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Correlations of visual scores, carcass traits, feed efficiency and retail product yield in Nellore cattle

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ABSTRACT: The growing use of visual scores (VS) and ultrasound (US) for carcass evaluation in breeding programs, calls for a knowledge of the relationships between these traits and other relevant characteristics, such as feed efficiency and production of commercial cuts. The objective of this study was to evaluate correlations between body visual scores and carcass traits identified by ultrasound (US) and feed efficiency (FE), carcass weight (HCW), dressing percentage (DP) and retail product yield (RPY) in beef cattle. Nellore cattle (male), 42 non-castrated [NCAST] and 44 castrated [CAST]) were evaluated by both VS and US, at the postweaning (15-month old) and finishing phases (21-month old). Visual scores of conformation (C), precocity (P) and muscling (M) were assessed and the backfat thickness (UBFT), rump fat thickness (URFT) and ribeye area (UREA) were measured by ultrasound. Gain-to-feed (G:F) ratio and residual feed intake (RFI) were measured in feedlot. Hot carcass weight, DP and RPY were determined at harvest. Non-castrated cattle had greater HCW and RPY but lower UBFT and URFT than CAST. Postweaning VS and US were poorly correlated with FE in both sexual conditions. Finishing VS were negatively correlated with G:F in CAST and finishing URFT was negatively correlated with RPY in NCAST. The relationship of VS and US with feed efficiency and meat yield is affected by age at the date of evaluation and by castration. Feed efficiency is not related to the yield of meat cuts in Nellore cattle.

Introduction

Recently, producers and packing plants have taken more interest in the area of carcass quality and the benefits it can deliver. Producing carcasses with greater dressing percentage can improve the revenues of producers in the finishing activity as their remuneration is based directly on carcass weight. Moreover, carcasses with higher yield of commercial cuts decrease fabrication costs per unit of product in the packing plant.

Besides carcass traits, feed efficiency has also been considered an economically relevant factor. Cattle that eat less feed to achieve the same performance as their cohorts are more profitable and environmentally friendly (Hegarty et al., 2007; Cruz et al., 2010). However, as measuring feed efficiency is labor intensive and expensive, there are constraints on the adoption of feed efficiency in breeding programs. Consequently, there is a growing interest in technologies that indirectly improve cattle feed efficiency.

Visual scores of conformation, precocity and muscling (CPM) and ultrasound for carcass evaluation, are techniques employed in beef cattle selection for carcass quality in Brazil. Although ultrasound provides realistic measures of carcass traits, CPM is a low-cost and effortless measurement, and both are heritable and genotypically correlated with carcass traits (Weber et al., 2009; Yokoo et al., 2009; Koury Filho et al., 2010). Nevertheless, how feed efficiency, carcass dressing and retail product yield would be affected by selecting cattle based on CPM is still unclear.

Additionally, the relationship between finishing feed efficiency and retail product yield has been poorly explored. Animals with better conformation are probably more biologically efficient, and are thus more profitable to farmers (Pascoal et al., 2010). However, if improvements in feed efficiency are counteracted by losses in yield of commercial meat cuts, the genetic selection for feed efficiency would have to be re-evaluated. Hence, the objective of this study was to evaluate the degrees of correlation between postweaning and finishing CPM scores and ultrasound carcass traits with feed efficiency, dressing percentage and retail product yield of carcasses in castrated and non-castrated Nellore cattle, finished in feedlot. A further objective was to evaluate the relationship between feedlot feed efficiency and retail product yield.

Materials and Methods

The study was carried out at Pirassununga, state of São Paulo, Brazil (21°57′11″ S; 47°27′11″ W). This study used 86 Nellore yearlings, 44 castrated (surgically) and 42 non-castrated. Following castration, the cattle were allowed to recover for three months, grazing in *Brachiaria* spp. pastures. Following the recovery period, visual scores of conformation (C), finishing precocity (P) and muscling (M) from 1 to 6 were attributed to cattle individually by a trained technician (postweaning phase measurements). On the same day, ultrasound carcass

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traits were evaluated using a real-time SSD 500 Micrus (Aloka Co. Ltd.) instrument equipped with a 17-cm, 3.5 MHz linear array transducer. The ribeye area and subcutaneous backfat thickness were measured by scanning the *Longissimus* muscle between the 12th and 13th ribs, and the ultrasound rump fat thickness by scanning the *Biceps femoris* muscle. The images were collected and analyzed by a UGC (Ultrasound Guidelines Council) certified technician.

