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Phenotypic characterization for milk traits in crossbred cattle population from the state of Norte de Santander

Caracterização fenotípica das características do leite em uma população de bovinos mestiços do estado de Norte de Santander

Luisa Fernanda Naranjo Guerrero*[1] (ORCID 0000-0003-0743-0655), Nancy Rodríguez Colorado[2] (ORCID 0000-0002-1087-3150), Luis Gabriel González Herrera[1] (ORCID 0000-0001-7156-9753)

[1]Universidad Nacional de Colombia, Medellín, Antioquia, Colombia. * Author for correspondence: lfnaranjog@unal.edu.co
[2]Universidad Francisco de Paula Santander, Ocaña, Norte de Santander, Colombia.

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ABSTRACT

Crossbred cattle are used in dual-purpose systems to obtain meat and milk, becoming one of Colombia's systems with the greatest presence. However, studies characterizing productive variables in crossbred individuals are scarce, making it pertinent to conduct analyses evaluating their potential. The objective of this study was to phenotypically characterize a population of crossbred cattle from the state of Norte de Santander (Colombia) in terms of milk traits. Up to a maximum of 4 controls per female was obtained, and information on milk yield (MY), fat percentage (FP), protein percentage (PP), and somatic cell count (SCC) of first parity crossbred females was evaluated. The information was filtered and analyzed with the R program. The mean, standard deviation, and general variation coefficient were calculated for each trait and the means and deviations by non-genetic categorical factors. For the numeric factors, graphs of trends related to the response variables were made. Multiple correspondence analysis was performed, and the standardized residual values were estimated to recognize associations between levels of non-genetic factors and each trait. Mean values for controls were: 3.06±1.40 kg/day (MY), 3.21±0.40% (PP), 3.32±0.77% (FP), and 357±256x10^3 cells/ml (SCC). The non-genetic factors that showed the most significance were the pasture type, the control season, and the region. Thus, MY from 1.00 to 2.00 kg is associated with the levels of region 1 (R1) and summer 1 (S1), MY from 2.10 to 3.99 kg with region 2 (R2), group 1 (G1) and winter 1 (W1), MY from 4.00 to 8.30 kg with R1, group 3 (G3) and W1, PP from 2.45 to 2.99% there was association with G1, PP from 3.00 to 3.40% with group 2 (G2), PP from 3.41 to 6.04% with G3, FP of 1.94 to 3.00% is associated with R1, G3, S1, and S2, FP of 3.01 to 4.00% with R2, G1 and W1, FP from 4 to 4.82 % with region 3 (R3), G2, and S1, SCC from 8.00 to 100x10^3 cells/ml is associated with R1, R3, and S1, SCC of 101 to 499x10^3 cells/ml with R2, G1, and W1. Finally, SCC of 500 to 888x10^3 cells/ml is associated with R2 and W1. A variation of medium to high magnitude of the traits evaluated within the population was evidenced, revealing that no standards that allow unifying the management of animals within herds, which can affect the efficiency of dual-purpose systems.

KEYWORDS: multiple correspondence analysis; dual purpose; animal production; milk yield; standardized residues.

RESUMO

O gado cruzado é utilizado nos sistemas de dupla aptidão procurando se obter carne e leite; este é o sistema produtivo bovino com maior representação na Colômbia. Estudos de caracterização de variáveis produtivas em indivíduos cruzados são escassos, tornando, pertinente realizar análises que avaliem o seu potencial. Objetivou-se caracterizar fenotipicamente uma população de gado cruzado no estado de Norte de Santander (Colômbia), considerando características relacionadas com a produção de leite. Foram obtidos até um máximo de 4 controles por fêmea e avaliadas informações sobre produção de leite (MY), porcentagem de gordura (FP), porcentagem de proteína (PP) e contagem de células somáticas (SCC) de fêmeas cruzadas de primeira ordem de parto. A informação foi depurada e analisada com o programa R. Foi calculada a média, desvio padrão e coeficiente de variação para cada característica de maneira geral e detalhando por fatores categóricos não genéticos. Para os fatores numéricos foram elaborados gráficos de tendencias relacionados com as variáveis resposta. Realizou-se uma análise de correspondência múltipla e estimados os valores dos resíduos padronizados para reconhecer níveis de fatores não genéticos com influência sobre as características. Os valores médios para os controles foram: 3.06±1.40 kg/dia (MY), 3.21±0.40% (PP), 3.32±0.77% (FP), e 357 ± 256x10^3 células/ml (SCC). Os fatores não genéticos que apresentaram maior influência foram o tipo de pastagem, a estação de controle e a região. Assim, a MY de 1,00 a 2,00 kg está associada aos níveis da região 1 (R1) e verão 1 (S1), a MY de 2,10 a 3,99 kg à região 2 (R2), grupo 1 (G1) e inverno 1 (W1), EM de 4,00 a 8,30 kg com R1, grupo 3 (G3) e W1, PP de 2,45 a 2,99% foi associado ao G1, PP de 3,00 a 3,40% ao grupo 2 (G2), PP de 3,41 a 6,04% ao G3 , FP de 1,94 a 3,00% está associado a R1, G3, S1 e S2, FP de 3,01 a 4,00% a R2, G1 e W1, FP de 4 a 4,82% à região 3 (R3), G2 e S1, SCC de 8,00 a 100x10^3 células/ml está associado a R1, R3 e S1, SCC de 101 a 499x10^3 células/ml a R2, G1 e W1. Finalmente, SCC de 500 a 888x10^3 células/ml estão associadas a R2 e W1. Foi evidenciada uma variação de média a alta magnitude das características avaliadas dentro da população, revelando que não existem padrões que permitam unificar o manejo dos animais dentro dos rebanhos, o que pode afetar a eficiência dos sistemas de dupla aptidão. Foi evidenciada uma variação de magnitude média a alta das características avaliadas dentro da população, revelando que não existem padrões para unificar o manejo dos animais dentro das fazendas, o que pode influenciar a eficiência dos sistemas de dupla aptidão.

PALAVRAS-CHAVE: análise de correspondência múltipla; dupla aptidão; produção animal; produção de leite; resíduos padronizados.

