

**Intake pattern and feed sorting of two beef cattle genetic groups fed different nutritional strategies**

**Padrão de alimentação e consumo seletivo de dois grupos genéticos de bovinos de corte alimentados com diferentes estratégias nutricionais**

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**ABSTRACT**

Feed sorting consists in the natural behavior of cattle to selectively consume the various feeds of the diet according to the particle size. The objective of this work was to determine the intake pattern and feed sorting of 36 non-castrated males (18 Nelore and 18 F1 Angus × Nelore) fed diets containing either fixed or variable nutritional levels, and housed in individual or collective pens. Intake pattern and feed sorting were measured on days 13, 27, 41, 55, 69, and 83 days after the beginning of the experiment in three times post-feeding (4, 10, and 24 hours). The experimental design utilized was completely randomized in a factorial scheme  $2 \times 2 \times 2$  (two genetic groups, two diets, and two types of housing). Animals belonged to the F1 genetic group and housed in collective pens increased ( $P < 0.05$ ) the intake pattern from 0-4, 4-10, and 10-24 hours post-feeding compared with Nelore animals. Likewise, F1 Angus × Nelore animals increased ( $P < 0.05$ ) the preference for the fine particles ( $< 4$  mm) of the diet (101.13 vs.  $112.76 \pm 2.65\%$  for the Nelore vs. F1 Angus × Nelore, respectively), whereas Nelore animals sorted for ( $P < 0.05$ ) the medium particles ( $< 19$ ,  $> 8$  mm) of the ration (127.70%) and the F1 genetic group sorted against ( $P < 0.05$ ) this same particle class (79.89%). The F1 Angus × Nelore genetic group increase feed intake pattern and the preference for the smaller particles of the ration. The use of a variable diet is not recommended to beef cattle finished in feedlot.

**Keywords:** Angus, Feedlot, Nelore, Particles, Preference, Refusal.**RESUMO**

O consumo seletivo consiste em um comportamento natural de bovinos em selecionar os ingredientes da dieta conforme o tamanho de partícula. Objetivou-se nesse trabalho determinar o padrão de alimentação e consumo seletivo de 36 machos não castrados (18 Nelore e 18 F1 Angus × Nelore) alimentados com dietas contendo níveis nutricionais fixos ou variáveis e alojados em baias individuais ou coletivas. Utilizou-se o delineamento experimental inteiramente casualizado em esquema fatorial  $2 \times 2 \times 2$  (dois recursos genéticos, duas dietas e dois alojamentos). Os animais pertencentes ao grupo genético F1 alojados em baias coletivas aumentaram ( $P < 0,05$ ) o padrão de alimentação entre 0-4, 4-10 e 10-24 horas pós-alimentação em relação aos animais Nelore. Da mesma forma, os animais F1 Angus × Nelore aumentaram a preferência pelas partículas muito curtas ( $< 4$  mm) da ração (101,13 vs.  $112,76 \pm 2,65\%$ , Nelore vs. F1 Angus × Nelore, respectivamente), ao passo que os animais da raça Nelore selecionaram a favor ( $P < 0,05$ ) as partículas médias ( $< 19$ ,  $> 8$  mm) da ração (127,70%), enquanto que o grupo genético F1 selecionou contra ( $P < 0,05$ ) essa mesma classe de partículas (79,89%). O grupo genético F1 Angus × Nelore aumenta o padrão de alimentação e a preferência pelas partículas pequenas da ração. O uso da dieta variável não é recomendado na alimentação de bovinos de corte em confinamento.

**Palavras-chave:** Angus, Confinamento, Nelore, Partículas, Preferência, Rejeição.

## 1 INTRODUCTION

Researches involving animal behavior have been used to evaluate nutritional strategies of beef cattle finished in feedlot. As part of animal behavior, feed sorting is defined as the natural capacity of cattle to sort for (preferential consumption) or against (refusal) the various ingredients of the diet according to taste, nutritional value and particle size (LEONARDI and ARMENTANO, 2003). Therefore, the particle size distribution of beef cattle rations has provided to be useful to determine feed sorting and thereby estimate total dry matter intake (DMI), meal size, and feed intake pattern (CUSTODIO et al., 2016; DIAS et al., 2018).

