboy (*Jatropha cinerea*), palo colorado (*Colubrina viridis*), palo blanco (*Lysiloma candidum*), uña de gato [Mexican mimosa] (*Mimosa distachya*), pino pinto (*Chloroleucon mangense*), copal (*Bursera epinnata*), palo adán (*Fouquieria diguetii*), palo de arco (T*ecoma stans*), and lomboy colorado (*Jatropha vernicosa*).

Site 2 was used for Saanen and French-Alpine goats in a stabled system with goats confined in corrals 24 h and fed alfalfa hay and a commercial concentrate (sorghum, wheat husk, molasses,

wheat bran and soymeal produced by a local enterprise).

Animals

In Site 1, Creole goats selected had normal body condition of 3/5 and 36 kg average weight. In Site 2, Saanen and French-Alpine goats were used. Similarly, the animals selected had a body condition of 3/5 and 36 kg average weight. The study started in September 2018 (rainy). On that date, all the goats in study (n = 15) were in 80 ± 10 days of lactation. Subsequently, the goats were dried-up and started another milking period. In May 2019 (transition) all the goats were in 60 ± 10 milking days and by June 2019 (drought) in 150 ± 10 days. In both production systems, the females used were approximately in their fourth milking stage.

Seasons and milk sampling

Three seasons of the year were classified as rainy (September 2018), transition rain-drought (March 2019) and drought (June 2019).

Duplicate milk samples were taken from five creole goats in extensive grazing for five days (replicates in time), and similarly from five Saanen and five French-Alpine goats (five days, replicates in time). In both sites, milk was obtained by manual milking, stored in 100-mL jars and frozen at -20 °C for subsequent analysis.

Milk quality

Milk samples were analyzed according to Kljajevic et al (2018) using a Lactoscan® (ultrasonic milk analyzer device Model LW, Milkotronic Ltd., Nova Zagora, Bulgaria). The 50-mL milk samples were placed in duplicates and the device automatically determined the values for protein, fat, lactose, non-fat solids, density, salt contents (%), freezing point (°C), conductivity (mS cm^{-1}), and pH.

Experimental design

A complete randomized nested design within season (fixed effects) with three levels (rain, transition, and drought) and breed factor (fixed effects) with three levels (Creole -extensive grazing-, Saanen and French-Alpine -stabled). Thus, the breed factor was considered nested in seasons and non-balanced. Five goats of each breed were considered for each season and breed, each goat representing one replicate. In each season and for five consecutive days per season milk sampling was performed (replicates in time) and each sampling per day represented a subsample.

Statistical analyses

To comply with normality assumptions, data of the variables expressed in percentages were arcsine transformed (Little and Hills, 1989; Steel and Torrie, 1995). One-way analyses of variance were performed considering a complete and non-balanced randomized design with seasonality factor with three levels (rain, transition and drought), and breed factor with three levels (Creole, Saneen and French Alpine). Differences within dependent variables (protein, salt, fat, lactose, non-fat solid, density, freezing point, conductivity and pH contents) were determined by Tukey's test ($p \leq 0.05$). The analyses were performed in the General Linear Model (GLM) and Nested Design ANOVA with the statistical program Statistica® v. 13.3 (TIBCO®, 2018).

Results

Seasonality effect on milk quality

The effects of season on milk quality of grazing creole goats and stabled pure breeds (Saanen and French-Alpine) are shown in Table 1. Fat ($p=0.00$), non-fat solids ($p=0.0020$), protein ($p=0.0086$), lactose ($p=0.0022$), and salt ($p=0.0134$) were higher ($p \leq 0.05$) in milk from the rainy season followed by drought and transition, respectively. Milk freezing point was lower ($p \leq 0.05$) during the rainy season. Milk conductivity was higher ($p \leq 0.05$) in the drought season. Milk density and pH did not differ ($p \geq 0.05$) among seasons.