INTRODUCTION

The state of Norte de Santander traditionally has in its inventory the use of crossbred animals and the presence of dual-purpose livestock in its territory. Producers and researchers have begun to recognize the importance and need to conserve animal genetic resources, focusing on improving economically significant parameters. For this purpose, it is convenient to characterize the non-genetic factors that may be responsible for the variation in milk traits, to be able to separate the non-genetic effects from the genetic ones (NÚÑEZ-TORRES & ALMEIDA-SECAIRA 2022). In addition, recognizing non-genetic factors that influence the performance of individuals can be used for decision-making at the herd level, since, knowing the factors that most impact milk yield, the farmer can take appropriate measures, providing the opportunity for their animals to produce more and better-quality milk.

Among the non-genetic factors that have been considered influential in milk yield in the first lactation, health parameters, feeding, housing traits (CASTILLO-BADILLA et al. 2019), farm, the number of calving, breeding group, and year of calving are included (VITE et al. 2015). In the case of compositional and sanitary quality of milk, it has been found that the milking routine, management, production system, nutrition, and the productive stage of the animals (AINSWORTH et al. 2012) are determining factors in the variation of these traits. By the above, the objective of this work was to phenotypically characterize a population of crossbred cattle from the state of Norte de Santander for milk traits (milk yield, protein percentage, fat percentage, and somatic cell count).

MATERIAL AND METHODS

Study population and data

Four hundred twenty (420) first-calving females from the municipalities of El Tarra, El Zulia, Ocaña, Arboledas, and Pamplona were selected, located at altitudes ranging from 225 to 2700 meters above sea level, with average temperatures ranging from 12 °C to 28 °C. and rainfall that varies between 921 and 2128 mm per year. The predominant pastures in these municipalities are Brachiaria (*Brachiaria decumbens*), Brizantha (*Brachiaria brizantha*), Elephant (*Pennisetum purpureum*), Kingrass purple (*Pennisetum purpureum x Pennisetum typhoides*), king grass (*Pennisetum purpureum x Pennisetum glaucum*), African star grass (*Cynodon nlemfuensis*), Guinea (*Megathyrsus maximus*), Angleton (*Dichanthium aristatum*) and Kikuyu (*Cenchrus clandestinus*).

Test day milk yield were performed (approximately every fortnight) during the morning milking of first-parity females, which had only one milking per day, performing up to a maximum of four controls per female throughout three to four months. The samples were taken to the AGROSAVIA-certified laboratory for the measurement of variables related to the compositional and sanitary quality of the milk. The traits considered were milk yield (MY), fat percentage (FP), protein percentage (PP), and somatic cell count (SCC). The MY was obtained based on the weighing carried out in the field; FP and PP were determined by the infrared spectroscopy method (standardized method, ISO 9622, IDF 141; 2013), with value intervals between 1.93 to 9.06% (g/100g) and 2.45 to 6.37% (g/100g), respectively. The SCC was determined by the flow cytometry method (standardized method, ISO-13366-2, IDF 148-2; 2006) with intervals from 8,000 to 10,000,000 cells/ml. All the information was filtered and analyzed using the R program (R CORE TEAM 2021). Information with little consistency was eliminated, obtaining MY values between 1.00 and 8.3 kg/day, PP between 2.45 and 6.04%, FP between 1.94 and 6.0%, and SCC between 8x10^3 cells/ml to 888x10^3 cells/ml. In the same way, females with complete information related to pastures to which they had access, production system, date of birth, calving date, control dates, days in milk, body condition, and data on MY, PP, FP, and SCC were considered. Based on this, the information analyzed had a total of 584 data for MY, 644 data for PP, 197 data for FP, and 517 data for SCC.

Statistical analysis

The mean, standard deviation, and coefficient of variation were calculated for each of the traits and by region, where region 1 (R1) comprised the municipalities of Arboledas and Pamplona, region 2 (R2), El Zulia and Chinácota and region 3 (R3) included El Tarra and Ocaña. In turn, the mean and standard deviation of the traits were calculated based on other non-genetic factors that were considered to influence the evaluated traits. Such factors were: the type of production system, pastures, calving season, control season, age at first calving (AFC), days in milk (DIM), and body condition (BC).

The seasons were created based on the precipitation information reported for the six evaluated municipalities and they were grouped as follows: summer 1 (December, January, February, and March as S1), winter 1 (April, May, and June, W1), Summer 2 (July and August, S2), and winter 2 (September, October, November, W2). For the control season 2 (W2), no data were obtained in the evaluation period. In the case of productive systems, the following were considered: productive systems under continuous grazing (CG), productive systems under rotational grazing (RG), and productive systems under semi-dry lot (SD). In the same way, the pastures were grouped since there were cases of females grazing pastures with a diversity of forage species. In this way, three groups of pastures were formed, group 1 (predominance of Angleton, Guinea, African star grass, Sabana, and Mombasa, G1), group 2 (predominance of Braquiarias, G2), group 3 (predominance of Kikuyu and ryegrass, G3)

Subsequently, trend graphs were made for the response variables (MY, PP, FP, and SCC) using the three levels established for AFC and BC throughout the lactation trajectory. A multivariate multiple correspondence analysis was performed in which the previously mentioned non-genetic factors and the variables MY, PP, FP, and SCC were related. In the case of the AFC and the BC, they were categorized into three levels and the DIM into seven levels. All the quantitative variables except the DIM (grouped every 15 days) were categorized using the mean and standard deviation values obtained for each variable as a guide, that is, the observations that were below less than one standard deviation were part of the category 1, those that were between minus one and one standard deviation were in category 2 and finally, those that were above one standard deviation were in category 3. In this way, for MY (kg) the range of values was MY1 (1.00 - 2.00), MY2 (2.10 - 3.99) and MY3 (4.00 - 8.30), for PP (%) there was PP1 (2.45 - 2.99), PP2 (3.00 - 3.40) and PP3 (3.41 - 6.04), for FP (%) there was FP1 (1.94 - 3.00), FP2 (3.01 - 4.00) and FP3 (4.01 - 4.82), for SCC (x10^3 cells/ml) there was SCC1 (8.00 - 100), SCC2 (101 - 499) and SCC3 (500 - 888), for AFC (months) there was AFC1 (27.00 - 34.99), AFC2 (35.00 - 40.00) and AFC3 (40.01 - 51.00), for BC (points) had C1 (2.50 - 3.00), C2 (3.10 - 3.90) and C3 (4.00 - 4.50) and finally for DIM (days) it had 15 (1 - 15), 30 (16 - 31), 45 (31-45), 60 (46-60), 75 (61-75), 90 (76-90) and 105 (91-105).

