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# Performance of finishing steers fed different sources of carbohydrates

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**ABSTRACT** - The objective of this study was to evaluate the effect of carbohydrate sources (corn, soybean hulls or wheat bran) in the diet on performance of feedlot steers in the finishing phase. Twenty-four Charolais × Nellore crossbred steers, aged 22 months and initial weight of 335.0±10.9 kg were used in the experiment. Diets contained 40% sorghum silage and 60% concentrate. The intakes of dry matter (DM; 10.68, 10.16 and 10.34 kg/day) and crude protein (1.66, 1.70 and 1.72 kg/day) were not affected by diets with corn, soybean hulls or wheat bran, respectively. The intakes of neutral and acid detergent fiber were higher for soybean hulls, but the diet containing corn provided higher intake of non-fibrous carbohydrates, total digestible nutrients and digestible energy. Weight gain was higher and better feed conversion for animals fed corn (1.57 kg/day, 6.85 kg DM/kg gain) or soybean hulls (1.58 kg/day and 6.61 kg DM/kg gain) compared with steers receiving wheat bran (1.29 kg/day and 8.14 kg DM/kg gain) in the diet. There was no significant effect of carbohydrate sources on the final body score (3.78 points), energy conversion (28.25 Mcal digestible energy/kg gain), hot carcass yield (57.63 kg/100 kg BW) and fat thickness (3.1 mm). From an economic point of view, soybean hulls can be an alternative source of carbohydrate to corn in diets of finishing steers with 60% concentrate.

Key Words: corn, intake, soybean hulls, wheat bran, weight gain

## Introduction

Cattle finishing in Brazil is performed almost exclusively on natural pasture; about 95% of the animals for slaughter are finished in this system per year (Cervieri et al., 2009). However, in the last nine years the number of confined animals increased by 47.6%, to more than 2.7 million heads in 2009 (Anualpec, 2010). Among the factors that contributed to the growth of feedlots in Brazil, we can highlight the progress made in the areas of nutrition, health, environment and genetics (Cervieri et al., 2009) and also the increase in the agricultural production of the country, which produced approximately 158 million tons of grains (CONAB, 2012) in the harvest of 2011/2012, providing a large volume of grains and byproducts that could be used in ruminant feeding.

The interest in alternative agroindustrial byproducts to corn has increased in recent years because of the nutritional potential that many of these byproducts have in formulating diets for cattle and also with the main objective of reducing the cost with feeding and consequently the price per kilogram of meat produced (Ezequiel et al., 2006a; Cervieri et al., 2009). Among the supplements, corn grain is the most used ingredient to meet the energy requirement of animals. But when coupled with roughage and used in large quantities, it can reduce the digestibility of the fiber fraction of the diet due to a marked reduction of ruminal pH (Hoover, 1986).

In the 2011/2012 period Brazil produced about 71.7 million tons of soybeans largely aimed at the production of vegetable oil (CONAB, 2012), providing various byproducts such as soybean meal, soybean hulls and soybean soapstock to be used in cattle diets. Soybean hulls are a co-product of high nutritional value, having 11.6% crude protein (CP), 68.4% neutral detergent fiber (NDF) and 68.7% of total digestible nutrients (TDN) in its composition (Valadares Filho et al., 2010). Its fiber is potentially digestible, which gives it the ability to be used as a roughage or concentrate source, because its use leads to reduction in metabolic disorders, causing less adverse effect on fiber digestion (Anderson et al., 1988; Ipharraguerre & Clark, 2003), allowing for performance and carcass characteristics similar to those obtained with corn (Faulkner et al., 1994; Fischer & Mühlbach, 1999; Mendes et al., 2005a; Restle et al., 2006). The soybean soapstock is obtained in the process of refining crude soybean oil during the neutralization of free fatty acids. This product has a pasty consistency and high

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energy density and can provide around 30-50% of lipids in natural matter (Da Fré, 2009), and has been used in the diets of dairy cattle and calves (Shain et al., 1993; Abel-Caines et al., 1998).

Wheat is the main cereal produced worldwide and, unlike corn, is used primarily for human consumption. The national wheat production in 2011 was approximately 5.8 million tons (CONAB, 2012), and its processing generates valuable by-products, especially wheat bran, which contains approximately 16.6% CP, 44.3% NDF and 72.4% TDN (Valadares Filho et al., 2010). Studies have shown that when corn was replaced with wheat bran, the weight gain of finishing cattle was slightly reduced when this substitution was higher than 10% of the feed grains in diets with elevated concentrate (Keith & Donald, 1991; Dhuyvetter et al., 1999).

