Milk yield and composition of primiparous recipient cows influence the performance and carcass ultrasonography of Nellore calf

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ABSTRACT
This study investigates the influence of the breed of primiparous recipient cows on milk yield and composition during the lactation stage, as well as evaluating the carcass and performance characteristics of their calves at weaning. The experiment was conducted in a commercial Nellore herd with two groups of primiparous recipient beef cattle, Nellore (n = 11) and ½ Angus × Nellore (n = 11). Variables were measured monthly from birth to weaning. Days in milk affected milk intake and composition. There was an effect of the interaction of breed and time on milk fat, protein and lactose, measured in g/kg of milk. Calves from Angus primiparous cows had greater body weight, average daily gain (ADG), longissimus muscle area (LMA) and longissimus weight-to-width ratio than others, since those traits are associated with milk yield. In contrast, considering area/100 kg, backfat and marbling, the Nellore cows delivered similar calves to the Angus cows, due to the better quality of their milk. Milk intake was positively correlated with ADG, BW and LMA, but negatively correlated with milk protein, fat and lactose. The nutrients in milk were positively correlated with milk intake, and body weight was positively correlated with LMA, weight-to-width ratio, backfat, milk intake and ADG.

1. Introduction
Calves’ development at the preweaning stage is related to their genetic potential, maternal ability and the environment in which they are raised (Rodrigues et al. 2014). Maternal environment is one of the most important factors determining the growth of calves, since milk is the primary source of nutrients during the initial period of their lives (Brown and Brown 2002). As a consequence, differences in the dams’ breed and consequently their milk production, can affect calves’ performance, meat production and meat quality. Meat is one of the most important foods in the diet for the vast majority of people (Delgado 2003). For the last few years, there has been increasing consumer concern about meat quality traits, resulting in the meat industry and farmers attempting to produce meat to satisfy consumer demand for high-quality meat. Meat quality is a broad term covering a variety of characteristics, and sensory parameters have the highest influence on consumers’ purchase decisions (O’Quinn et al. 2012). Marbling can improve juiciness and tenderness, which in turn are the most important parameters affecting quality. The marbling window, or the period of time when the nutritional management of cattle can enhance marbling, starts to close after birth and marbling reaches very low rates after 250 days of age (Du et al. 2010). As a consequence, preweaning is an important period for increasing adipocytes in the muscle, and this is completely dependent on feeding. In this sense, the cow’s milk production has higher importance in this period, because milk is the only source of nutrients in the early stages of life.

Meat quality traits can also be measured in life using ultrasound (US), and this can be an important tool to identify superior animals with respect to many traits, for breeding programmes (Bertrand 2009). According to Bertrand (2009), the mean estimates of US measurements ranged from 0.34 to 0.46, which indicates that they would respond to selection in breeding programmes. The main carcass traits that are considered in evaluation programmes are longissimus muscle area, backfat thickness measured between the 12th and 13th rib and over the rump and marbling score, which is measured in the ribeye muscle and is a subjective measure of intramuscular fat. These are important traits that measure the carcass composition, growth patterns and meat quality.

Therefore, authors hypothesized that calves of Nellore primiparous recipient present productive performance and quality of meat equal to Angus primiparous recipient, in addition we hypothesize that Angus primiparous recipient have better production and milk composition in relation to Nellore. The present study aims to investigate the influence of the breed of primiparous recipient cows on milk yield and composition during the lactation stage, as well the influence of breed of primiparous

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recipient on carcass characteristics and the performance of their calves at weaning, as well as to correlate the quantity and quality of the milk intake by the calves with the carcass characteristics of the same.