Finally, for the correspondence analysis, the corrected standardized residual values were estimated for each of the levels of non-genetic effects evaluated with the following equation (HABERMAN 1978). This is to recognize between which levels of non-genetic factors and each trait there was an association ($p < 0.05$).

$$r_{ij}^{c} = \frac{\frac{(n_{ij}-e_{ij})}{\sqrt{e_{ij}}}}{\sqrt{\left(1-\frac{N_{i\cdot}}{N}\right)\left(1-\frac{N_{\cdot j}}{N}\right)}} \approx N(0,1)$$

Where, r_{ij}^{c}; is the corrected standardized residual, n_{ij}; is the observed frequency, e_{ij}; is the expected frequency, $N_{i\cdot}$; is the sum of the n_{ij} horizontal, $N_{\cdot j}$; is the sum of the n_{ij} vertical, N; is the sum of total observations in the population. The calculation of residuals is applied to those variables in which the Ho (both variables are independent), are rejected with a $p < 0.05$. In addition, it must be kept in mind that for a significance level usually adapted to 5%, the residuals must be greater than 1.96 to denote excess occurrences (positive association between the pair of levels evaluated between pairs of variables), or less than - 1.96 to denote lack of occurrences (negative association between the pair of levels evaluated between pairs of variables).

RESULTS AND DISCUSSION

The coefficients of variation (CV) found for MY (45.8%), PP (12.4%), FP (23.2%), and SCC (71.5%) show that there is a variation of medium to high magnitude in these traits within the cross population, revealing that no standards allow unifying the management of animals within herds, which can affect the efficiency of dual-purpose systems. Medium to high CVs has been reported with values of 36.3 %, 40.6 %, and 61.8% for MY in females with different breed composition (SALAMANCA & BENTEZ 2012). For PP and FP, low CV values of 5.07% and 10.2%, respectively, have been reported for dual-purpose cattle (VALLEJO et al. 2018). Regarding the SCC, high CVs have been written with values of 72.0% in purebred cattle (FRANZOI et al. 2019). In the same way, for evaluating the traits by region, values of medium to high magnitude were observed for the standard deviation, especially in milk yield and somatic cell count (Table 1).

Table 1. Means and standard deviations for milk yield (MY), protein percentage (PP), fat percentage (FP), and somatic cell count (SCC) according to region.

Group	MY (kg/day)	PP (%)	FP (%)	SCC ($x10^3$ cells/ml)
General	3.06 ± 1.40	3.21 ± 0.40	3.32 ± 0.77	357 ± 256
Region 1 (R1)	3.04 ± 1.71	3.19 ± 0.40	2.82 ± 0.67	239 ± 217
Region 2 (R2)	3.16 ± 1.32	3.20 ± 0.36	3.36 ± 0.70	441 ± 221
Region 3 (R3)	2.89 ± 1.12	3.27 ± 0.46	3.76 ± 0.84	329 ± 305

Region 1: Arboledas and Pamplona municipalities, Region 2: Chinácota and El Zulia municipalities, Region 3: El Tarra and Ocaña municipalities.

For MY, a mean value was observed (Table 1) within the ranges reported by other studies, with values between 2.06 and 6.18 kg of milk/day for the first quarter of lactation in crossbred animals from Caquetá (PARRA et al. 2017). However, they are lower than those found in dual-purpose systems in Mexico, with means that varied from 4.14 ± 1.23 kg of milk/day to 5.57 ± 2.00 kg of milk/day in crossed populations (JUÁREZ-BARRIENTOS et al. 2015). The differences observed between studies may be related to the physiological development of the females, since in this study, females with first calving were evaluated, which generally present a lower level of production when compared to females with higher calving, since they must have a large part of its energy resources to finish its growth. Similarly, in the estimation of means by regions, R3 (El Tarra and Ocaña) shows lower productions than the other two regions evaluated. These differences may be related to the differential management that occurs between regions and by soil and climatic conditions.

For PP, values between 2.90 and 3.20 % were reported for dual-purpose livestock herds (DURÁN-ROJAS et al. 2020). On the other hand, mean values of 2.90 ± 0.18 % have been found in Holstein and Norman cattle, with slightly lower values than those found in this study (JURADO-GÁMEZ et al. 2019). These differences between studies show that it is possible to obtain good protein values in crossbred animals and that they can become competitive in this trait with the additional advantage that they are animals that can adapt to different geographical areas. The FP presented a mean value lower than that reported by DURÁN-ROJAS et al. (2020), with values between 4.20 to 5.00%. Some authors have shown that cows that nurse their calves during the milking process have lower FP values; therefore, the FP is higher in the milk consumed by the calves and lower in the milk that goes for sale (COZMA et al. 2013). Similarly, in the estimation of means by region, R1 (Pamplona and Arboledas) shows a lower FP than the other two regions evaluated. As with the protein, in the case of the regions, R1 produced the greatest amount of milk yield and presented the lowest FP values, and R3 produced less milk yield and obtained a higher FP; this inverse relationship is what is generally seen in production systems due to a dilution effect (VARGAS SOBRADO et al. 2017).

The average SCC value of this study (Table 1) coincides with that DURÁN-ROJAS et al. (2020) reported with SCC that varied between 50 x103 cells/ml and 885 x103 cells/ml. However, in a study in Manabí-Ecuador in double-purpose animals, SCC was found to varied from 95 x103 cells/ml to 311 x103 cells/ml (VALLEJO et al. 2018), with lower values than those found in this study. Similarly, in the estimation of means by region, R1 (Pamplona and Arboledas) shows lower SCC than the other regions evaluated.