Six months later (21-month old), the cattle were enrolled in a feedlot feeding trial. CPM and carcass ultrasound were assessed again on arrival at the feedlot (finishing phase measurements) and feed efficiency traits were measured throughout the feeding trial. The animals were housed in individual pens (5 × 8 m) and in group pens (10 × 23 m) with Calan gates (American Calan Inc.), following a complete randomized block design. The cattle were adjusted to the installs and to a total mixed ration (TMR) for 21 days before the finishing phase commenced. The diet contained 74.8 % of total digestible nutrients (TDN) and 14.4 % of crude protein (CP) and comprised sugarcane bagass (15 %, dry basis), ground corn (50 %), soybean meal (5.6 %), corn gluten feed (28 %), mineral premix (1 %) and urea (0.4 %).

The TMR was offered twice daily on an *ad libitum* basis and dry matter intake was monitored by weighing the orts daily. The cattle were weighed every 28 days, and feed efficiency was measured in terms of the gain-to-feed ratio and the residual feed intake (Gomes et al., 2012). Harvesting was carried out at four stages (70, 91, 115 and 129 days on feed) ensuring a balance between castrated and non-castrated cattle.

The cattle were slaughtered at an experimental abattoir in Pirassununga, SP, in accordance with humanitarian slaughter guidelines, as required by Brazilian legislation. Carcass processing followed common industry practice employed in Brazil. Carcasses were weighed before (hot carcass weight) and after being subjected to a 24-h chill and split into wholesale cuts, which were weighed and manually dissected into retail products (commercial cuts with 5 mm of covering fat). Retail product yield (RPY) was then calculated as a percentage of the cold carcass weight.

Pearson simple correlations were computed, using SAS 9.3 (Statistical Analysis System, Cary, North Carolina). Analysis of variance were performed to test the effects of castration (sexual condition) and period of evaluation, following a complete randomized design for body weight, CPM scores and ultrasound carcass traits. A complete randomized block design was employed for feed efficiency (housing as block term, n = 2) and carcass traits at slaughter (date at harvesting as block term, n = 4). A significance level of 5 % was adopted.

Results and Discussion

Interactions between period of evaluation and castration for muscling score, backfat thickness and rump fat thickness were observed ($p < 0.05$) (Table 1). In the postweaning phase, there were no differences between castrated and non-castrated males for muscling score and backfat thickness ($p > 0.05$). On the other hand, in the finishing phase, the non-castrated males had higher muscling scores and lower ultrasound backfat thickness ($p < 0.05$). For rump fat thickness, castrated cattle had greater values in both phases; however, the differences were even greater at the beginning of the finishing phase, when compared with the postweaning phase.

Kuss et al. (2009) observed that differences between castrated and non-castrated cattle were greater in older ages for backfat thickness, which agrees with the current findings. These three traits are directly related to muscle and adipose tissue growth which may differ between castrated and non-castrated cattle. These differences may have been intensified during the period before the finishing phase of this study, where cattle had access to high quality forage during the Brazilian rainy season, resulting in higher growth rates.

No interactions were observed for the other traits ($p > 0.05$, Table 1). The higher body weight of non-castrated cattle and the similarity in C score of both sexual conditions remained consistent across periods of evaluation. The greater body weight in non-castrated cattle was due to their higher growth rates and the similarity in C score was not expected to change as it is more directly related to genetic differences in frame size, given that all animals were exposed to the same environmental conditions. The simililarity in conformation score between castrated and non-castrated cattle showed that skeletal growth was not affected by castration.

Differences between sexual conditions in the P score, as well as in ribeye area, were observed at the beginning of the finishing phase only (Table 1). This result is probably related to the conditions under which cattle were raised immediately prior to feedlot enrolment, as explained above, which supported greater growth rates in non-castrated cattle. Greater muscling scores and ribeye in non-castrated cattle are in accordance with the literature that supports a positive relationship between these traits (Yokoo et al., 2009).

There were differences in finishing precocity score between castrated and non-castrated cattle in the finishing phase but they occurred in the direction opposite to what had been expected ($p < 0.05$, Table 1). As finishing precocity is an indicator of the capacity of backfat deposition in early ages, the results obtained are completely inverted between castrated and non-castrated cattle. The visual scores may sometimes fail to sort cattle according to precocity of fat deposition. Differences in muscularity are more correctly determined than fat deposition by visual measurements, in particular when animals show small fat deposition (Yokoo et al., 2009). The overall differences in body weight and carcass traits between castrated and non-castrated cattle reported herein are very well supported by results found in the literature, as can be seen in Restle et al. (1996).