2. Materials and methods

2.1. Animals and experimental design

Experimental procedures involving animals were performed in accordance with the recommendations of the Ethics Committee of the Federal University of Grande Dourados (CEUA/UFGD; 043/2017). The study was conducted on a commercial farm, located in the city of Bela Vista, in the state of Mato Grosso do Sul, in Central-West Brazil, from November 2017 to May 2018. A total of 22 primiparous recipient cows (mean ± s.d.: 24 ± 2.3 months of age, 328 ± 30.9 kg body weight) were used. Treatments were according to the breed of the primiparous recipient. Half were Nellore (Nellore) and the other half were ½ Nellore × Angus (Angus). The females were used as recipients for pure-bred Nellore male embryos, following the methodology described by Baruselli et al. (2010). Male calves were born with a mean body weight of 32 ± 3.5 kg and were kept in five pickets of 12 ha each, in a rotation pasture system (15 days in each picket). The pasture used was Brachiaria brizantha cv. BRS Piatã, with mean available dry matter (DM) of 3,500 kg/DM/ha, 69% of FDN, 53% in vitro dry matter digestibility (IVDMD) and 11% of crude protein (CP). During the whole experimental period (180 days) dams were also supplemented with a solid mineral mix (containing 34% crude protein, 30% non-protein N, 6% Ca, 2% Na, 4% P, 0.6% S, 0.6% Mg, 1000 mg/kg Cu, 2,000 mg/kg Mn, 50 mg/kg iodine, 3,000 mg/kg Zn, 15 mg/kg Se, 200,000 IU/kg vitamin A, 20,000 IU/kg vitamin D3, 1,000 IU/kg vitamin E and 1500 mg/kg monensin) supplied by MUB® Animal Nutrition (De Heus company).

2.2. Milk intake and composition and performance measurements

Every month, the milk intake was measured using the first suckling of the calves in the morning. Calves and dams were separated during the night (12 h), and at 6 am the calves were weighed before suckling. They then had access to the dam for one hour, and were then weighed again to determine the amount of milk ingested, according to the methodology previously described by Restle et al. (2004). Dams were also weighed before and after the calves sucked.

To evaluate the milk composition, 300-mL samples obtained by manual milking were taken every month. To facilitate the dams’ milk production, oxytocin (30 units) was injected intramuscularly, according to the methodology described by Restle et al. (2004). Samples of milk were analysed for fat, protein and lactose content, using an infrared methodology (Lactoscan®, Entelbra, Sao Paulo, Brazil).

To measure the calves’ performance, the animals were weighed on the day of birth and every 30 days thereafter up to 180 days of age, using an electronic balance (WBECK BK+1, Beckhauser®, Paranavai, PR). The primiparous cows were also weighed at calving and every 30 days thereafter. The body condition score (BCS) was evaluated to measure the body mass mobilization during lactation. This was evaluated using a specialized technical scale with points from 1 to 5, where a value of 1 represents very thin cows and 5 represents very fat cows.

The ultrasound images were taken and analysed by technicians accredited by the Brazilian Association of Ultrasound Technicians (Associação de Técnicos de Ultrassom do Brasil – ATUBRA) to measure loin-eye area in cm² in the longissimus dorsi muscle (striploin) between the 12th and 13th ribs, LEA per 100 kg of live weight (LEA/100 kg) in cm²/100 kg, ratio (LEA height/width) measured in the longissimus dorsi muscle (striploin) between the 12th and 13th ribs, marbling or intramuscular fat score (MAR) in points, observing the percentage of lipids measured by reading the image with the transducer placed lengthwise between the 11th and 13th ribs, backfat thickness (BFT) in mm, measured in the longissimus dorsi (striploin) between the 12th and 13th ribs, BFT per 100 kg of live weight (BFT/100 kg) in mm/100 kg and rump fat thickness (RFT) in mm, measured at the intersection of the gluteus medius and biceps femoris muscles, located between the ilium and the ischium. These measurements were taken in all animals at weaning.

2.3. Pasture samples and composition

Pasture samples were collected each month, dried for 72 h in a forced-ventilation oven at 55°C and ground sufficiently to pass through a 1-mm screen in a Wiley mill (Tecnal, Piracicaba, Brazil). The DM was analysed according to AOAC (2000) method 930.15. The N content was determined by combustion (LECO protein/N analyzer, model FP528; LECO Corp., St. Joseph, MI), CP was determined by multiplying the N content by 6.25 and concentration of NDF was determined according to the method of Van Soest et al. (1991), using heat-stable α-amylase (Sigma-A3306; Sigma Chemical Co., St. Louis, MO), using an ANKOM A200 Fiber Analyzer (ANKOM Technology Corp., Fairpoint, NY).