Feeding beef cattle finished in feedlot with total mixed rations (TMR) is a common practice, which consists in mixing all diet ingredients into a single feed load. The objective of the TMR feeding is to provide a well-balanced ration to maintain health and maximize the daily weight gain of beef animals. However, a great concern about TMR feeding is the intrinsic ability of cattle to selectively consume for or against the ingredients of the ration according to the particle size. This selective intake, which is known by feed sorting, may result in a great fluctuation of the nutritional value of the ration across the day in the feed bunk in comparison with what was initially formulated, and consequently may lead to the intake of a diet that does not meet the daily nutrient demands of beef animals or even result in ruminal acidosis depending on the degree of preferential consumption for the small particles of the diet (DEVRIES et al., 2014).

Several studies have been conducted in the US and Canada with dairy cows housed in individual pens or free-stalls in which authors have consistently reported a rejection for the longer particles in favor of smaller particles of the diet (LEONARDI and ARMENTANO, 2003; DEVRIES et al., 2007; LEONARDI et al., 2005; CARVALHO et al., 2012). However, beef cattle finished in feedlot appear to have an opposed feed sorting behavior compared with dairy cows (CUSTODIO et al., 2016; DIAS et al., 2018), although not much is still known about feed sorting in feedlot beef cattle in tropical conditions.

The use of diets with increasing levels of energy and decreasing concentration of protein is not a common practice in beef cattle finished in feedlot, although in poultry and swine this nutritional strategy is well established with the objective to provide higher performance and better carcass finishing (LONGO et al., 2006; GONÇALVES et al., 2015). Hence, the formulation of a diet based on the actual demands for energy and protein according to the animal's body weight (BW) may have the potential to reduce feed sorting in beef cattle finished in feedlot.

In this context, the objective of this study was to determine the intake pattern and feed sorting of 36 non-castrated males (18 Nellore and 18 F1 Angus × Nellore) fed diets containing either a fixed

or a variable nutritional composition (decreasing levels of crude protein and increasing levels of non-fiber carbohydrates), and housed in individual or collective pens.

## **2 MATERIALS AND METHODS**

### **2.1 LOCATION AND ANIMALS**

The experiment was conducted at the Dairy and Beef Research and Education Center of the Goiano Federal Institute of Education, Science, and Technology (IF Goiano), Iporá, Goiás State, Brazil, from June 4 through September 12, 2016. The study was run during 98 days (14 days for adaptation of the animals for the feedlot facilities and experimental diets and 84 days for data collection). Thirty-six non-castrated males (18 Nellore e 18 F1 Angus × Nellore) with approximately 24 months of age were ranked by BW and randomly assigned to receive diets containing either a fixed or a variable nutritional composition, as described in Table 1.

After the first randomization by initial BW to each diet group, animals were again randomly assigned according to the type of housing with twelve animals housed in individual pens, and 24 animals were housed in eight collective pens (three animals per pen).

Animals' distribution alongside the individual pens was the following: one Nellore fed a fixed diet, one F1 fed a fixed diet, one Nellore fed a variable diet, and one F1 fed a variable diet. The same sequence was repeated twice to result in twelve animals. Similarly, the same distribution design was used in the collective pens: pen 1 = three Nellore fed a fixed diet, pen 2 = three F1 fed a fixed diet, pen 3 = three Nellore fed a variable diet, pen 4 = three F1 fed a variable diet, pen 5 = three Nellore fed a fixed diet, pen 6 = three F1 fed a fixed diet, pen 7 = three Nellore fed a variable diet, and pen 8 = three F1 fed a variable diet.

### **2.2 FEEDLOT INFRASTRUCTURE**

Individual pens measured two meters wide by five meters long (10 m<sup>2</sup>/animal) whereas collective pens measured five meters wide by ten meters long (16.66 m<sup>2</sup>/animal). The volumetric capacity of feeders in the individual and collective pens was 0.35 and 1.05 m<sup>3</sup>, respectively. The feed bunk space in each collective pen was 3.8 meters long (1.26 m/animal).

There were six drinkers alongside the twelve individual pens (one drinker for two animals) with a capacity of 240 L and four drinkers for the eight collective pens (one drinker for two pens) with an individual capacity of 380 L. All drinkers had automatic floats that allowed a continuous water flow.

