

## WHOLE GRAIN OF DIFFERENT CORN HYBRIDS IN THE FINISHING DIET OF LAMBS

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**ABSTRACT** – The objective of this study was to compare whole grains of different corn hybrids in the finishing diet of lambs in terms of apparent digestibility, ingestive behavior and feedlot performance. Twenty-four crossbred lambs housed in individual pens were used. The animals were fed 7.35% hay and 92.65% concentrate (dry matter basis) containing 23.05% of a protein supplement plus 69.6% whole corn grains of the hybrids P3862, P4285 or Status for 72 days and were then slaughtered. The final body weight (40.82 kg) or daily weight gain (251 g) did not differ between lambs fed the different hybrids. Daily dry matter intake, expressed as percentage of live weight, was lower in the group fed the Status hybrid and intermediate in the group fed the P3862 hybrid. The Status hybrid resulted in lower digestibility of dietary crude protein, dry matter, and organic matter. There was no difference in hot carcass weight (19.8 kg), hot carcass yield (48.6%) or ingestive behavior between animals fed the different hybrids. Whole grains of the corn hybrids P3862 and P4285 are more indicated for fattening lambs fed with high-concentrate diets.

**Key words:** ingestive behavior, performance, digestibility, sheep, *Zea mays*

## GRÃOS INTEIROS DE DIFERENTES HÍBRIDOS DE MILHO NA ALIMENTAÇÃO DE CORDEIROS EM TERMINAÇÃO

**RESUMO** – O objetivo foi comparar grãos de diferentes híbridos de milho na dieta de cordeiros quanto à digestibilidade aparente, comportamento ingestivo e desempenho em confinamento. Foram utilizados 24 cordeiros cruzados, alojados em baias individuais e alimentados com 7,35% de feno e 92,65% de concentrado na matéria seca, contendo: 23,05% de suplemento proteico mais 69,60% de grãos inteiros de milho dos híbridos P3862, P4285 ou Status, por 72 dias, e depois abatidos. O peso corporal final (média de 40,82 kg) e o ganho de peso diário (média de 251 g) não diferiram entre os cordeiros alimentados com os diferentes híbridos. A ingestão diária de matéria seca em porcentagem do peso vivo foi de 3,41% nos animais alimentados com Status e de 3,60% nos animais alimentados com P3862, e estatisticamente diferentes. O híbrido Status apresentou menor digestibilidade da proteína bruta, matéria seca e orgânica da dieta. O peso de carcaça quente (média de 19,8 kg) e o rendimento de carcaça quente (média de 48,6%) e o comportamento ingestivo não diferiram entre os animais alimentados com os diferentes híbridos. Grãos inteiros dos híbridos de milho P3862 e P4285 são mais indicados para alimentar cordeiros em terminação recebendo dietas com alta proporção de concentrado, com base na sua maior eficiência de conversão e digestibilidade.

**Palavras-chave:** comportamento ingestivo, desempenho, digestibilidade, ovinos, *Zea mays*

The feedlot finishing system of lambs using high-concentrate diets is a technology increasingly adopted by Brazilian sheep farmers (Gallo et al., 2014), since it provides benefits such as higher weight gain and fast finishing. Among the ingredients used in this concentrate, corn grain is the main energy feed source.

Whole corn grain can be used in lamb diets, accounting for up to 80% of dry matter (Crane et al., 2014), because this ingredient is more economical, not adding processing expenses, and is therefore more convenient and practical for the producer (Oliveira et al., 2015). In these cases, the corn hybrid used and its nutritional features have an additional economic value since they interfere directly with feedlot profitability.

One of the features that interfere with the quality of corn grains is their texture (Pereira et al., 2004), which can be flint, semi-flint, semi-dent, or dent. The harder the kernel, the higher the quantity of vitreous endosperm; on the other hand, the more dent the kernel, the higher the quantity of floury endosperm. Considering that vitreous endosperm exhibits certain resistance to digestion, the ratio between vitreous and floury endosperm can directly affect the digestibility of corn and utilization by the animal (Cantarelli et al., 2007). Indirectly, kernel density indicates the variation in the proportion of corneous and starchy endosperm in the grain (Delalibera et al., 2008).