In vitro DM digestibility values were determined after 48 h of incubation in a DaisyII (ANKOM Technology Corp., Fairpoint, NY) incubator consisting of four fermenter bottles, following the methodology proposed by Holden (1999).

2.4. Statistical analyses

The data for productive performance and milk intake and composition were subjected to analysis via SAS (version 9.1.3; SAS Institute, Cary, NC, USA, 2004), verifying the normality of residuals and homogeneity of variances using PROC UNIVARIATE. Data were analysed using PROC MIXED according to the following model of repeated measures:

\[
Y_{ijkt} = \mu + A_i + B_j + T_k + (A_i \times B_j) + e_{ijkt}
\]

where \(Y_{ijkt}\) is the dependent variable, \(\mu\) is the overall mean, \(A_i\) is the random effect of the animal, \(B_j\) is the fixed effect of breed, \(T_k\) is the fixed effect of time (in weeks), \(A_i \times B_j\) is the interaction effect of breed and time and \(e_{ijkt}\) is the residual error. DF values were calculated according to Satterthwaite’s method (DDFM = SATTERTH). Autoregression 1 was the best covariance method of Van Soest et al. (1991), using heat-stable α-amylase (Sigma-A3306; Sigma Chemical Co., St. Louis, MO), using an ANKOM A200 Fiber Analyzer (ANKOM Technology Corp., Fairpoint, NY).
structure, based on the smallest Akaike's information criterion values. Other covariance structures were tested, including compound symmetry, heterogeneous compound symmetry, unstructured and heterogeneous autoregression 1. For covariate adjustment, we first used the calves' birth body weight and primiparous dams' body weight at day zero, but these were not significant in the statistical model. The significance level was set at \( P \leq 0.05 \).

The data on ultrasound parameters were subjected to analysis via SAS (version 9.1.3; SAS Institute, Cary, NC, USA, 2004), with the normality of residuals and homogeneity of variances verified using PROC UNIVARIATE. Data were analysed using PROC MIXED according to the model measures:

\[
Y_{ij} = \mu + A_i + B_j + e_{ij},
\]

where \( Y_{ij} \) is the dependent variable, \( \mu \) is the overall mean, \( A_i \) is the random effect of the animal, \( B_j \) is the fixed effect of breed and \( e_{ij} \) is the residual error. DF values were calculated according to Satterthwaite's method (DDFM = SATTERTH). The significance level was set at \( P \leq 0.05 \).

Pearson's correlation analysis between milk quality, US values and calf performance was performed using PROC CORR in SAS (version 9.1.3; SAS Institute, Cary, NC, USA, 2004). The significance level was set at \( P \leq 0.05 \).

3. Results

3.1. Milk yield and composition for primiparous cows

There was no effect (\( P > 0.05 \)) of breed or the interaction of breed and time on milk intake or composition measured in kg/day (Table 1). Calves from an Angus dam had a greater milk intake than others at ages 60, 90 and 150 days, and calves from a Nellore dam had greater milk intake at 30 days of age (Figure 1(a)). In addition, the time of lactation affected (\( P < 0.05 \)) milk intake and all the parameters of milk composition.

There was an effect of the interaction between breed and time on milk fat (\( P = 0.043 \)), protein (\( P = 0.005 \)) and lactose (\( P = 0.005 \)), measured in g/kg of milk (Table 1). The Nellore primiparous cows had higher milk fat after 90 days of lactation compared to the Angus dams (Figure 1(b)). Similarly, regarding the protein content of the milk, the Angus and Nellore females presented the same content at day zero and day 60, but after that, higher protein content was found in milk from Nellore females (Figure 1(c)). For lactose, there was no difference between breeds at days zero, 30 and 60, but after that, the milk from Nellore females presented higher amounts of lactose (Figure 1(d)).