Table 1 – Conformation, precocity and muscling scores and ultrasound carcass traits at the postweaning and finishing phases, feedlot feed efficiency and slaughter carcass traits of castrated (CAST) and non-castrated (NCAST) Nellore cattle.

Trait[1]	Postweaning		Finishing		R^2	CV[2]	P-value [3]		
	CAST	NCAST	CAST	NCAST			Castration	Phase	C × P[4]
BW, kg	309 a	318 b	345 x	369 y	0.41	8.24	0.0014	< 0.0001	0.1427
C	3.9 a	3.8 a	3.8 x	4.2 x	0.02	28.6	0.4213	0.4276	0.2448
P	3.44 a	3.36 a	3.86 x	4.57 y	0.13	31.8	0.1587	0.0003	0.0803
M	3.69 a	3.56 a	3.59 x	4.71 y	0.11	31.6	0.0316	0.0236	0.0072
UBFT, mm	0.25 a	0.05 a	1.65 x	0.26 y	0.46	143.5	< 0.0001	< 0.0001	< 0.0001
URFT, mm	0.59 a	0.15 b	3.31 x	1.64 y	0.61	83.9	< 0.0001	< 0.0001	0.0008
UREA, cm^2	51.6 a	52.8 a	61.4 x	64.4 y	0.52	9.07	0.0364	< 0.0001	0.3584
G:F, kg kg^{-1}			0.183 x	0.191 x	0.06	18.6	0.3031		
RFI, kg d^{-1}			0.05 x	-0.01 x	0.05	-330.820	0.7942		
HCW, kg			292 x	321 y	0.40	6.05	< 0.0001		
DP, %			59.4 x	59.1 x	0.08	2.98	0.3931		
RPY, %			71.8 x	74.5 y	0.34	2.64	< 0.0001		

[1]BW = body weight; C = conformation score; P = precocity score; M = muscling score; UBFT = ultrasound backfat thickness; URFT = ultrasound rump fat thickness; UREA = ultrasound ribeye area; G:F = gain-to-feed ratio; RFI = residual feed intake; HCW = hot carcass weight; DP = dressing percentage; RPY = retail product yield; [2]coeficient of variation (CV) and of determination (R^2) of the analysis of variance; [3]probability of a type I error; [4]Castration × Phase interaction. Means within each phase and with different letters differ at $p < 0.05$.

There were no differences between castrated and non-castrated cattle for gain-to-feed ratio, residual feed intake and dressing percentage ($p > 0.05$, Table 1). Nor were any differences observed between castrated and non-castrated cattle for dressing percentage by Kuss et al. (2009). Nevertheless, non-castrated cattle had greater slaughter body weight, hot carcass weight and retail product yield than castrated cattle in the current study ($p < 0.05$). These results are obviously attributable to the higher rate of muscle growth and lower protein degradation rates in non-castrated cattle (Morgan et al., 1993) and are supported by differences previously measured in body weight and carcass traits.

Feed efficiency was expected to be negatively affected by castration (Morais et al., 1993; Restle et al., 1997). However, this was not the case (Table 1). The mean values of feed-to-gain ratio were about 5 % lower for castrated cattle which may be considered a small difference that might be explained by the fact that cattle received a high energy diet which may have supported high growth rates, irrespective of sexual condition.

In the postweaning phase, scores of muscling, conformation and precocity, as well as ultrasound backfat thickness, rump fat thickness and ribeye area showed low correlations with feedlot residual feed intake and gain-to-feed ratio, irrespective of being castrated or not (Table 2). The muscling score in particular could be expected to have greater correlation with feed efficiency as muscle growth is more efficient than the growth of the adipose tissue. However, again this was not the case. Therefore, the absence of relationships between these traits showed that future feedlot feed efficiency cannot be assessed or inferred only by visual scores or even objective measurements of carcass traits early in the life of young cattle.

Conversely, greater ribeye area is positively associated with feedlot feed efficiency in castrated males. A negative correlation between ultrasound ribeye area and residual feed intake existed both in the postweaning and finishing phases ($r = -0.27$, $p < 0.10$). This suggests that animals with greater ribeye area early in the postweaning phase or in the feedlot enrollment may have greater feed efficiency during the finishing phase.