The grains of most corn cultivars commercially available in Brazil have a smooth or semi-dent crown and generally a dense and hard endosperm (Oliveira et al., 2015). Thus, knowledge of the performance of different corn hybrids used for feeding feedlot animals permits breeders to choose the ideal plant genotype in order to obtain the best economic outcome of their activity.

Based on these premises, the objective of the study was to evaluate the apparent digestibility,

performance and ingestive behavior of feedlot lambs fed high-concentrate diets containing whole grains of three different corn hybrids.

## Material and Methods

Twenty-four uncastrated, male, crossbred lambs of the paternal Dorper breed, weaned at a mean age of 70 days and a mean weight of  $29.76 \pm 1.8$  kg, were used. The animals were kept in feedlots in suspended individual pens with a slatted floor and were randomly assigned to receive one of three commercial whole grain corn hybrids: P3862 (Pioneer – semi-flint), P4285 (Pioneer - flint), or Status (Syngenta - flint), characterized in Table 1.

The animals were submitted to a period of adaptation of 14 days, receiving a diet with a concentrate/roughage ratio of 50:50 and 75:25 in the first and second week, respectively. The final proportion used was 92.75:7.25 (Table 1). The diet was formulated to attend nutritional requirements of lambs with weight gain of 250 g/day (National Research Council, 2007) and consisted 7.25% of coast cross hay grounded plus concentrate with 69.7% corn, 13.84% soy hulls, 5.8% soybean meal, 1.32% urea, 1% mineral salt, 0.59% limestone, and 0.5% ammonium chloride. Coast cross hay (*Cynodon dactylon*) was used as roughage. Feed was offered twice a day (7:30 and 16:00 h) as complete ration with 10% leftovers. The leftovers were removed and weighed daily.

After adaptation to the diet, feces collection bags were attached to the animals for the determination of apparent digestibility of the diets. The animals remained with the bags for 10 days, including 5 days for adaptation and 5 days for the collection of feces, feed offered and leftovers. The fecal samples were

weighed daily, sampled, and frozen. At the end of the sampling period, the samples of each animal were pooled and analyzed regarding dry matter, mineral matter and crude protein content according to the Association of Official Analytical Chemists (1995) and regarding neutral and acid detergent fiber content according to Silva and Queiroz (2002).

Performance was evaluated over a period of 48 days, in addition to the days for the determination of nutrient digestibility, with weight recording at the beginning and end of the experimental period after

a 14-h fast from solids. The feed efficiency was determined by the relation between weight gain in kilograms and dry matter in kilograms.

In the middle of the performance-testing period, the animals were observed individually by a trained team for the evaluation of ingestive behavior. Individual behaviors were recorded at intervals of 10 minutes over a period of 24 h for determination of the time spent eating, ruminating and idling as described by Johnson and Combs (1991). During night observation of the animals, the environment was

**Table 1.** Bromatological composition on a dry matter (DM) basis and physical characterization of the corn hybrid grains and nutritional composition of the diets

Variable	Corn hybrid		
	P3862	P4285	Status
<b>Bromatological composition</b>			
Dry matter, %	89.84	89.97	90.28
Crude protein, % DM	8.44	10.02	7.36
Ether extract, % DM	4.42	4.78	3.52
Mineral matter, % DM	1.39	1.52	1.48
Acid detergent fiber, % DM	3.02	3.66	3.39
Neutral detergent fiber, % DM	11.08	12.73	12.36
Cellulose, % DM	2.36	3.08	2.63
Lignin, % DM	0.78	0.62	0.84
Hemicellulose, % DM	8.07	9.08	8.97
<b>Physical characterization</b>			
Floating kernels <sup>1</sup> , %	45	34	18
Crown appearance	Semi-hard	Hard	Hard
<b>Diet composition (% DM)</b>			
Dry matter, %	89.9	90.0	90.2
Crude protein, % DM	12.7	13.8	12.0
Acid detergent fiber, % DM	11.2	11.7	11.5
Neutral detergent fiber, % DM	23.1	24.3	24.0
Metabolizable energy <sup>2</sup> , Mcal/kg	3.69	3.68	3.87

<sup>1</sup> Kernels floating in a standard solution of sodium nitrate according to Peplinski et al. (1992). <sup>2</sup> Calculated according to Weiss et al. (1992).

illuminated artificially and the animals were adapted for 5 days to the artificial illumination of the barn. Rumination efficiency was calculated as dry matter intake (g)/rumination time (h), and intake efficiency was calculated as dry matter (g)/eating time (h). The number of chewing cycles and the time spent ruminating each rumen bolus were determined with a digital timer (Bürger et al., 2000). For this purpose, three rumen boluses were observed at three different times of the day (10-12:00, 14-16:00, and 20-22:00 h).