Breed effect (nested in seasonality) on milk quality

The variables related to milk quality by the effect of breed in extensive grazing and stabled systems, respectively, nested in seasonality are shown in Table 2. Fat content was greater ($p \leq 0.05$) in creole goats during the drought season followed by both Saanen and creole breeds in the rainy season. Fat content was lower ($p \leq 0.05$) in Saanen goats in drought. The non-fat solid content was also higher ($p \leq 0.05$) in creole goats in the three seasons -transition, rain and drought, respectively- while milk of French-Alpine goats during drought showed the lowest content ($p \leq 0.05$) of non-fat solids. Milk density increased significantly ($p \leq 0.05$) in creole goats during transition and rainy seasons, respectively, while the lowest values were recorded for French-Alpine goats in drought and transition. Protein content increased ($p \leq 0.05$) in creole goat milk during transition and rainy seasons, while that of French-Alpine goats decreased during drought. Lactose content was higher ($p \leq 0.05$) in creole goats during drought and rainy season, while that of French-Alpine was reduced during drought. The lowest freezing point ($p \leq 0.05$) was recorded for creole goats sampled in transition, while the opposite was observed for French-Alpine goats in drought. Conductivity showed the highest value ($p \leq 0.05$) in French-Alpine goats during drought and the lowest one in creole goats in transition. Milk pH of the three breeds in the three seasons showed values close to neutrality. However, milk from creole goats had a slightly higher ($p \leq 0.05$) pH in the rainy season, while the opposite was observed in Saanen goat milk in the same season. Salt content was higher ($p \leq 0.05$) in creole goats in rainy, transition and drought, respectively, while salt content in French-Alpine goats slightly decreased in drought.

Discussion

Seasonality effect on milk quality

Goat milk composition depends on several factors, such as breed, milking stage, feed, differences among animals, climate and locality (Guo *et al.*, 2001). According to our results, seasonality has an effect on milk quality in grazing and stabled goats, with the rainy season allowing for increased quality. The milk fat content was higher ($p \leq 0.05$) during the rainy season. This result may be attributed to the diet composition– particularly the amount and composition of fat that has an effect on milk fat content (Vega *et al.*, 2007). The protein content in milk was greater ($p \leq 0.05$) in the rainy season with an average of 3.04%. Similar results have been reported in French-Alpine during summer (Milewski *et al.*, 2018), with higher protein values in the rainy season. Moreover, Vega *et al.* (2007) found that protein content was lower in the rainy season compared to the dry season. Protein increase in the rainy season is attributed to an increase in feed consumption. According to Maldonado *et al.* (2017), lactose is the most stable component in ruminant milk. In the present study, lactose was higher ($p \leq 0.05$) in the rainy season. In this respect, Vega *et al.* (2007) reported 4.45% lactose in Saanen goats during the rainy season and 4.2% in French-Alpine in the summer. Lactose values fluctuate from 4.46 in winter to 4.45% in summer for French-Alpine goats (Milewski *et al.*, 2018).

Breed effect (nested in seasonality) on milk quality

Different feed sources exist, such as forage, pasture and concentrates that are used in animal diets, as well as different feeding strategies, which have a direct bearing on goat milk quality (Tsiplakou *et al.*, 2010). The results in this study showed significant differences in milk quality of Saanen and French-Alpine stabled goats with respect to creole grazing goats, of which the latter were those that showed the greatest milk quality. Fat content was the highest in creole grazing goats with respect to stabled Saanen and French-Alpine. These results agreed with those of Tsiplakou el al. (2010), who reported that fat was greater in milk of goats raised in a conventional system with respect to those in an organic one, which is attributed to the type of food consumed by the animals.

Table 1. Seasonality effect on milk quality of creole goats in traditional extensive grazing system and two breeds, Saanen and French-Alpine goats in a stabled system.

Seasons of the year	Fat (%)	NF (%)	Density (g/cm^3)	Protein (%)	Lactose (%)	Freezing point (°C)	Conductivity (mS cm^{-1})	pH	Salts (%)
Drought	3.79±0.20^{b*}	7.96±0.08^{b}	1.02687±0.22^{a}	2.90±0.02^{b}	4.38±0.04^{b}	-0.50±0.006^{b}	5.85±0.05^{a}	7.03±0.01^{a}	0.653±0.006^{b}
Transition	3.73±0.17^{b}	8.09±0.12^{ab}	1.02751±0.40^{a}	2.98±0.04^{ab}	4.50±0.07^{ab}	-0.51±0.01^{ab}	5.35±0.06^{b}	6.99±0.03^{a}	0.659±0.01^{ab}
Rain	4.92±0.15^{a}	8.37±0.09^{a}	1.02736±0.37^{a}	3.04±0.03^{a}	4.64±0.06^{a}	-0.54±0.007^{a}	5.48±0.04^{b}	7.06±0.04^{a}	0.682±0.008^{a}

NFS = non-fat solids. Values correspond to the average ± standard error. *Average values within the same column with different letters (a, b, c, d) differ statistically (Tukey's HSD p≤0.05).

Table 2. Breed effect (on creole goats in a traditional extensive grazing system and Saanen and French-Alpine goats in a stabled system) considering seasonality.