Rotational grazing (RG) presented the highest MY and PP means (Table 2), which may be because better forage management is carried out in RG systems, considering adequate occupation and rest periods that avoid the degradation of pastures, allowing animals to graze forage of better quality (TERÁN 2014). The average SCC was lower in the semi-dry lot system (SD) compared to CG and RG, which may be related to the fact that in the SD the management of animals is much more controlled, making it possible for producers to identify situations that can affect the health of the animal's udder and correct it in time. Another situation that can be observed and highlighted is related to the differences present in the means obtained from MY for animals in RG and SD since it would be expected that animals under partial confinement where they are protected from the hottest hours and in which they give them cutting grass they had better MY; however, females in RG had a better quality pastures in paddock compared to females in SD (NARANJO-GUERRERO et al. 2022); additionally, 68.5 % of the females evaluated under RG were supplied with cutting grass.

Table 2. Means and standard deviations for milk yield (MY), protein percentage (PP), fat percentage (FP), and somatic cell count (SCC) according to the type of production system and feeding.

	Group	MY (kg/day)	PP (%)	FP (%)	SCC (x10^3 cells/ml)
	SD	3.14 ± 1.64	3.16 ± 0.33	2.91 ± 0.77	257 ± 227
System	CG	2.89 ± 1.16	3.21 ± 0.39	3.51 ± 0.73	366 ± 264
	RG	3.30 ± 1.54	3.25 ± 0.44	3.19 ± 0.75	416 ± 241
	G1	2.77 ± 1.04	3.17 ± 0.34	3.29 ± 0.65	375 ± 225
Pastures	G2	3.12 ± 1.41	3.20 ± 0.39	3.45 ± 0.81	352 ± 265
	G3	**3.60 ± 2.20**	**3.34 ± 0.51**	**2.80 ± 0.62**	**347 ± 256**

SD: semi-dry lot, CG: continuous grazing, RG: rotational grazing, G1; group 1 (predominance of Angleton, Guinea, Estrella, Sabana, and Mombaza), G2; group 2 (Brachiaria predominance), G3; group 3 (predominance of Kikuyu and Raygrass)

In the analysis carried out, it was found that the cows of G3 (cows that are located at a higher altitude above sea level) presented a higher mean for MY and PP compared to the cows of G1 and G2. In turn, the cows of G2 presented a higher mean of MY, PP, and FP, compared to the G1 cows (Table 2). The difference found may be marked by the presence of certain forage species that are commonly found in specialized dairy systems, such as Kikuyo sp. and Ryegrass sp., being congruent with the generalized characterization of high tropical pastures that present higher nutritional value, reflected in higher protein and digestibility, than low tropical pastures (SOSSA & BARAHONA 2015).

For the control season, cows evaluated in W1 presented higher mean values for MY, FP, and SCC, while cows evaluated in S1 and S2 showed low MY, FP, and SCC (Table 3). In the winter seasons, adverse conditions related to the accumulation of mud in some areas of the paddock and roads are usually generated at this time, which, together with the application of poor hygiene practices, imply an increase in SCC (RODRÍGUEZ et al. 2015). On the other hand, the cows evaluated in summer showed low SCC consistent with less presence of waterlogging, where mammary gland infections due to environmental causes are common. However, it is possible to observe that the cows evaluated in S2 presented much higher SCC than the cows evaluated in S1, this may be related to the fact that the S2 cows showed higher mean MY compared to the cows evaluated in S1 and it has been described that cows that produce more milk increase their milking time and with this the teat opening time, exposing them to different infections (VÉLEZ-ECHEVERRI & GONZÁLEZ-HERRERA 2018). In the same way, the impact generated by the conditions of each season can be mitigated if feeding is adequately managed, based on pasture management or the use of conservation systems such as haymaking and silage.

Table 3. Means and standard deviations for milk yield (MY), protein percentage (PP), fat percentage (FP), and somatic cell count (SCC) according to calving and control season.

	Group	MY (kg/day)	PP (%)	FP (%)	SCC (x10^3cel/ml)
	S1	2.77 ± 1.18	3.21 ± 0.41	3.25 ± 1.01	245 ± 252
Season	S2	3.12 ± 1.46	3.13 ± 0.25	1.94 ± 0.01	434 ± 220
Control	W1	3.44 ± 1.57	3.21 ± 0.39	3.38 ± 0.67	492 ± 185
	W2	NA	NA	NA	NA

S1; summer 1 (December, January, February, and March), W1; winter 1 (April, May, and June), S2; summer 2 (July and August), and W2; winter 2 (September, October,and November).

The DIMs evaluated were between 15 and 105 days, corresponding to a stage that includes initial lactation and early mid-lactation. In turn, Figure 1 shows a trend in which as the days in milk increase, the MY (Figure 1 A), PP (Figure 1 B), and SCC (Figure 1 D) decrease. However, the FP (Figure 1C) increases, having its maximum peak at 90 days. Several authors have reported that the shape of the curve for PP and FP follows an inverse relationship to the MY curve (MADRID et al. 2020). Which during the first days related to colostrum production, the solid components of the milk are high, but they fall rapidly in the same proportion as the MY increases; towards the last third of lactation, the solids become significant again (ACOSTA-ACOSTA et al. 2020). However, less pronounced and even linear lactation curves have been reported for animals under less controlled management conditions, with a drop in production immediately or after passing the first days of lactation (RODRÍGUEZ et al. 2015).

For the SCC, a drastic drop can be seen after 75 days of lactation. It has been mentioned that the SCC is high in the first two weeks of lactation; it decreases during mid-lactation and increases at the end of it (ÁLVAREZ 2015). In the same way, it was evidenced in buffaloes that the mean SCC in the first month of lactation was 108,000 ± 234,000 cells/ml, decreased in the second, third, and fourth months (91,000 ± 227,000 cells/ml) and increased progressively until the ninth month of lactation (103,000 ± 197,000 cells/ml) (MENDOZA-SÁNCHEZ et al. 2009). This situation presents a behavior similar to that evidenced in this study for the recipient females, in which it was found that in the first month of lactation, the average SCC was 372,210 cells/ml and decreased in the second and third months of lactation (305,923 cells/ml).