## 2.3 DIET DESCRIPTION

Animals were fed once daily from 05:00 to 07:00 am in amounts that ensured *ad libitum* intake (10 to 15% of orts) with rations containing sugar cane silage, soybean hulls, ground corn, soybean meal, urea, mineral/vitamin premix, and sodium bicarbonate (Table 1). Urea was added (1 kg/100 kg on a green matter basis) during sugar cane ensiling to reduce ethanol production during the fermentation process (CASTRO NETO et al., 2008).

One experimental diet contained a fixed nutritional composition throughout the entire experiment (control), whereas a variable diet contained increasing levels of non-fiber carbohydrates (NFC) by a gradual increase of ground corn and a decreasing concentration of crude protein (CP) by a gradual reduction of soybean meal (ROMAN et al., 2011). Both experimental diets were formulated and balanced to meet the NRC (2000) guidelines for beef cattle finished in a feedlot with an expected weight gain of 1.8 kg/day. The variable diet was rebalanced every time the animals' BW was registered, which occurred every two weeks. More details about diet formulation and animal performance can be found in SANTOS et al. (2020). All experimental protocols were approved by the "IF Goiano" Ethical Committee in the Use of Animals (decision n° 2284220216).

Table 1- Ingredient and nutrient composition of the experimental diets<sup>1</sup>

Ingredients, % of DM	Fixed diet	Variable diet					
		Day 1-14	Day 15-28	Day 29-42	Day 43-56	Day 57-70	Day 71-84
Sugar cane silage	11.0	11.0	11.0	11.0	11.0	11.0	11.0
Soybean hulls	13.0	13.0	13.0	13.0	13.0	13.0	13.0
<b>Ground corn</b>	<b>66.0</b>	<b>59.5</b>	<b>61.5</b>	<b>63.5</b>	<b>65.4</b>	<b>67.1</b>	<b>68.6</b>
<b>Soybean meal</b>	<b>6.0</b>	<b>12.5</b>	<b>10.5</b>	<b>8.5</b>	<b>6.6</b>	<b>4.9</b>	<b>3.4</b>
Urea	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mineral/vitamin Premix <sup>2</sup>	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Sodium bicarbonate	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nutrient composition							
DM <sup>3</sup> , %	72.51	71.95	72.49	73.91	71.50	73.15	74.41
<b>CP<sup>4</sup>, % of DM</b>	<b>13.71</b>	<b>16.06</b>	<b>15.93</b>	<b>14.69</b>	<b>14.34</b>	<b>13.29</b>	<b>12.00</b>
NDF <sup>5</sup> , % of DM	38.43	42.64	40.11	38.69	37.36	36.77	38.02
ADF <sup>6</sup> , % of DM	21.71	20.40	16.20	23.17	19.95	19.96	18.27
Cellulose, % of DM	17.14	14.27	13.41	18.38	16.49	16.63	14.45
Hemicellulose, % of DM	16.72	21.71	20.49	19.47	17.41	16.81	19.75
Lignin, % of DM	4.57	6.13	2.79	4.79	3.46	3.33	3.82
Ash, % of DM	5.98	5.73	6.32	5.32	5.69	5.62	4.93
EE <sup>7</sup> , % of DM	4.38	4.66	4.85	4.96	4.44	4.83	4.23
<b>NFC<sup>8</sup>, % of DM</b>	<b>37.50</b>	<b>30.91</b>	<b>32.79</b>	<b>36.34</b>	<b>38.17</b>	<b>39.49</b>	<b>40.82</b>

<sup>1</sup>Mean analysis of composite samples (n = 6), <sup>2</sup>Contained 18% Ca, 20 g/kg P, 17g/kg Mg, 26.7g/kg S, 66.7 g/kg Na, 25.2 mg/kg Co, 416 mg/kg Cu, 490 mg/kg Fe, 25.2 mg/kg I, 832 mg/kg Mn, 7 mg/kg Se, 2,000 mg/kg Zn, 833.5 mg/kg Monenzin, 83,200 IU/kg vitamin A, 10,400 IU/kg vitamin D, 240 IU/kg vitamin E, <sup>3</sup>Dry matter, <sup>4</sup>Crude protein, <sup>5</sup>Neutral detergent fiber, <sup>6</sup>Acid detergent fiber, <sup>7</sup>Ether extract, <sup>8</sup>Non-fiber carbohydrates = 100 – CP% – NDF% – EE% – ash%.