3.2. Calves' performance and ultrasound measurements

There was no effect of the interaction between breed and time (\( P > 0.05 \)) on calves' performance, but animals from Angus primiparous cows had greater body weight by 14% (\( P = 0.033 \)) and greater ADG by 12% (\( P = 0.031 \)) than those from Nellore dams (Table 2). In addition, the BW increased (\( P < 0.001 \)) and ADG decreased (\( P = 0.039 \)) thought days' age (Figure 2(a,b)). Furthermore, calves from Angus primiparous dams showed an increase of 14.8% and 8.6% in longissimus muscle area (\( P = 0.033 \)) and longissimus weight-to-width ratio (\( P = 0.022 \)). However, it should be noted that the parameters of meat quality (marbling: \( P = 0.142 \)) and productive efficiency (longissimus muscle area/100 kg: \( P = 0.920 \)) were not affected by the dam's breed (Nellore or Angus).

3.3. Correlation between milk quality, US and calf performance

There was a positive correlation between milk intake and LMA (\( r = 0.118, P < 0.05 \)) and LMA/100 kg (\( r = 0.289, P < 0.05 \)). In addition, the milk fat, protein and lactose had a high positive correlation (\( P < 0.05 \)) with marbling (\( r = 0.840, 0.860 \) and 0.885, respectively) but a negative correlation (\( P < 0.05 \)) with milk intake (\( r = -0.460, -0.516 \) and -0.513 for fat, protein and lactose, respectively, see Table 3). Additionally, milk protein was highly correlated (\( P < 0.001 \)) with fat (\( r = 0.942 \)) and lactose was also correlated (\( P < 0.001 \)) with fat (\( r = 0.871 \)) and protein (\( r = 0.966 \)). The ADG had a positive correlation with LMA (\( r = 0.519; P < 0.001 \)), weight-to-width ratio (\( r = 0.544; P < 0.05 \)) and milk intake (\( r = 0.402; P < 0.001 \)), but a negative correlation with LMA/100 kg (\( r = -0.116; P < 0.05 \), see Table 3). Furthermore, BW was positively correlated with LMA (\( r = 0.722; P < 0.001 \)), weight-to-width ratio (\( r = 0.591; P < 0.05 \)), backfat measured over the longissimus (\( r = 0.396; P < 0.05 \)), milk intake (\( r = 0.344; P < 0.001 \) and ADG (\( r = 0.524; P < 0.001 \)), but negatively correlated with LMA/100 kg (\( r = -0.527; P < 0.05 \), see Table 3).

4. Discussion

The data showed no differences in average milk intake between dam breeds. However, despite no changes in the interaction between breed and time, calves from Angus dams had a greater milk intake only at 60 and 150 days of age, compared with those from the Nellore dams. The Nellore females showed peak intake at 30 days, declining thereafter. This could be due to the higher milk yield of the crossed dams, compared to the Nellore dams. As a consequence, calves from the Angus dams sometimes experienced greater milk availability and milk intake. One very important trait for beef cows is the