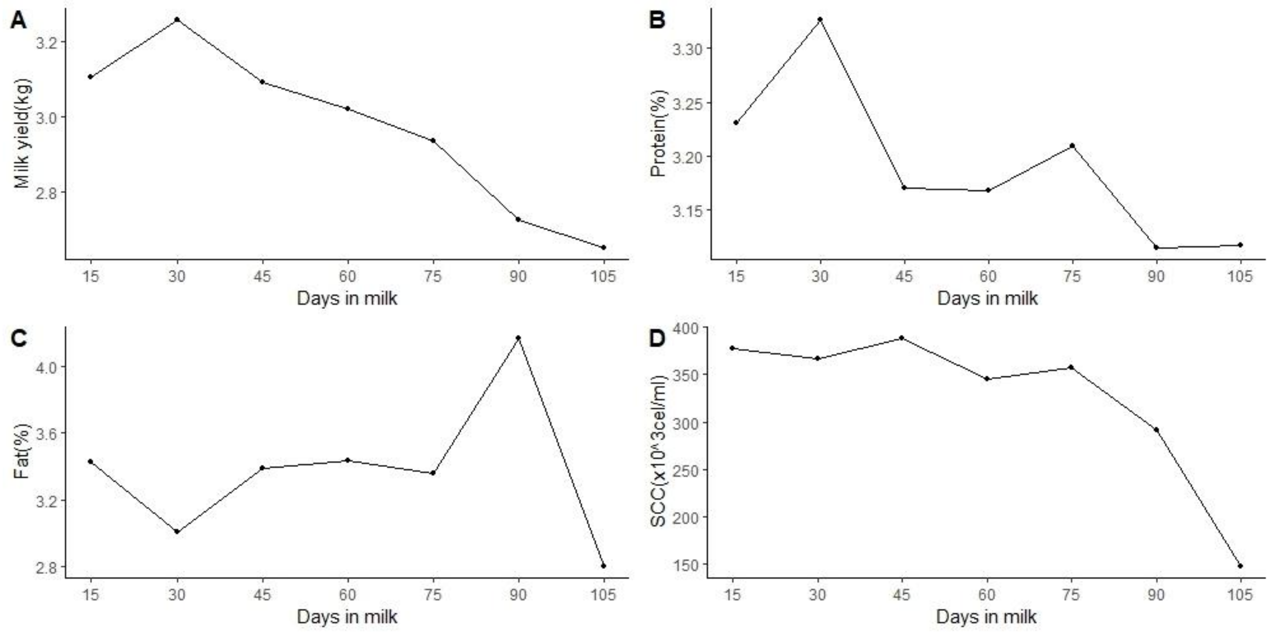

Figure 1. Milk yield, protein percentage, fat percentage, and somatic cell count according to the days of lactation.

It is possible to observe (Figure 2) that the curve for individuals of category C3, presented the highest value for MY at 30 days of lactation and subsequently showed a drop until 105 days of lactation. On the other hand, the curve with C1 individuals presented two marked peaks at 30 days and 75 days of lactation. Similarly, it is possible to observe lower values for PP from day 30 to 90 in C1 category females. Regarding the FP, marked peaks of increase and decrease of this trait are observed throughout lactation; and it is evident that the females of the C1 category begin to decrease the FP in milk from day 60 to day 105. In general, the PP presented slightly more homogeneous curves than those represented for the FP throughout lactation. This result may be related to the fact that fat is a much more sensitive parameter than protein in relation to foraging quality and consumption (BAÉZ et al. 2015).

Finally, the curves for the SCC decreased for females with C2 and C3 throughout the lactation period evaluated. In turn, the SCC values were higher in females with C2 and C3 up to 60 days in milk, which may be related to what was exposed by BREEN et al. (2009), who found that there is a higher risk of presenting SCC greater than 199,000 cells/ml in cows that present a BC lower than 1.5 or greater than 3.5 compared to other BC, which suggests that this was due to an unbalanced nutritional status that could have decreased the efficiency of the immune response in animals.

For the effect of AFC, it was found that AFC1 had a more homogeneous behavior with the variables MY (Figure 3 A), PP (Figure 3 B), FP (Figure 3 C), and SCC (Figure 3 D). It is also possible to observe that the older females at calving and the younger ones presented lower milk yield than middle-aged females. It has been mentioned that an early age at first calving translates into a longer useful life and, therefore, a greater number of offspring, which results in a greater economic benefit of the system (MARINI PR & DI MASSO RJ. 2019; SÁNCHEZ-CASTRO et al. 2019; DE VRIES & MARCONDES 2020).