Accordingly, the objective of this study was to evaluate the use of different sources of carbohydrate in concentrate diets with sorghum silage as roughage on the performance of feedlot steers.

## Material and Methods

The experiment was carried out in the Beef Cattle Laboratory of the Animal Science Department of Universidade Federal de Santa Maria (UFSM) from September to December 2009.

Twenty-four crossbred Charolais × Nellore steers born in the same season of calving and weaned and grown under the same conditions of management and feeding were used in the experiment. At the beginning of the adaptation period, the animals were 22 months of age and their initial body weight was of 335.0±10.9 kg. The treatments consisted of different carbohydrate sources in concentrate: corn, soybean hulls or wheat bran (Table 1).

Before the experiment began, animals were treated with Ivermectin for controlling endo- and ectoparasites. The steers were housed in individual stalls of $12m^2$, paved with concrete, covered, provided with individual wooden troughs and water troughs and arranged for every two animals. Sixteen days were used for animals to adapt to the diet, facilities and for standardization of consumption.

The animals were fed their diet *ad libitum*, divided into two meals, supplied at 08h00 and 14h00, with the concentrate mixed with sorghum silage in the feeder at the time of feeding.

Every day before the morning feeding, the leftovers were removed and weighed for adjustments at the supply of feed and subsequent determination of dry matter intake and feed conversion. The leftovers were kept between 5 and 10% of the total offered.

During the experimental period, samples of sorghum silage and leftovers were collected weekly. The samples were pre-dried in a forced air circulation oven at 55 $^{o}C$ for 72 hours, and subsequently processed in a Willey mill with with 1 mm mesh sieves and stored. The samples of soybean, soybean soapstock, corn, soybean hulls and wheat bran were collected at the time of preparation of diets. All samples were homogenized and a sample was taken for laboratory testing.

In the samples of the diet components (except for soybean soapstock) and leftovers, dry matter (DM) and organic matter (OM) and crude protein (CP) were determined by the Kjeldahl method, and ether extract (EE)

Table 1 - Chemical composition of the ingredients used in the diets

| Nutrients | Ingredient | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sorghum silage | Soybean | Corn | Soybean hulls | Wheat bran | Soybean soapstock | Calcitic limestone | Sodium chloride |
| | (g/kg of dry matter) | | | | | | | |
| Dry matter | 305.6 | 879.7 | 866.0 | 875.4 | 865.9 | 609.0 | 1000.0 | 1000.0 |
| Organic matter | 916.7 | 939.8 | 983.5 | 955.9 | 945.1 | 921.2 | 736.7 | - |
| Mineral matter | 83.3 | 60.2 | 16.5 | 44.1 | 54.9 | 78.8 | 363.3 | 1000.0 |
| Crude protein | 65.6 | 498.1 | 96.2 | 126.1 | 184.7 | 57.5 | - | - |
| Neutral detergent insoluble nitrogen | 4.1 | 4.2 | 3.1 | 8.5 | 7.5 | - | - | - |
| Acid detergent insoluble nitrogen | 2.8 | 2.1 | 0.8 | 2.1 | 2.1 | - | - | - |
| Ether extract | 11.0 | 23.0 | 22.8 | 17.7 | 34.6 | 863.7 | - | - |
| Neutral detergent fiber | 651.0 | 138.6 | 183.2 | 689.6 | 470.3 | - | - | - |
| Neutral detergent fiber[1] | 601.9 | 100.1 | 159.1 | 625.8 | 406.9 | - | - | - |
| Acid detergent fiber | 417.8 | 77.2 | 43.1 | 512.4 | 153.9 | - | - | - |
| Acid detergent lignin | 54.3 | 4.5 | 4.8 | 10.8 | 42.5 | - | - | - |
| Total carbohydrates | 840.1 | 418.7 | 864.6 | 812.0 | 725.7 | - | - | - |
| Non-fiber carbohydrates | 238.3 | 318.6 | 705.4 | 186.2 | 318.8 | - | - | - |
| Total digestible nutrients | 541.2 | 826.9 | 848.7 | 681.4 | 690.1 | 1908.3 | - | - |
| Digestible energy (Mcal/kg) | 23.8 | 36.4 | 37.3 | 30.0 | 30.4 | 84.0 | - | - |

[1] Corrected for ash and protein.

and ash (MM) according to the AOAC (1995). The contents of neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to Van Soest et al. (1991), using alpha-amylase enzyme without the addition of sulfite in the determination of NDF. The acid detergent lignin (ADL) was estimated according to the methodology suggested by Robertson & Van Soest (1981). The contents of neutral detergent insoluble nitrogen (NDIN) and acid detergent insoluble nitrogen (ADIN) were analyzed according to Licitra et al. (1996).