## 2.4 SAMPLE COLLECTION AND ANALYSES

Intake pattern and feed sorting were determined on days 13, 27, 41, 55, 69, and 83 days after the beginning of the experiment in three times post-feeding (4, 10, and 24 hours). In each of the times indicated, the amount of feed from the individual and collective pens was briefly removed, weighed, returned to the corresponding pen, and 0.5 kg samples were obtained for dry matter (DM) analyses (AOAC, 2000). Intake pattern was calculated by the following:

DMI (0-4 hours) = kg of DM offered at feed delivery minus kg of DM remaining at 4 hours post-feeding;

DMI (4-10 hours) = kg of DM remaining at 4 hours post-feeding minus kg of DM remaining at 10 hours post-feeding;

DMI (10-24 hours) = kg of DM remaining at 10 hours post-feeding minus kg of DM remaining at 24 hours post-feeding.

Diet samples of 1.4 L were collected at feed delivery (time zero), 4, 10, and 24 hours post-feeding prior to removing and weighing the amount of feed, and stored frozen at -4°C. Soon after the end of the experiment, diet samples were thawed at room temperature and separated using the three-screen (19, 8, and 4 mm) and a bottom pan Penn State Particle Separator (PSPS, Nasco, Fort Atkinson, WI) to yield long (>19 mm), medium (<19, >8 mm), short (<8, >4 mm) and fine (<4 mm) particles, following the method of LAMMERS et al. (1996) and KONONOFF et al. (2003).

Post-separated materials were placed in aluminium trays, identified according to the animal's ear-tag, type of diet (fixed or variable), days of evaluation (13, 27, 41, 55, 69, and 83) and hours post-feeding (0, 4, 10, and 24) for DM analyses (AOAC, 2000).

The sorting index or feed sorting of the experimental diets was calculated by expressing the actual DMI of each particle size as a percentage of the theoretical DMI of the corresponding particle size (LEONARDI and ARMENTANO, 2003), as described in the equations below:

$$\begin{aligned} \text{TDMI}_{\text{ps}} &= \text{DMI}_t * \text{PSD}_{t0} \\ \text{ADMI}_{\text{ps}} &= \text{DMI}_t * \text{PSD}_{t4, t10, t24} \\ \text{SI (\% of DM)} &= \frac{\text{ADMI}_{\text{ps}} * 100}{\text{TDMI}_{\text{ps}}} \end{aligned}$$

$\text{TDMI}_{\text{ps}}$  = theoretical DMI by particle size (>19 mm; <19, >8 mm; <8, >4 mm; <4 mm);  $\text{ADMI}_{\text{ps}}$  = actual DMI by particle size (>19 mm; <19, >8 mm; <8, >4 mm; <4 mm);  $\text{DMI}_t$  = DMI between 0-4, 4-10, and 10-24 hours post-feeding;  $\text{PSD}_{t0}$  = particle size distribution at feed delivery (time zero);  $\text{PSD}_{t4, t10, t24}$  = particle size distribution at 4, 10, and 24 hours post-feeding;  $\text{SI (\% of DM)}$  = sorting index or feed sorting.

Values = 100% indicate absence of sorting by particle size, values <100% indicate selective refusal or sorting against by particle size, and values >100% indicate selective consumption or sorting for by particle size (LEONARDI and ARMENTANO, 2003).

## 2.5 DATA ANALYSIS

The experimental design utilized was completely randomized in a factorial scheme  $2 \times 2 \times 2$  (two genetic groups, two diets, and two types of housing). The data were analyzed using the “R” open system (R CORE TEAM, 2014) in a mixed model of double repeated measurements in time (days and hours post-feeding), considering genetic group (Nellore or F1 Angus  $\times$  Nellore), diet (fixed or variable), and housing (individual or collective) as fixed effects, and animal as random.

The structure of covariance that best fitted to the model was chosen according to the lowest Bayesian Information Criterion. Analysis for feed intake pattern was run separately between individual and collective housing, and considered only genetic group and diet as fixed effects. Analysis for feed sorting was run considering all three fixed effects (genetic group, diet, and housing).