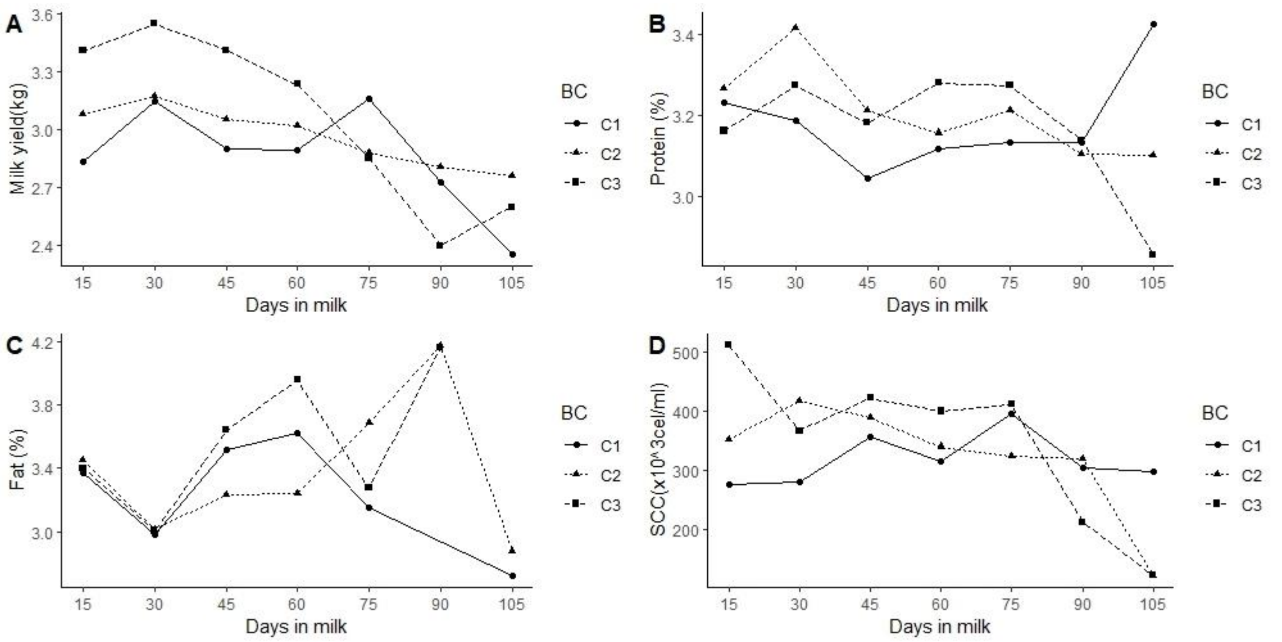

Figure 2. Milk yield, protein percentage, fat percentage, and somatic cell count according to body condition throughout the lactation trajectory. BC; body condition, C1; body condition 1 (2.50 – 3.00), C2; body condition 2 (3.01 – 3.99) and C3; body condition 3 (4.00 – 4.50)

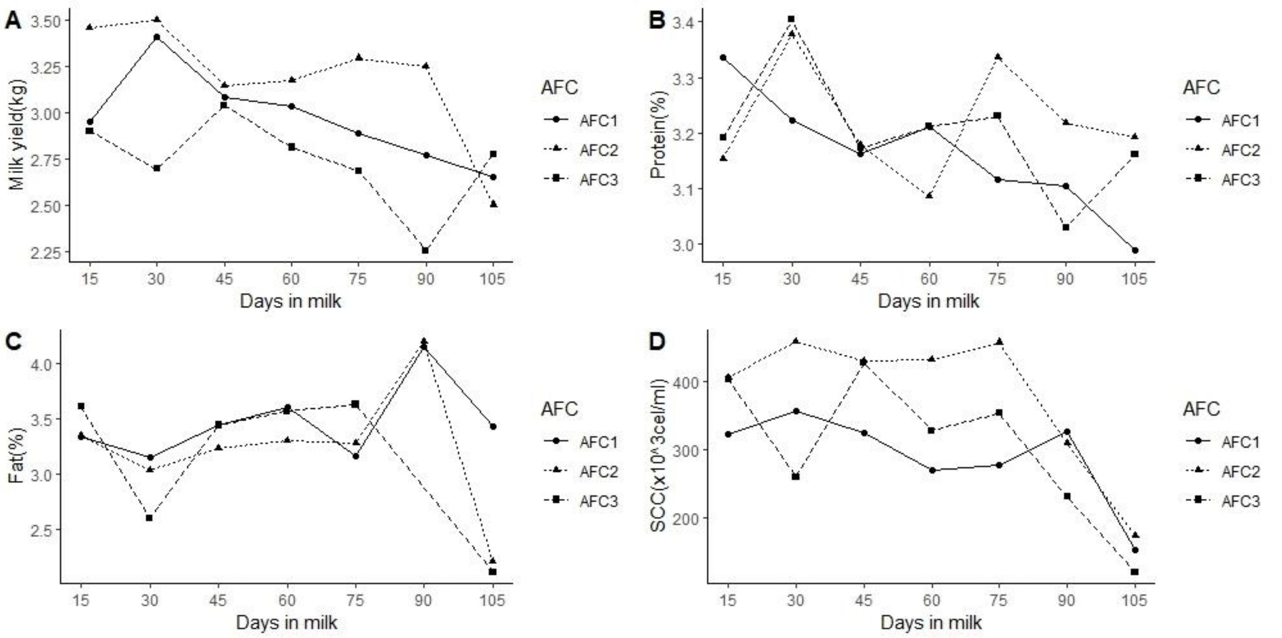

Figure 1. Milk yield, protein percentage, fat percentage, and somatic cell count according to age at first calving. AFC; age at first calving, AFC1; age at first calving 1 (<=34.99 months), AFC2; age at first birth 2 (35.00 - 40.00 months), AFC3; age at first calving 3 (>= 40.01)

For the SCC, a behavior was evidenced in which older females at calving (AFC2 and AFC3) presented higher SCC values than younger females, which is related not only to age but also to the increase in episodes of infections due to mechanical effects such as lacerations or environmental infections that increase throughout the life of the cow (WERNER 2014). On the other hand, it has been shown that there is a greater risk of presenting high SCC in cows with older ages at first calving (PERSSON WALLER et al. 2020).

It was possible to explain a percentage of inertia, including the first two dimensions of 58.0%, 55.2%, 64.9%, and 57.6% for the analyzes related to MY, PP, FP, and SCC, respectively. On the other hand, through multiple correspondence graphs, it was possible to observe the relationship between the different levels of MY (Figure 4 A), PP (Figure 4 B), FP (Figure 4 C), and SCC (Figure 4D) with the levels of non-genetic factors, which were after that verified by standardized residue analysis (Table 4).