In the finishing phase, scores of conformation, precocity and muscling in castrated cattle were all negatively correlated with gain-to-feed ratio ($p < 0.05$, Table 2). Negative correlations of CPM scores with feedlot gain-to-feed are hard to explain since conformation, muscling and precocity are different traits and may be somewhat antagonistic in some cases. For instance, greater muscling is expected to be negatively correlated with backfat thickness, which in turn is directly related to precocity score. On the other hand, positive genetic correlations between the three scores have been reported (Kouri Filho et al., 2010; Regatieri et al., 2011). A possible explanation for negative correlation of CPM and gain-to-feed is that the visual scores may be influenced by the nutritional status in such a way that fatter cattle will score higher and in feedlot they will perform lower, with lower feed efficiency. However, this may not be completely true in this case since the cattle received exactly the same nutritional regime from weaning to slaughter.

Unlike gain-to-feed, the coefficients of correlation of the visual scores with residual feed intake were not significant and were low ($p > 0.05$, Table 2). Although both gain-to-feed ratio and residual feed intake express feed efficiency in cattle, the residual feed intake is unrelated to body size (Arthur et al., 2001), which can partially explain the divergent results between the two traits. In general, for non-castrated cattle, both visual scores and ultrasound carcass traits were not correlated with feed efficiency traits ($p > 0.05$). This demonstrates that a simple evaluation of visual characteristics is not enough to identify animals with superior efficiency of conver-

Table 2 – Pearson correlation coefficients of conformation (C), precocity (P) and muscling (M) scores and ultrasound backfat thickness (UBFT), rump fat thickness (URFT) and rib eye area (UREA) with feedlot gain-to-feed ratio (G:F), residual feed intake (RFI), hot carcass weight (HCW), dressing percentage (DP) and retail product yield (RPY).

Trait	Postweaning phase					Finishing phase				
	G:F	RFI	HCW	DP	RPY	G:F	RFI	HCW	DP	RPY
						Castrated				
C	-0.17	0.14	0.34*	-0.11	0.04	-0.39*	0.24	0.37*	0.19	0.04
P	-0.25	0.17	0.04	-0.31*	0.13	-0.50**	0.15	0.18	-0.09	-0.03
M	-0.06	-0.06	0.04	-0.32*	0.00	-0.50**	0.09	0.28†	-0.05	0.07
UBFT	0.16	0.13	0.25	0.20	0.24	-0.05	0.13	0.16	0.23	-0.01
URFT	0.15	-0.09	-0.03	0.09	0.05	0.02	-0.09	0.04	0.01	0.03
UREA	-0.09	-0.27†	-0.14	-0.51**	-0.07	-0.16	-0.27†	0.03	-0.40**	0.13
						Non-castrated				
C	-0.13	0.06	0.24	-0.25	-0.03	0.09	-0.01	0.07	-0.16	-0.06
P	-0.01	-0.04	-0.07	-0.39*	-0.03	0.09	-0.15	0.10	-0.11	-0.07
M	-0.09	-0.09	0.00	-0.19	-0.03	0.22	-0.25†	0.23	-0.07	0.11
UBFT	0.02	0.01	0.14	0.11	0.08	-0.21	0.01	-0.15	0.19	-0.29†
URFT	0.02	-0.14	-0.20	0.17	-0.06	-0.28†	-0.14	-0.15	0.00	-0.41**
UREA	0.04	0.05	0.22	0.11	0.11	-0.15	0.05	0.19	-0.07	0.19

†$p < 0.10$; *$p < 0.05$; **$p < 0.01$.

sion of feed into body weight in young bulls, suggesting the need for feeding trials to calculate feed consumption and weight gain.

There was negative correlation between ultrasound scans on the ribeye area and residual feed intake in castrated cattle ($p < 0.10$, Table 2). Correlation between muscling score and residual feed intake tended to be negative, as well as between ultrasound rump fat thickness and gain-to-feed ratio in non-castrated cattle ($p < 0.10$). Greater feed efficiency is obtained when there is a higher rate of muscle growth and lower rate of adipose tissue growth, as indicated by the muscling score, ultrasound scans on the ribeye area and rump fat thickness (Basarab et al., 2003). Carcass traits might be linked to feed efficiency. However, most of them referred to the association between feed efficiency and the final carcass trait (Gomes et al., 2012; Santana et al., 2012), when cattle are greatly heavier and fatter. The present results suggest that measurements taken when cattle enter the finishing phase may be useful for assigning specific nutritional management programs according to feed efficiency potential.