The model accounted for the effects of genetic group (gg), diet (d), housing (h), days of the experiment (days), hours post-feeding (t), gg  $\times$  d, gg  $\times$  h, gg  $\times$  days, gg  $\times$  t, d  $\times$  h, d  $\times$  days, d  $\times$  t, h  $\times$  days, h  $\times$  t, days  $\times$  t, gg  $\times$  d  $\times$  h, gg  $\times$  d  $\times$  days, gg  $\times$  d  $\times$  t, gg  $\times$  h  $\times$  days, gg  $\times$  h  $\times$  t, gg  $\times$  days  $\times$  t, d  $\times$  h  $\times$  days, d  $\times$  h  $\times$  t, d  $\times$  days  $\times$  t, h  $\times$  days  $\times$  t, gg  $\times$  d  $\times$  h  $\times$  days, gg  $\times$  d  $\times$  h  $\times$  t, gg  $\times$  d  $\times$  days  $\times$  t, gg  $\times$  h  $\times$  days  $\times$  t, d  $\times$  h  $\times$  days  $\times$  t, and gg  $\times$  d  $\times$  h  $\times$  days  $\times$  t, according to the following equation:  $y_{ijklmn} = \mu + gg_i + d_j + h_k + days_l + t_m + ggd_{ij} + ggh_{ik} + ggdays_{il} + ggt_{im} + dh_{jk} + ddays_{jl} + dt_{jm} + hdays_{kl} + ht_{km} + dayst_{lm} + ggdh_{ijk} + ggddays_{ijl} + ggdt_{ijm} + ggghdays_{ikl} + ggght_{ikm} + ggdayst_{ilm} + dhdays_{jkl} + dht_{jkm} + ddayst_{jlm} + hdayst_{klm} + ggdhdays_{ijkl} + ggdht_{ijkm} + ggddayst_{ijlm} + ggghdayst_{iklm} + dhdayst_{jklm} + ggdhdayst_{ijklm} + e_{ijklmn}$ ; where  $y$  = independent variable,  $\mu$  = mean, and  $e$  = experimental error. When a fixed effect was significant at a 5% probability, means were compared using the Tukey test. Values are reported as least square means and associated standard errors of means (SEM).

## 3 RESULTS AND DISCUSSION

The intake pattern data of Nellore and F1 Angus  $\times$  Nellore animals fed either a fixed or a variable diet, and housed in individual or collective pens are reported in Table 2. F1 Angus  $\times$  Nellore animals housed in collective pens increased ( $P < 0.05$ ) the DMI in all assessed post-feeding intervals (0-4, 4-10, and 10-24 hours).

F1 Angus  $\times$  Nellore animals are reported to have higher net energy requirements for weight gain compared with Nellore animals (GOULART et al., 2008), which explains the increased ( $P < 0.05$ ) feed intake pattern in the F1 genetic group (Table 2). Moreover, Nellore animals have a lower net

energy requirement for maintenance (PAULINO et al., 2004) due to differences in the size of internal organs, which are smaller in Nellore than in *Bos taurus* and F1 *Bos taurus* versus *Bos indicus* crosses (SOUZA et al., 2012; PERIPOLLI et al., 2013), which may also help to comprehend the reduced ( $P < 0.05$ ) feed intake pattern in Nellore animals (Table 2).

There was no response ( $P > 0.05$ ) of diet (fixed or variable) on the feed intake pattern (Table 2), which confirms a previous study reported by ROMAN et al. (2011), who investigated diets with constant or variable nutritional levels (decreased CP and increased NFC and starch concentrations) fed to beef cattle finished in a feedlot, and also did not find differences in total DMI. A possible reason for the absence of diet effect ( $P > 0.05$ ) on intake pattern in the present study could be the short period of time in feedlot compared with the total animal life cycle.

The particle size distribution at feed delivery was not affected ( $P > 0.05$ ) by the type of diet (Table 3), which indicates that the gradual increase of ground corn with a concomitant reduction of soybean meal every 14 days (when BW was recorded) in the variable diet did not alter ( $P > 0.05$ ) the overall particle size distribution of both experimental diets.

F1 Angus  $\times$  Nellore animals increased ( $P < 0.05$ ) the preferential consumption (sorting for) of the fine particles ( $< 4$  mm) of the diet compared with Nellore (101.13 vs.  $112.76 \pm 2.65\%$  for the Nellore vs. F1 Angus  $\times$  Nellore, respectively; Table 4). This result is consistent with the fact that the F1 genetic group has a higher nutritional demand for maintenance and weight gain (GOULART et al., 2008; MARCONDES et al., 2011) and therefore is more eager to increase the preference for the fine particles ( $< 4$  mm) of the ration, which have a higher concentration of energy and protein.