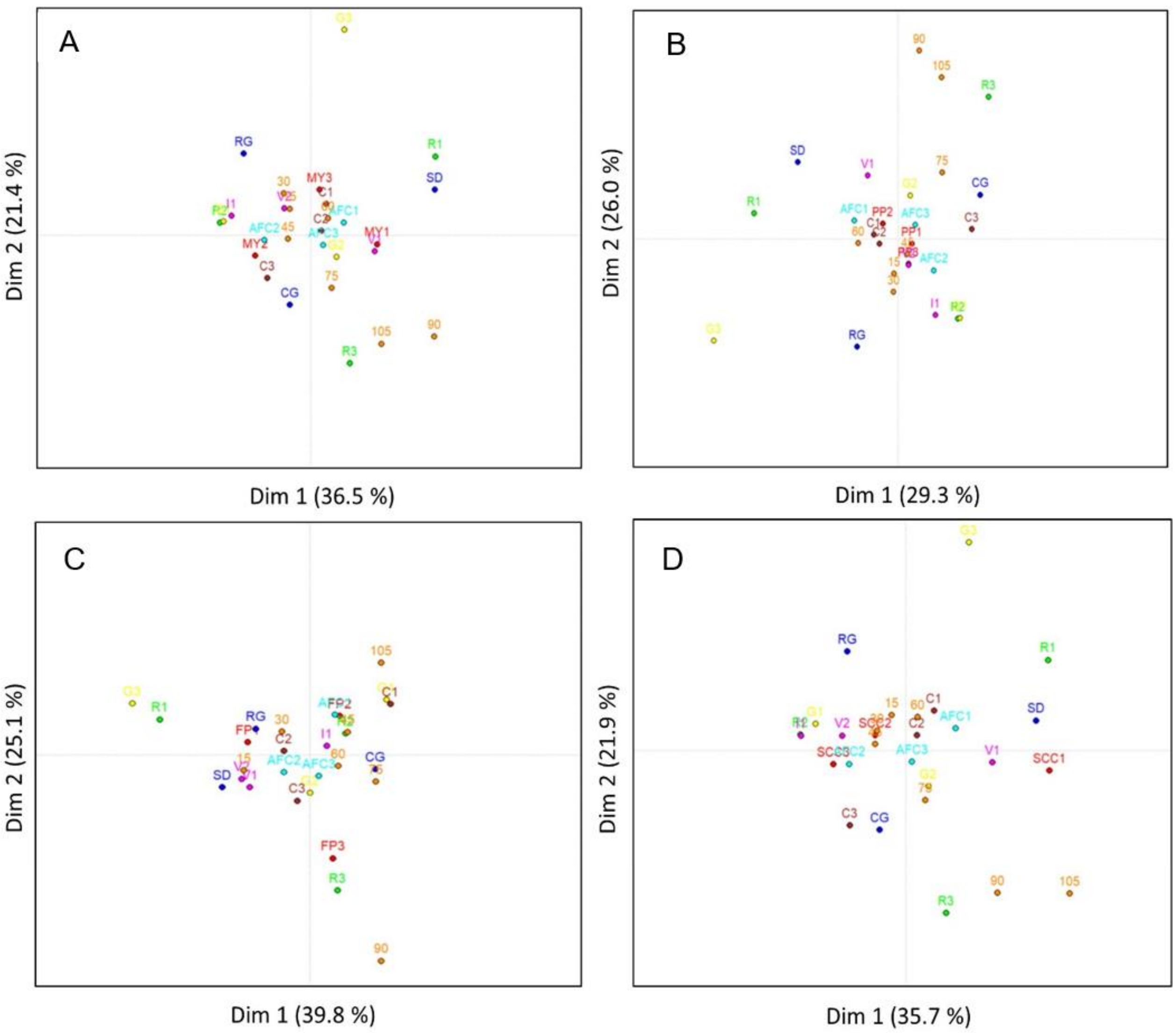

Figure 4. Multiple correspondence analysis for milk yield (MY) (A), protein percentage (PP) (B), fat percentage (FP) (C), and somatic cell count (SCC) (D) for non-effects genetic, R1: Arboledas and Pamplona, R2: Chinácota and El Zulia, R3: El Tarra and Ocaña, CG: continuous grazing, RG: rotational grazing, SD: semi-dry lot, G1: predominance of Angleton, Guinea, African star grass, Sabana, and Mombasa, G2: predominance of Braquiarias, G3: predominance of Kikuyu and ryegrass, S1: December to March, W1: April to June, S2: July and August, C1: 2.50 - 3.00, C2: 3.10 - 3.90 and C3: 4.00 - 4.50, AFC1: <= 34.99 months, AFC2: 35.00 – 40.00 months, AFC3: >= 40.01, days in milk: 15-105.

It is possible to observe that the levels G3, R3, R1, 90, and 105 DIMs (Figure 4 A - D), SD (Figure 4 A, B, D), FP3 (Figure 4 C), and SCC1 (Figure 4 D) are the ones that provide further explanation. In the same way, it can be observed that in general, in all the graphs, the levels of RG, G3, SD, and R1 are located in opposite plans to R3, 105, and 90 DIMs, indicating that the product and management events that occur in RG, G3, SD, and R1 (more associated with MY3, PP2, and FP1), behave differently than those that occur in R3, 105 and 90 DIMs (more associated with MY1, PP1, and FP3). In Table 4 it is possible to observe corrected standardized residual values that show excess (blue values) and lack of occurrence (red values). The results will be mentioned considering the excesses of occurrence. In this way, in the case of MY, it is possible to state that when evaluating region 1, the semi-dry lot system, summer 1, body condition 2, and high ages at calving, MY is low. When considering region 2, continuous grazing, pastures of G1, winter season 1, body condition 1, and middle ages at calving, there is intermediate MY, and when evaluating region 1, the semi-dry lot system and rotational, the pastures of G3 and the winter season 1 show high MY.

Table 4. Association between levels of milk yield (MY), protein percentage (PP), fat percentage (FP), somatic cell count (SCC), and levels of non-genetic effects (standardized residuals).