In the soapstock samples of soybean the moisture content and ash were determined in accordance with AOCS (2009) and the crude protein according to ISO (2009). Ether extract was determined according to AOAC (2010). The total carbohydrates (TC) were determined by the equation suggested by Sniffen et al. (1992): TC = 100 - (% CP + %EE + %ash) and non-fiber carbohydrates (NFC) according to Hall (2000): NFC = TC - NDFap, where: NDFap = neutral detergent fiber corrected for ash and protein. The content of total digestible nutrients (TDN) was calculated according to Weiss et al. (1992) and digestible energy (DE) was calculated according to NRC (2000), where 1 kg of TDN = 4.4 Mcal of DE.

The diets, formulated according to the NRC (2000) to provide CP, Ca and P sufficient for a daily gain of 1.2 kg, were composed of 40.2% forage (sorghum) and 59.8% concentrate, composed of soybean meal, ground corn, soybean hulls, wheat bran, soybean soapstock, calcium carbonate and sodium chloride; the composition varied according to the treatment (Table 2).

The animals were weighed at the beginning of the adaptation and at the beginning and end of the evaluation period, always after a 14-hour period of solid- and liquid deprivation. At the beginning and end of the experiment period, the body condition score (BCS) of animals was subjectively evaluated by three evaluators, with an adapted methodology of Lowman et al. (1973), with scores ranging from 1 to 5, where 1 = very thin, 2 = thin, 3 = average, 4 = fat and 5 = very fat.

The duration of the experimental period was defined by time required for animals of the treatments to reach the pre-determined average slaughter weight, which was set at approximately 430 kg of body weight. After reaching slaughter weight, the animals were transported to a slaughter house and the slaughter of animals occurred according to the Regulation of the Industrial and Sanitary Inspection of Animal Products (Regulamento da Inspeção Industrial e Sanitária de Produtos de Origem Animal - RIISPOA) and followed the normal flow of the plant. After obtaining slaughter and hot carcass weights, the carcass yield of the animals was calculated. Carcasses were immediately cooled in a cold room at a temperature between 0 and 1 $^{o}$C for 24 hours. After that, a section between the 10-11-12th ribs and half of the right cold carcass, called “section HH,” was made, according to the methodology proposed by Hankins & Howe (1946). In this section the subcutaneous fat thickness was determined, measured by the arithmetic mean of three measurements around exposed *longissimus* muscle.

The experimental design was completely randomized with three replications and eight treatments, with the animal as the experimental unit. Data were subjected to analysis of variance using proc GLM and when differences between the means were detected, they were compared by Tukey test at a significance level of $\alpha = 0.05$ and Pearson correlation test was also conducted. The mathematical model used in the analysis of variance was: $\gamma_{ij} = \mu + \tau_i + \varepsilon_{ij}$, where: $\gamma_{ij}$ = dependent variables; $\mu$ = overall mean of all observations; $\tau_i$ = effect of the i-th source of carbohydrate, where 1 = corn, 2 = soybean hulls and 3 = wheat bran; and $\varepsilon_{ij}$ = residual random error NID (0, σ2).

The data were tested for normality by the Shapiro-Wilk test. All statistical analyses were performed on the software SAS (Statistical Analysis System, version 9.2).