Contrarily, Nellore animals sorted for ( $P < 0.05$ ) the medium particles ( $< 19, > 8$  mm) of the ration, whereas the F1 genetic group displayed a sorting against behavior ( $P < 0.05$ ) for this same class of particle size ( $127.70$  vs.  $79.89 \pm 6.36\%$  for the Nellore vs. F1 Angus  $\times$  Nellore, respectively; Table 4), also suggesting that the feed sorting behavior for a certain class of particle size is influenced by the animal nutritional demand for weight gain, which is higher in *Bos taurus* and F1 crosses, and lower in *Bos indicus* (PRADO et al., 2008).



Table 2- Effect of genetic group (Nellore or F1 Angus × Nellore) and diet (fixed or variable) on feed intake pattern of 36 males finished in feedlot and housed in individual or collective pens

Item	Genetic group		SEM <sup>3</sup>	P-values						
	Nellore	F1 Angus × Nellore		GG <sup>4</sup>	Days <sup>5</sup>	Hours <sup>6</sup>	GG × diet	GG × days	GG × hours	GG × days × hours
DMI, kg (IP <sup>1</sup> )										
0-4 hours post-feeding	5.00	5.22								
4-10 hours post-feeding	4.12	5.16	0.42	0.11	<0.05	<0.05	0.24	0.72	0.59	0.60
10-24 hours post-feeding	2.34	2.74								
DMI, kg (CP <sup>2</sup> )										
0-4 hours post-feeding	11.20	17.26								
4-10 hours post-feeding	12.10	14.27	1.26	<0.05	0.08	<0.05	0.63	0.35	0.10	0.06
10-24 hours post-feeding	10.12	11.93								
Item	Diet		SEM	P-values						
	Fixed	Variable		Diet	Days	Hours	Diet × GG	Diet × days	Diet × hours	Diet × days × hours
DMI, kg (IP)										
0-4 hours post-feeding	5.14	5.09								
4-10 hours post-feeding	4.51	4.77	0.42	0.88	<0.05	<0.05	0.24	0.97	0.91	0.15
10-24 hours post-feeding	2.57	2.51								
DMI, kg (CP)										
0-4 hours post-feeding	14.41	14.04								
4-10 hours post-feeding	13.17	13.20	1.26	0.92	0.08	<0.05	0.63	0.96	0.84	0.63
10-24 hours post-feeding	10.64	11.41								

<sup>1</sup>Dry matter intake (kg) in individual pens, <sup>2</sup>Dry matter intake (kg) in collective pens, <sup>3</sup>Standard error of means, <sup>4</sup>Genetic group, <sup>5</sup>Days when intake pattern was determined (13, 27, 41, 56, 69, and 83), <sup>6</sup>Hours post-feeding when feed intake pattern was determined (4, 10, and 24)

Table 3- Particle size distribution of the experimental diets at feed delivery

% of DM retained on screen	Fixed diet	Variable diet	SEM <sup>1</sup>	P-values		
				Diet	Days	Diet × days
Long (>19 mm)	4.92	5.10	0.15	0.40	<0.05	<0.05
Medium (<19, >8 mm)	17.61	17.43	0.59	0.83	<0.05	0.44
Short (<8, >4 mm)	13.59	12.68	0.39	0.12	<0.05	0.40
Fine (<4 mm)	63.88	64.79	0.71	0.38	<0.05	0.67

<sup>1</sup>Standard error of means

Beef animals from both genetic groups fed the variable diet selectively consumed for ( $P<0.05$ ) the medium particles (<19, >8 mm) of the ration, while animals fed the fixed diet showed a refusal ( $P<0.05$ ) for this same particle size (86.37 vs.  $121.21 \pm 6.36\%$  for the fixed vs. variable diet, respectively; Table 4). Furthermore, animals fed the fixed diet increased ( $P<0.05$ ) the preference for the fine particles (<4 mm) of the ration ( $112.61$  vs.  $101.27 \pm 2.65\%$  for the fixed vs. variable diet, respectively; Table 4).