The conformation score was positively correlated with hot carcass weight in castrated cattle at both the postweaning and finishing phases ($p < 0.05$, Table 2). Animals with higher conformation scores had greater carcass weight, which may be explained by their larger body size and, consequently, larger carcass size (Koury Filho et al., 2010; Boligon et al., 2011). Nevertheless, precocity and muscling scores, ultrasound backfat thickness, rump fat thickness and ribeye area were not correlated with hot carcass weight ($p > 0.05$). This may be due to the fact that carcass weight is more dependent on body size than carcass composition in fat and muscle. Likewise, there were no correlations of visual scores and ultrasound carcass traits with hot carcass weight in non-castrated cattle ($p > 0.05$). Silva et al. (2003) observed that carcass weight was highly correlated with ultrasound ribeye area in Nellore bulls, but lower coefficients were found with ultrasound backfat thickness and rump fat tickness when the carcass traits were measured when entering the feedlot.

The postweaning precocity score was negatively correlated with dressing percentage in both castrated and non-castrated cattle ($p < 0.05$, Table 2). Nevertheless, this result was not consistent with the finishing phase, where no correlations were observed between precocity and dressing percentage for both sexual conditions ($p > 0.05$). Conversely, castrated cattle with greater postweaning muscling score and ribeye area were related to lower dressing percentage ($p < 0.05$). Negative correlation between ultrasound scans of the ribeye area and dressing percentage was also observed in castrated cattle in the finishing phase ($p < 0.01$). Neither ultrasound scans of backfat thickness nor rump fat thickness were correlated with dressing percentage, irrespective of sexual condition and period of evaluation.

Silva et al. (2003) reported correlations of dressing percentage with ultrasound scans of the ribeye area, backfat thickness and rump fat thickness of 0.28, 0.01 and 0.32, respectively. When Silva et al. (2003) generated predicting equations for hot carcass weight and dressing percentage, the model contained positive coefficients for ribeye area and a negative coefficient for backfat thickness, indicating that both carcass weight and dressing percentage were greater in leaner cattle. However, the relationship of carcass traits to carcass dressing is highly dependent on variations observed in body weight at harvest and body composition.

Retail product yield was not correlated to any trait obtained in the postweaning phase for either sexual condition and in the finishing phase for castrated

cattle ($p > 0.05$, Table 2). This suggests that postweaning measurements may be taken too early to evidence variations in retail product yield at slaughter. Conversely, finishing backfat and rump fat thickness were negatively correlated with retail product yield in non-castrated cattle ($p < 0.10$). As non-castrated cattle are more musculous, the percentage of retail product in the carcass may be more sensitive to variations in fat deposition, which could explain the relationship observed. Tarouco et al. (2007) used ribeye area and backfat thickness for estimating retail product yield in Braford cattle and observed that both traits were positively correlated with retail product yield and were included in the prediction model generated in that study. Silva et al. (2012) observed that measurements of ultrasound scans of the ribeye area, backfat thickness and rump fat thickness at slaughter partially explained the variation in retail product yield. In addition, the authors reported positive coefficients for ribeye area and negative coefficients for backfat and rump fat thickness.

There were no correlations of gain-to-feed with hot carcass weight, dressing percentage and retail product yield, irrespective of castration ($p > 0.05$, Table 3). The residual feed intake was not correlated with hot carcass weight and retail product yield in both castrated and non-castrated cattle and with dressing percentage in castrated cattle as well ($p > 0.05$). The residual feed intake was positively correlated with dressing percentage in non-castrated cattle ($p < 0.05$). According to this result, less efficient cattle would show greater carcass dressing, which may be considered contradictory when taking into account the fact that greater carcass dressing is obtained with lower viscera weights. Conversely, lower viscera weights have been related to lower oxygen consumption and internal fat deposition, which in turn are characteristics of efficient cattle (Basarab et al., 2003; Gomes et al., 2012).

The associations of visual body scores and ultrasound carcass traits with feed efficiency traits, dressing percentage and retail product yield are affected by age at evaluation and castration. Visual scores and ultrasound carcass traits in the postweaning phase are not consistently correlated with retail product yield, but greater subcutaneous fat thickness when entering the feedlot may indicate cattle with lower retail product yield. Feed efficiency shows little correlation with dressing percentage and retail product yield, such that selecting cattle for improved feed efficiency will not negatively affect beef production.

Table 3 – Pearson correlation coefficients of feedlot gain-to-feed ratio (G:F) and residual feed intake (RFI) with hot carcass weight (HCW), dressing percentage (DP) and retail product yield (RPY).

Trait	HCW	DP	RPY
		Castrated	
G:F	-0.03	0.19	0.13
RFI	-0.07	-0.12	-0.16
		Non-castrated	
G:F	-0.06	-0.25	0.14
RFI	0.12	0.32*	0.13

*$p < 0.05$.

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