Table 2 - Composition of experimental diets (g/kg dry matter)

| Ingredient | Source of carbohydrate | | |
|---|---|---|---|
| | Corn | Soybean hulls | Wheat bran |
| Sorghum silage | 402.0 | 402.0 | 402.0 |
| Soybean | 112.0 | 79.0 | 12.1 |
| Corn | 444.1 | - | - |
| Soybean hulls | - | 485.5 | - |
| Wheat bran | - | - | 524.9 |
| Soybean soapstock | 29.9 | 29.9 | 29.9 |
| Calcitic limestone | 9.0 | 0.6 | 28.1 |
| Sodium chloride | 3.0 | 3.0 | 3.0 |
| Nutritional composition | | | |
| Dry matter | 636.2 | 639.2 | 637.3 |
| Organic matter | 944.7 | 934.8 | 924.2 |
| Mineral matter | 56.2 | 65.2 | 78.6 |
| Crude protein | 126.6 | 128.7 | 131.0 |
| NDIN | 3.5 | 6.1 | 5.6 |
| ADIN | 1.7 | 2.3 | 2.3 |
| Ether extract | 42.9 | 40.7 | 48.7 |
| Neutral detergent fiber | 358.6 | 607.5 | 510.3 |
| NDFap | 323.8 | 553.7 | 456.8 |
| Acid detergent fiber | 195.7 | 422.8 | 249.7 |
| Acid detergent lignin | 24.5 | 27.4 | 44.2 |
| Total carbohydrates | 768.6 | 765.0 | 723.8 |
| Non-fibrous carbohydrates | 444.8 | 211.4 | 267.0 |
| Total digestible nutrients | 744.1 | 670.8 | 646.8 |
| Digestible energy | 32.7 | 29.5 | 28.5 |

NDIN - neutral detergent insoluble nitrogen; ADIN - acid detergent insoluble nitrogen; NDFap - neutral detergent fiber corrected for ash and protein.

## Results and Discussion

The different sources of carbohydrates used for feeding calves had no effect (P>0.05) on the daily intake of dry matter (DM) even when expressed in relation to body weight (BW) or metabolic body weight during the confinement, averaging 10.39 kg/day; 26.57 g/kg BW; and 118.11 g/kg of $BW^{0.75}$, respectively (Table 3).

Considering the average weight of the animals during the experiment, the DM intake is compatible with the level of intake for finishing steers, as recommended by the NRC (2000). Furthermore, the results of DM are in agreement with the majority of studies reviewed (Restle et al., 2004; Mendes et al., 2005a; Ezequiel et al., 2006a; Kazama, 2006).

However, when Pereira et al. (2007) evaluated the corn replaced by wheat bran or corn gluten meal in the diet of young bulls and Canchim Nellore, with 24% of Tanzania grass silage and 76% concentrate, they found no significant difference in DM intake for corn diets (9.69 kg/day) or wheat bran (9.82 kg/day), but smaller intake of DM was found for the corn gluten meal (9.31 kg/day). Studying the substitution of corn (0, 25, 50 and 75% of DM) by soybean hulls fed to heifers, Fischer & Mülbach (1999) observed that the DM intake increased linearly with the substitution of corn by soybean hulls. The authors reported that the occurrence of negative effects of soybean hulls on the digestibility of the fiber may have favored increased consumption, or the lower energy density of soybean hulls could possibly have led the animals to increase the intake to compensate the lower level of energy intake. Several studies have demonstrated that the use of energy sources rich in highly digestible fiber, such as soybean hulls when fed to cattle in substitution to corn had higher dietary fiber digestion (Highfill et al., 1987; Anderson et al., 1988; Mendes et al., 2006), which is the main reason why no difference was found in animal performance (Faulkner et al., 1994; Mendes et al., 2005a; Ezequiel et al., 2006b; Restle et al., 2006).

The daily intake of crude protein (CP) did not differ (P>0.05) among the sources of carbohydrates, even when expressed as g/kg BW. A similar result was obtained by Ezequiel et al. (2006a), who evaluated the performance of steers fed soybean hulls or corn gluten meal in partial substitution (70% DM) of maize in concentrate and found no difference in BW intake (average of 1.34 kg/day). Soares et al. (2004) replaced corn (0, 33, 67 and 100% of DM) by wheat bran in concentrate for lactating cows and found no difference in the BW intake (average of 2.86 kg/day).

Because of the higher content of neutral detergent fiber (NDF) in the diet with soybean hulls (Table 2) and similar DM intakes among sources of carbohydrates (Table 3), it was observed that the intake of NDF was higher (P<0.05) for soybean hulls, superior by 66.7 and 20.0% when compared with diets with corn and wheat bran, respectively. The same behavior was observed even when the intake of NDF was expressed in relation to the body weight of the animals, with a greater value for soybean hulls (20.35 g/kg BW), intermediary for the wheat bran (17.01 g/kg BW) and lower for the corn-based diet (12.2 g/kg BW).