The diet response ( $P<0.05$ ) on the sorting behavior for the medium (<19, >8 mm) and fine (<4 mm) particles of the ration suggest that the gradual substitution of soybean meal with ground corn in the variable diet changed ( $P<0.05$ ) the feed sorting behavior of these particle classes, however, animal weight gain was not altered by the type of diet as reported by SANTOS et al. (2020).

There was no effect ( $P>0.05$ ) of housing on the feed sorting of animals from both genetic groups and fed both diets (Table 4), in agreement with findings from a previous study (CUSTODIO et al., 2016). In the present study, the area per animal and feed bunk space of the collective pens exceeded animal welfare guidelines for beef cattle finished in feedlot (GRANDIN, 2016), which suggests that social hierarchy of animals grouped together in the same pen, as in the case of commercial feedlots, did not influence the sorting behavior between individual versus collective housing. Nevertheless, there should be caution when extrapolating this information, since data from this same experiment revealed that animals housed in individual pens had an increased BW compared with collective housing (SANTOS et al., 2020), a clear evidence that social hierarchy in collective housing may have influenced animal performance, but not feed sorting.

Nonetheless, more studies are necessary with different number of animals in collective pens to investigate the effect of social hierarchy on intake pattern, feed sorting, behaviors, and animal performance.

Table 4- Effect of genetic group (Nellore or F1 Angus × Nellore), diet (fixed or variable), and housing (individual or collective) on feed sorting of 36 males finished in feedlot

Particle sorting index (%)	Genetic group		SEM <sup>1</sup>	P-values						
	Nellore	F1 Angus × Nellore		GG <sup>2</sup>	Days <sup>3</sup>	Hours <sup>4</sup>	GG × diet	GG × days	GG × hours	GG × days × hours
Long (>19 mm)	34.88	42.75	2.88	0.06	<0.05	<0.05	0.58	0.81	<0.05	0.85
Medium (<19, >8 mm)	127.70	79.89	6.36	<0.05	<0.05	0.15	0.39	<0.05	<0.05	<0.05
Short (<8, >4 mm)	92.11	98.74	3.02	0.13	<0.05	<0.05	0.27	0.65	0.91	0.90
Fine (<4 mm)	101.13	112.76	2.65	<0.05	0.20	<0.05	0.95	<0.05	<0.05	0.32

  

Particle sorting index (%)	Diet		SEM	P-values						
	Fixed	Variable		Diet	Days	Hours	Diet × GG	Diet × days	Diet × hours	Diet × days × hours
Long (>19 mm)	39.84	37.79	2.88	0.62	<0.05	<0.05	0.58	0.30	0.14	0.66
Medium (<19, >8 mm)	86.37	121.21	6.36	<0.05	<0.05	0.15	0.39	<0.05	<0.05	0.45
Short (<8, >4 mm)	93.60	97.26	3.02	0.40	<0.05	<0.05	0.27	0.50	0.25	0.98
Fine (<4 mm)	112.61	101.27	2.65	<0.05	0.20	<0.05	0.95	0.17	<0.05	0.75

  

Particle sorting index (%)	Housing		SEM	P-values						
	Individual	Collective		Housing	Days	Hours	Housing × GG	Housing × diet	Housing × days	Housing × GG × diet
Long (>19 mm)	36.36	41.27	3.15	0.23	<0.05	<0.05	0.93	0.10	0.11	0.19
Medium (<19, >8 mm)	105.74	101.85	6.97	0.67	<0.05	0.15	0.26	<0.05	0.06	0.59
Short (<8, >4 mm)	95.07	95.79	3.30	0.87	<0.05	<0.05	<0.05	0.74	<0.05	0.23
Fine (<4 mm)	105.96	107.92	2.95	0.61	0.20	<0.05	0.88	0.09	<0.05	0.87

<sup>1</sup>Standard error of means, <sup>2</sup>Genetic group, <sup>3</sup>Days when intake pattern was determined (13, 27, 41, 55, 59, and 83), <sup>4</sup>Hours post-feeding when feed sorting was determined (4, 10, and 24)

#### 4 CONCLUSION

F1 Angus × Nellore animals have an increased feed intake pattern and preference for the smaller particles of the ration, which is consistent with the higher nutritional demand of this genetic group.

The variable diet should not be fed to beef cattle finished in feedlot, since there was no response on the feed intake pattern.

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