The animals were slaughtered after a 14-h fast from solids and the carcass was weighed one hour after slaughter.

A completely randomized design consisting of three treatments and eight replications were used. The data were submitted to analysis of variance and means were compared by the Tukey test, adopting a level of significance of 5%. The PROC GLM procedure of the SAS package (SAS Institute, Inc., Cary, NC, USA) was used for statistical analysis.

## Results and Discussion

Weight gain or dry matter intake did not differ among treatments, but the ratio of these traits showed that the use of different hybrids altered feed efficiency (Table 2). An increase in feed efficiency was observed for animals fed the diet containing hybrid P3862, classified as semi-flint. Feed efficiency decreased in animals receiving the diet containing the Status hybrid, classified as hard and denser.

The group receiving hybrid P4285, also classified as hard but less dense than Status, exhibited intermediate feed efficiency values and similar to the other two hybrids. Hardness is relatively similar for materials with hard and semi-hard texture and is therefore not an efficient factor to measure nutritional

differences between corn hybrids. This is because the evaluation of crown appearance is not an efficient method to predict kernel density (Duarte et al., 2007). The differences in weight traits and dry matter intake found in the present study would indicate that density is more valuable to predict nutritional value than texture classification (Table 2).

Carcass weight or yield did not differ between animals fed the different corn hybrids studied. In addition, to promoting rapid finishing of the animals, the high concentrate content of the diet was probably the factor that most influenced carcass yield. However, according to Moreno et al. (2011), the ratio of roughage to concentrate and the type of roughage influence the digestive tract content of lambs, indirectly affecting carcass yield.

The use of the Status hybrid with denser kernels in the diet caused a reduction in apparent digestibility of crude protein, dry matter, and organic matter (Table 2). The differences in dry matter and organic matter digestibility between the diets containing the hybrids classified as hard, P4285 and Status, reinforce the fact that crown appearance does not necessarily indicate kernel density. It is interesting to consider the hardness of the whole grain of corn in diets with high proportion of this food, since they can directly influence the efficiency of the use of the diet, despite the efficient chewing of the lambs. This is due to the need of different forces for fragmentation when compressing kernels with different densities, with this requirement being proportional to the amount of corneous endosperm (Delalibera et al., 2008).

The diets containing the higher digestibility hybrids, P3862 and P4285, also provided better feed efficiency, although only hybrid P3862 was different from the Status hybrid (Table 2). Probably, starch digestion of hybrid P3862 had a lower impact on

**Table 2.** Performance and carcass traits of lambs fed different corn hybrids, apparent digestibility of the diets, and ingestive behavior

Trait	Corn hybrid			CV <sup>1</sup>	P <sup>2</sup>
	P3862	P4285	Status		
<b>Performance</b>					
Initial body weight, kg	29.37	29.66	30.24	8.07	0.7656
Final body weight, kg	40.37	40.36	41.74	0.18	0.7042
Daily weight gain, kg	0.292	0.222	0.239	27.63	0.1367
<b>Daily dry matter intake</b>					
kg	0.984	0.905	1.056	12.83	0.0793
% body weight	3.60 <sup>ab</sup>	3.89 <sup>a</sup>	3.41 <sup>b</sup>	9.53	0.0367
Feed efficiency, kg/kg <sup>3</sup>	0.294 <sup>a</sup>	0.240 <sup>ab</sup>	0.226 <sup>b</sup>	21.51	0.0501
<b>Carcass</b>					
Hot carcass weight, kg	20.25	19.01	19.98	10.46	0.4619
Hot carcass yield, %	50.51	47.15	48.15	11.31	0.4685
<b>Apparent digestibility (%)</b>					
Dry matter	81.84 <sup>a</sup>	81.56 <sup>a</sup>	78.17 <sup>b</sup>	3.78	0.0456
Organic matter	83.19 <sup>a</sup>	83.25 <sup>a</sup>	79.70 <sup>b</sup>	3.69	0.0450
Crude protein	71.08 <sup>a</sup>	71.06 <sup>a</sup>	62.97 <sup>b</sup>	7.99	0.0095
Acid detergent fiber	52.20	49.92	44.91	18.65	0.2856
Neutral detergent fiber	54.80	53.01	48.71	13.23	0.2167
<b>Behavior</b>					
Intake, h/day	2.88	3.31	3.06	19.74	0.3726
Rumination, h/ day	4.10	4.41	4.54	27.89	0.7612
Other activities, min/ day	17.02	12.26	16.40	8.27	0.5139
Chewing <sup>4</sup> , No./bolus	58.00	64.00	65.00	13.10	0.2578
Rumination time <sup>5</sup> , s/bolus	35.00	37.00	37.00	18.58	0.8808
Total chewing time <sup>6</sup> , h	6.98	7.73	7.60	18.44	0.5139
<b>Efficiency (g/h)</b>					
Rumination of dry matter	246	212	260	30.07	0.4016
Intake of dry matter	352	287	352	22.32	0.1526