Nivel	MY			PP			FP			SCC		
	MY1	MY2	MY3	PP1	PP2	PP3	FP1	FP2	FP3	SCC1	SCC2	SCC3
R1	3.96	-5.93	2.48	--	--	--	4.16	-0.97	-3.51	5.01	-0.72	-4.14
R2	-4.89	6.37	-1.98	--	--	--	-2.68	4.51	-2.47	-6.77	3.43	2.70
R3	1.57	-1.20	-0.32	--	--	--	-0.98	-4.89	7.07	2.66	-3.39	1.33
CG	-0.58	4.14	-4.06	--	--	--	-2.90	-0.38	3.74	0.27	-0.02	-0.24
RG	-1.74	-0.33	2.23	--	--	--	1.54	0.68	-2.57	-3.09	0.70	2.26
SD	2.54	-4.53	2.42	--	--	--	2.24	-0.47	-1.96	3.06	-0.74	-2.18
G1	-0.39	2.98	-2.95	2.41	-2.30	-0.01	-0.56	3.08	-3.13	-2.38	3.66	-1.94
G2	0.21	-0.96	0.87	-0.97	2.25	-1.62	-2.07	-1.99	4.76	1.85	-2.82	1.47
G3	0.30	-3.46	3.59	-1.65	-0.35	2.40	3.82	-1.25	-2.78	0.48	-0.79	0.45
W1	-6.34	3.86	2.40	--	--	--	-3.61	6.74	-4.14	-9.16	4.72	3.58
S1	6.50	-4.05	-2.36	--	--	--	2.43	-6.19	4.80	9.83	-4.86	-4.07
S2	-0.61	0.63	-0.06	--	--	--	3.38	-2.16	-1.18	-2.16	0.52	1.54
15	--	--	--	0.36	-0.48	0.16	-1.08	0.06	1.15	1.53	-1.87	0.68
30	--	--	--	-2.94	0.48	2.90	3.53	-2.31	-1.17	-1.13	0.79	0.19
45	--	--	--	1.88	-1.42	-0.48	-1.65	2.87	-1.64	-2.39	2.06	-0.04
60	--	--	--	0.06	1.96	-2.50	-0.61	0.05	0.63	1.06	-1.53	0.75
75	--	--	--	-0.08	-0.45	0.66	-0.06	-0.43	0.59	-1.07	1.29	-0.44
90	--	--	--	0.03	0.81	-1.03	-1.17	-1.67	3.35	-0.78	1.33	-0.80
105	--	--	--	1.47	-1.22	-0.24	0.83	0.09	-1.05	4.81	-2.77	-1.53
C1	-1.46	3.05	-1.90	--	--	--	--	--	--	--	--	--
C2	3.01	-3.40	0.63	--	--	--	--	--	--	--	--	--
C3	-2.14	0.98	1.17	--	--	--	--	--	--	--	--	--
AFC1	0.53	-0.45	-0.05	--	--	--	-1.58	2.88	-1.72	1.82	1.55	-3.64
AFC2	-3.18	2.19	0.92	--	--	--	1.85	-2.51	-0.26	-2.06	-1.79	4.16
AFC3	2.79	-1.82	-0.92	--	--	--	-1.72	0.96	0.75	0.24	0.23	-0.52

Red values with non-occurrence. Blue values with the excess occurrence and with – cases in which Ho was not rejected. R1: Arboledas and Pamplona, R2: Chinácota and El Zulia, R3: El Tarra and Ocaña, CG: continuous grazing, RG: rotational grazing, SD: semi-dry lot, G1: predominance of Angleton, Guinea, African star grass, Sabana, and Mombasa, G2: predominance of Braquiarias, G3: predominance of Kikuyu and ryegrass, S1: December to March, W1: April to June, S2: July and August, C1: 2.50 - 3.00, C2: 3.01 - 3.99 and C3: 4.00 - 4.50, AFC1: <=34.99 months, AFC2: 35.00 – 40.00 months, AFC3: >= 40.01, 15 -105: days in milk.

For PP, it is possible to state that when evaluating G1 pastures, protein percentage are low (PP1); when evaluating G2 pastures and lactations close to 60 days, protein percentage are intermediate (PP2); and finally, with G3 pastures and lactations close to the 30 days, protein percentage are high (PP3). Regarding FP, it can be stated that region 1, the semi-dry lot system, G3 pastures, summer seasons 1 and 2, and lactations close to the 30 days presented low (FP1), whereas region 2, G1 pastures, winter season 1, lactations close to 45 days, and younger age at birth presented medium fat percentage (FP2); and that region 3, the continuous grazing system, the G2 pastures, summer season 1, and lactations close to 90 days presented high fat percentage (FP3). The SCC shows that it is possible to affirm that low SCC values are associated (SCC1) with region 1, region 3, the semi-dry lot system, summer season 1, and lactation periods close to 105 days. Region 2, G1 pastures, winter season 1, and lactation periods close to 45 days exhibit intermediate SCC values (SCC2); while region 2, rotational grazing, winter season 1, and intermediate age at calving present high SCC values (SCC3).

One of the most striking patterns in this analysis is related to what was found for the non-genetic effect of the control season represented by levels W1 and S1, where it can be observed that when there is a high occurrence of a certain level in a season, this same level is low in the other. For example, medium to high values of milk yield and somatic cell counts were found to be related to the winter season (W1), while low values of MY and SCC are related to the summer season (S1). On the other hand, the percentage of low fat (FP1) and high fat (FP3) presented in association with the summer season (S1). G3 pastures were shown to be associated with high levels of milk yield (MY3) and protein production (PP3); however, they are related to low fat percentage (FP1). G1 pastures were shown to be associated with medium milk yield levels (MY2), low protein percentages (PP1), and medium fat percentages (FP2).

In a study carried out in Brazil using multivariate statistical analysis on milk quality variables, an association was found between milk yield, cow age, lactation period, and the health status of the mammary gland (NAVARRO et al. 2021). It was observed that young females (AFC1) are not related to high somatic cell counts (SCC3), while middle-aged females (AFC2) are associated with high somatic cell counts (SCC3).

Additionally, females with late calving age (AFC3) are associated with low milk yield (MY1). Body condition has been related to milk yield in various studies. In this case, it can be observed that animals with lower body conditions (C1) are associated with medium milk yield. In contrast, animals with medium body conditions (C2) are associated with low milk yield. One study found that animals with lower body conditions had higher milk yields than those with higher body conditions (CHEROBIN et al. 2019).

CONCLUSION

There is a variation of medium to high magnitude in the traits included in this study, allowing us to observe that there are no standards that help to unify the management of the animals within the herds and consequently the efficiency of the dual-purpose systems can be affected.

From the phenotypic characterization analysis carried out; it is shown are non-genetic factors that can influence the variation of milk traits. Generally, the non-genetic factor that influenced all the milk traits evaluated in this study was the pasture type, showing significant standardized residue values. However, in the case of MY, FP, and SCC, the control season and the region showed high values for the standardized residues, implying high significance.

Knowledge of the influence of non-genetic factors on productive characters in traditional dual-purpose systems and the evidence of high variability in the studied traits caused by these will allow the generation of essential information for management that will enable the producer to make technical decisions that have a positive impact on production and thus the profitability of the system.

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