Seasons of the year	Breeds	Fat (%)	NFS (%)	Density (g/cm^3)	Protein (%)	Lactose (%)	Freezing point (°C)	Conductivity (mS cm^{-1})	pH	Salts (%)
Drought	Creole	5.50±0.32^{a}	8.55±0.13^{ab}	1.0276±0.44^{bc}	3.11±0.04^{ab}	4.70±0.07^{abc}	-0.56±0.01^{cde}	5.49±0.10^{cd}	7.12±0.02^{ab}	0.702±0.01^{ab}
Drought	F-Alpine	2.77±0.12^{e}	7.38±0.06^{d}	1.02555±0.22^{c}	2.69±0.02^{d}	4.06±0.03^{e}	-0.46±0.004^{a}	6.22±0.06^{a}	6.97±0.02^{ab}	0.604±0.005^{d}
Drought	Saanen	2.76±0.13^{e}	7.83±0.08^{cd}	1.0272±0.29^{bc}	2.86±0.03^{cd}	4.31±0.04^{cde}	-0.49±0.005^{ab}	5.92±0.04^{ab}	7.00±0.01^{ab}	0.642±0.006^{cd}
Transition	Creole	4.25±0.39^{bcd}	8.91±0.19^{a}	1.03022±0.53^{a}	3.32±0.08^{a}	5.04±0.12^{a}	-0.58±0.02^{e}	5.15±0.08^{d}	7.00±0.01^{ab}	0.726±0.01^{a}
Transition	F-Alpine	3.69±0.25^{cde}	7.58±0.17^{cd}	1.02567±0.77^{c}	2.76±0.06^{cd}	4.18±0.0.10^{de}	-0.48±0.01^{ab}	5.38±0.16^{cd}	7.05±0.12^{ab}	0.623±0.01^{cd}
Transition	Saanen	3.14±0.11^{de}	7.60±0.10^{cd}	1.02608±0.39^{c}	2.77±0.03^{cd}	4.18±0.05^{de}	-0.47±0.007^{ab}	5.57±0.08^{cd}	6.93±0.02^{b}	0.614±0.01^{cd}
Rain	Creole	5.03±0.22^{ab}	8.85±0.18^{a}	1.0290±0.76^{ab}	3.22±0.06^{a}	4.87±0.10^{ab}	-0.57±0.01^{de}	5.22±0.07^{cd}	7.22±0.09^{a}	0.726±0.01^{a}
Rain	F-Alpine	4.66±0.28^{abc}	8.01±0.15^{bcd}	1.02627±0.51^{c}	2.91±0.05^{bcd}	4.55±0.15^{bcd}	-0.51±0.01^{abc}	5.64±0.06^{c}	7.02±0.03^{ab}	0.646±0.01^{bcd}
Rain	Saanen	5.04±0.30^{ab}	8.14±0.10^{bc}	1.02647±0.37^{c}	2.96±0.03^{bc}	4.46±0.05^{cde}	-0.52±0.008^{bcd}	5.64±0.09^{c}	6.91±0.02^{b}	0.667±0.009^{bc}

NFS = non-fat solids. Values correspond to the average ± standard error. *Average values within the same column with different letters (a, b, c, d) differ statistically (Tukey's HSD p≤0.05).

Moreover, Kondyli *et al.* (2012) showed similar results when fat content was evaluated in grazing goats in the mountains in spring and summer season. The non-fat solid content showed the highest values in creole grazing goats with respect to stabled Saanen and French-Alpine. Likewise, milk of creole grazing goats showed the greatest content in non-fat solids in transition and rainy seasons.

Declarations

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Conflicts of interest

The authors declare they have no conflicts of interest with regard to the work presented in this report.

This research was performed in absence of any commercial or financing relationship that could be interpreted as a possible conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Data availability

The authors confirm that all data underlying the findings of this study are totally available without restriction, before reasonable request to the corresponding author, Dr. Bernardo Murillo-Amador, at e-mail bmurillo04@cibnor.mx. All relevant and necessary data to replicate this study are described in the document.

Author contributions

Conceptualization, VASB and BMA; methodology, JJMS, VASB and ROP; formal analysis, BMA; research, VASB, BMA, ANG, JJMS, NA and ROP; resources, BMA; data curation, NA, ANG and ROP; writing-original draft preparation, VASB, ANG and NA; writing-review and editing, VASG, BMA and ROP; funding acquisition, ANG, and BMA. All authors have read and agreed to the final version of the manuscript

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