<sup>a, b</sup> Means in the same row followed by the same superscript letter do not differ by the Tukey test at the 5% level. <sup>1</sup> Coefficient of variation. <sup>2</sup> Probability. <sup>3</sup> kg weight gain/kg ingested dry matter. <sup>4</sup> Chews per food bolus. <sup>5</sup> Time spent ruminating per food bolus. <sup>6</sup> Intake plus rumination.

the ruminal environment, since no difference in the digestibility of the protein fraction was observed between hybrids P3862 and P4285.

The lowest digestibility of protein was probably related to vitreous endosperm. This kind of endosperm contains bonds which are difficult

to digest by the animal due to a continuous and abundant protein matrix with a larger size and quantity of protein bodies associated with compact and polygonal starch granules (Pereira et al., 2004). Although hybrids P4285 and Status are classified as hard, the difference in kernel density observed by the quantity of floating kernels (34% and 19% for P4285 and Status, respectively) indicates different proportions of endosperm and its association with the protein fraction (Table 1).

Differences in the chemical composition and physical structure of the starch present in the endosperm of kernels directly influence how ruminants digest them, especially the protein content in the vitreous endosperm matrix (Philippeau et al., 1999). It is not expected that the protein sources used in the concentrate (urea, hull, and soybean meal) have interfered with the performance of lambs, since the animals were fed a high-concentrate diet (Queiroz et al., 2008). Thus, the protein bound to the vitreous endosperm of the kernel was likely responsible for the differences in starch digestibility between the different corn hybrids, influencing feed efficiency by altering the sites of starch digestion and consequently the type of substrate absorbed by the digestive tract of the animals (Huhtanen & Sveinbjörnsson, 2006; Banchemo et al., 2015). This effect is important in intensive systems of lamb fattening with high-concentrate diets, which require some control of starch digestion to minimize the incidence of ruminal acidosis (Askar et al., 2008).

Crude protein, dry matter and organic matter digestibility were the most important parameters to differentiate the hybrids tested. The digestibility of neutral or acid detergent fibers were not different statistically among diets showing low influence on the performance of lambs fed high-concentrate diets

(Mendes et al., 2010).

The use of different corn hybrids in the diets did not alter the ingestive behavior of the animals (Table 2). The ingestive behavior of feedlot animals is limited to the choice of food offered and how easily it can be ingested (Catanese et al., 2013). In addition, dietary offering stimulus can increase the time spent eating after supply of the food (Cardoso et al., 2006).

The ingestive behavior, intake and rumination efficiency are directly related to the energy content of the diet (Fontenele et al., 2011). This fact was probably the determinant factor for the lack of observation of differences in these efficiencies between corn hybrids, since the metabolizable energy of the diets was similar for hybrids P3862, P4285 and Status (3.69, 3.68 and 3.87 Mcal/kg, respectively).

The data obtained in this study indicate that more research on this subject are needed, as will enable to identify maize cultivars that are better suited to different types of diets for lambs, especially those used in feedlot with high whole grain proportions.

## Conclusions

The classification of corn based on appearance in flint, semi-flint, semi-dent or dent is not an adequate tool to identify superior hybrids for the diet of fattening lambs when offered as whole grains. Whole grains of the P3862 hybrid, classified as semi-flint, and of the P4285 hybrid, classified as flint, are more indicated for the feeding of fattening lambs receiving a high-concentrate diet than the Status hybrid, also classified as flint, based on differences on feed efficiency.

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