| Table 1. Milk yield, composition and performance of Nellore or Angus recipient primiparous. |
|---------------------------------|-----------------|------------------|-----------------|-----------------|
| Variable                        | Recipient breed* | P-value          |
|                                 | Angus | Nellore | SEM | Breed | Time | Breed*Time |
| Milk intake (kg/day)            | 4.30  | 4.08    | 0.20 | 0.653 | 0.004 | 0.174    |
| Fat correct milk (kg/day)       | 5.18  | 5.15    | 0.15 | 0.924 | 0.011 | 0.429    |
| Energy correct milk (kg/day)    | 5.02  | 4.87    | 0.23 | 0.778 | 0.006 | 0.273    |
| Fat (kg/day)                    | 0.197 | 0.191   | 0.01 | 0.760 | 0.007 | 0.308    |
| Protein (kg/day)                | 0.149 | 0.147   | 0.01 | 0.887 | 0.006 | 0.342    |
| Lactose (kg/day)                | 0.194 | 0.194   | 0.01 | 0.982 | 0.007 | 0.392    |
| Fat (g/day)                     | 46.32 | 47.71   | 0.03 | 0.117 | 0.003 | 0.043    |
| Protein (g/day)                 | 35.32 | 36.82   | 0.02 | 0.021 | <0.001 | 0.005    |
| Lactose (g/day)                 | 45.72 | 48.82   | 0.03 | 0.002 | <0.001 | 0.005    |
| Body score condition (g/day)    | 3.08  | 2.89    | 0.03 | 0.042 | <0.001 | 0.887    |
| Body Weight (kg)                | 399.5 | 374.4   | 3.32 | 0.044 | <0.001 | 0.151    |

*Angus (recipient primiparous ½ Angus-Nellore); Nellore (recipient primiparous Nellore).

Fat correct milk: 3.5% of fat, according to NRC (2000).

Energy correct milk: according to NRC (2000).
Figure 1. Calves milk intake (kg) according to time and dam’s breed (a), milk fat (b), protein (c) and lactose (d) content (g/kg) of Nellore or Angus recipient primiparous over the lactation time.
volume of milk production and hence the milk intake by the calves, because the more milk the calf has access to at an early age, the heavier it will be by weaning time (Rodrigues et al. 2014; Dervishi et al. 2017). Cerdótes et al. (2004), comparing milk production and composition in taurine and zebu cow breeds in Brazil, identified higher milk yields in taurine cows. These authors also conclude that calves from taurine cows are heavier at weaning, due to greater milk availability and intake. In addition, several milk traits were extensively affected by breed throughout the lactation time. Milk composition traits such as fat and protein percentages have been used as indicators of milk quality and, together with the amount of milk produced, they can also affect calf performance and system efficiency (Cerdótes et al. 2004; Rodrigues et al. 2014; Contreras et al. 2015). In the present study, the Nellore cows had a greater content of milk fat and protein at 90, 120, 150 and

Table 2. Performance and carcass ultrasound of Nellore calves of Nellore or Angus recipient primiparous.

| Variable                  | Recipient breed* | SEM | Breed | Time | Breed*Time |
|---------------------------|------------------|-----|-------|------|------------|
| Body weight (kg)          | Angus            | 131.3 | 114.2 | 3.93 | 0.033      | <.0001 | 0.408 |
| Average daily gain (kg/day) | Nellore         | 0.913 | 0.815 | 0.02 | 0.031      | 0.039  | 0.680 |
| Longissimus muscle Area (cm²) |                | 40.10 | 34.93 | 1.24 | 0.033      | -     | -     |
| Area:100kg                |                  | 21.23 | 21.11 | 0.56 | 0.022      | -     | -     |
| Height:width ratio        |                  | 0.50  | 0.46  | 0.01 |            | -     | -     |
| Back fat (mm)             |                  | 2.49  | 2.21  | 0.10 | 0.213      | -     | -     |
| Over Longissimus          |                  | 2.33  | 1.34  | 0.06 | 0.923      | -     | -     |
| Over rump                 |                  | 4.45  | 3.95  | 0.23 | 0.289      | -     | -     |
| Marbling                  |                  | 2.69  | 2.94  | 0.08 | 0.142      | -     | -     |

*Angus (recipient primiparous ½ Angus-Nellore); Nellore (recipient primiparous Nellore).

Figure 2. Body weight (a) and average daily gain (b) of Nellore calves from Nellore or Angus recipient primiparous.
180 days after calving, offering greater nutritional support to the calves during the period of higher metabolic performance of the calves, compensating in terms of meat quality for the superior performance presented by calves from Angus dams. Calves from Angus dams may make the transition from the pre-ruminant to the ruminant phase earlier than calves from Nellore dams. As a consequence, they start to consume forage earlier, improving the intake of nutrients to support growth (Drackley 2008; Baldwin and Connor 2017). This fact, together with the greater milk intake for calves from Angus dams, can be confirmed by the improved performance in measures including ADG, BW and LMA (muscularity indicators), of calves from Angus dams, compared to calves from Nellore dams. However, according to our understanding of meat quality, the productive performance of cattle must be balanced with the meat quality attributes, and therefore the better milk content of the Nellore dams provides greater efficiency in the meat production process in the tropical climate, due to the enormous advantages of using a zebu dam compared to a taurine dam.

This superiority in growth and muscularity of calves from Angus dams is important, because it can improve the profitability when the calf is sold post weaning, since at this stage, animals are more efficient in converting food into body components. MacNeil and Mott (2006) reported that up to 60% of the variation in calf weight at weaning can be attributed to the milk production of the dam and to the composition of the milk (Brown et al. 2001).

On the other hand, 90 days after calving, Nellore dams had a higher milk fat, protein and lactose content in their milk. However, this did not improve the ADG. This is probably due to the lower influence of milk on calves’ development after 90 days of age than at earlier stages (up to 60 days of age), since the total number of suckling events declines as the calf grows older. Once calves become ‘real’ ruminants they make use of pasture, and milk is no longer the only food supplying the nutrient requirements (Espasandin et al. 2001). With regard to dam body weight and BCS, Angus cows have greater values for both traits than Nellore cows. This could be due to the greater genetic potential of the Angus breed to grow faster and deposit more muscle and fat than Nellore cows of the same age (Calegare et al. 2009).

Ultrasoundography is an important tool for evaluating muscle mass and adipose tissue deposition on carcasses. Sapp et al. (2002) have shown that ultrasound measures of fat thickness, longissimus muscle area and intramuscular fat percentage, are accurate predictors of their corresponding carcass traits in cattle. In addition, those traits have a moderate-to-high average heritability (Bertrand et al. 2000). This indicates that selecting seedstock animals based on ultrasound measurements has the potential to improve carcass traits in their progeny (Sapp et al. 2002).

Additionally, all these traits can estimate meat quality and can be used in a breeding programme to obtain high-quality meat production (Sapp et al. 2002). Over the last few decades, there has been an increasing consumer demand for meat and also for high-quality meat. Intramuscular fat or marbling is one of the important components contributing to eating quality, especially with respect to tenderness, juiciness and flavour. As a consequence, it can affect the consumer acceptance (Wheeler et al. 1994). In order to improve marbling in cattle, the concept of the ‘marbling window’ has been used (Du et al. 2010). According to Du et al. (2010) this is characterized as the period where nutrition can enhance the number of adipocytes in muscle mass. However, such enhancement starts to decrease after birth and becomes very low after 250 days of age. As a consequence, nutritional management to enhance marbling in beef cattle will be more effective at earlier stages of development, because of the presence of abundant multipotent cells in the skeletal muscle, a characteristic that wanes as animals mature (Du et al. 2010). Despite the fact that Angus dams have the higher milk quality up to 60 days of lactation, calves’ marbling is not changed by the dam’s breed. In other words, in terms of marbling, the Nellore dams deliver the same product.

This is probably because greater accession of lipids and hyperplasia of the adipocytes occurs in the finishing period. At early stages of life, calves may have differences in the number of adipocyte cells, but these intramuscular adipocytes will accumulate fat at later stages of life, especially during the finishing phase, forming marbling (Wheeler et al. 1994). Preliminary studies have demonstrated that fetal-stage and early nutritional management soon after birth is crucial for the formation of intramuscular adipocytes (Tong et al. 2008). There are studies

Table 3. Pearson correlation between carcass ultrasound parameters and productive performance of calves and milk yield and composition of Nellore or Angus recipients primiparous.

| Variable | LMA100 | Ratio | MAR | BFL | BFL100 | BFR | MI | Fat | Protein | Lactose | ADG | BW |
|----------|--------|-------|-----|-----|--------|-----|----|-----|---------|---------|-----|-----|
| LMA      | 0.164  | 0.376 | 0.199 | 0.316 | -0.249 | 0.333 | 0.118* | -0.352 | -0.347 | -0.409  | 0.519** | 0.722** |
| LMA100   | -0.351 | 0.177 | -0.110 | 0.361 | -0.161 | 0.289* | -0.019 | 0.063  | 0.093   | -0.166* | -0.527*|
| Ratio    | -0.109 | 0.338 | -0.064 | 0.428 | 0.262  | -0.136 | -0.235 | -0.286 | 0.544* | 0.591*  | 0.011  |
| MAR      | 0.188  | 0.138 | 0.375 | -0.227 | 0.840* | 0.860* | 0.885* | -0.457 | 0.011  |
| BFL      | 0.661  | 0.657 | 0.062 | 0.057  | 0.050  | 0.161  | 0.104  | 0.396* |
| BFL100   | 0.295  | -0.149 | 0.254 | 0.191  | 0.147  | -0.405 | 0.389  |
| BFR      | 0.143  | 0.225 | 0.124 | 0.079  | -0.011 | 0.456  |
| MI       | -0.460* | -0.316* | -0.513* | 0.402** | 0.344** |
| Fat      | 0.942** | 0.871** | 0.540  | 0.293  |
| Protein  | 0.966** | 0.592  | -0.348 |
| Lactose  | -0.622 | -0.419 |
| ADG      | 0.524** |

LMA = Longissimus muscle area; LMA 100 = LMA/100 kg of BW; Ratio = Longissimus muscle height:width ratio; MAR = marbling; BFL = Back fat thickness over Longissimus; BFL 100 = Back fat thickness over Longissimus/100 kg of body weight; BFR = Back fat thickness over the rump (Biceps femoris); MI = milk intake; Fat = milk fat content; Protein = milk protein content; Lactose = milk lactose content; ADG = average daily gain.

*P < .05; **P < .001.
indicating that nutritional management, including milk yield and quality, can increase marbling at later stages of life (Wertz et al. 2002; Pyatt et al. 2005).

Regarding correlation between traits, milk intake was positively correlated with ADG, BW and LMA. This can be explained by the fact that greater nutritional support from milk can improve performance traits, including muscularity. On the other hand, milk intake was negatively correlated with milk protein, fat and lactose concentrations. This may be due to the diluting effect, i.e. as the cows produce more milk, the milk solids can be decreased by dilution. Regarding the time of lactation, the solids were low until around 60 days after calving. This coincides with peaks between the 8th and the 10th weeks. After that, the milk yield starts to decrease, and as a consequence the milk solids content becomes higher. These results agree with those of NRC (2000), which established, based on a review of beef cow milk yield studies with different genetic groups, that peak milk yield occurs at around 8.5 weeks of lactation. This also coincides with a shift towards forage intake as the main feed source of calves.

Similarly, Mummed (2013) also found a higher correlation between weight change ($r = 0.98$) and ADG ($r = 0.44$) with daily milk suckling of calves. The authors suggested that this showed the importance of milk in the early stages of life, reflecting directly on calf performance. Furthermore, milk fat, protein and lactose contents were more positively correlated with marbling, because a higher nutritional value of the milk leads to a greater nutritional contribution to the calves at the very early stages of life, so that greater numbers of multipotent cells can differentiate to become adipocyte cells, improving marbling (Du et al. 2010). Contreras et al. (2015), studying milk yield and composition of Charolais cows, found a significant correlation between milk lactose and calves' weaning weight, but no correlation was found between fat and protein in milk and calves’ weight.

5. Conclusions

In conclusion, Nellore dams produced milk with greater nutritional value, and as a consequence, Nellore calves from Nellore dams, together with greater performance, muscularity and body weight.

Our correlation analyses show that the carcass weight is directly related to the amount of suckled milk and the quality of the meat is positively related to the quality of the milk suckled by the calves.

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Disclosure statement

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