The consumption of animals is regulated, among other factors, by the characteristics of the feed. In diets with high NDF and lower energy content, the intake increases until the energy requirement of animals is reached, observing a limit of 12 g/kg BW for filling physical effect of the rumen (Mertens, 1994). Ipharraguerre & Clark (2003) reported that the maintenance of the DM intake with the use of hulls in ruminant diets can be attributed to the high rate of NDF

Table 3 - Average daily nutrient intake of steers fed different sources of carbohydrate in the diet

| | Source of carbohydrate | | | P-value | CV (%) |
|---|---|---|---|---|---|
| | Corn | Soybean hulls | Wheat bran | | |
| | | Intake (kg/day) | | | |
| Dry matter | 10.68 | 10.16 | 10.34 | 0.4911 | 8.46 |
| Crude protein | 1.66 | 1.70 | 1.72 | 0.6821 | 8.33 |
| Neutral detergent fiber | 4.78C | 7.97A | 6.64B | 0.0001 | 9.41 |
| Acid detergent fiber | 2.54C | 5.58A | 3.24B | 0.0001 | 9.28 |
| | | Intake (g/kg BW) | | | |
| Dry matter | 27.28 | 25.93 | 26.49 | 0.4288 | 7.71 |
| Crude protein | 4.23 | 4.34 | 4.41 | 0.5747 | 7.49 |
| Neutral detergent fiber | 12.20C | 20.35A | 17.01B | 0.0001 | 8.01 |
| Acid detergent fiber | 6.47C | 14.25A | 8.30B | 0.0001 | 8.47 |
| | | Intake (g/kg $BW^{0.75}$) | | | |
| Dry matter | 121.28 | 115.33 | 117.71 | 0.3846 | 7.15 |

CV - coefficient of variation; BW - body weight.
Means in the same row followed by different letters differ (P<0.05) by the Tukey test.

digestion, to the small particle size and high hydration capacity of the soybean hull, providing increase in the rate of passage of NDF through the gastrointestinal tract. Data from *in situ* and *in vitro* experiments have shown that the microorganisms are able to extensively ferment soybean hulls at high rates. In a review written by Ipharraguerre & Clark (2003), in seven experiments analyzed *in situ*, the NDF fraction of fermented soybean hulls was at an average rate of 0.056/hour in four studies; about 90% of the total disappearance of the NDF fraction occurred after 96 hours of incubation.

Pereira et al. (2007), evaluating different energy sources in confined finishing bulls, observed that NDF intake was higher in animals fed wheat bran (3.99 kg/day) and corn gluten meal (4.06 kg/day) compared with corn (2.96 kg/day), attributing this difference to the higher NDF for diets based on co-products. However, other studies ratify that the partial substitution of corn (70% DM) by soybean hulls or corn germ meal in the diet does not influence the NDF intake of finishing cattle (Mendes et al., 2005a; Ezequiel et al., 2006a). The data reported by Soares et al. (2004) indicated increasing NDF intake when the wheat bran replaced corn (0, 33, 66 and 100% of DM) in the diet of dairy cows. Although the dry matter intake of the animals was similar, the data indicate reduction in the intake, possibly because they used only 30% of concentrate and because wheat bran had a higher rumen fill effect on the amount of NDF diet.

There were significant effects (P<0.05) of sources of carbohydrate in the intake of the ADF, with higher values for soybean hulls (5.58 kg/day) as compared with wheat bran (3.24 kg/day) and corn (2.54 kg/day). However, this increased intake of ADF was not enough to influence DM intake of animals (Table 3), possibly due to the fiber characteristics of soybean hulls, which have high ruminal digestion, or the highest rate of passage of this ingredient (Ipharraguerre & Clark, 2003). These results corroborate those found by Mansfield & Stern (1994), Mendes et al. (2005b) and Ezequiel et al. (2006a), who analyzed the substitution of corn by soybean hulls and found higher values of ADF in the diets containing soybean hulls without influencing DM intake of animals. The higher ADF intake for soybean hulls and wheat bran compared with corn was because soybean hulls and wheat bran presented higher levels of ADF in their composition (Table 1), which are values higher than those reported by Rocha Junior et al. (2003) and Valadares Filho et al. (2010).

The sources of carbohydrates influenced (P<0.05) the daily intake of non-fiber carbohydrates (NFC) (Table 4). This behavior was expected due to the composition of the diets (Table 2) which showed different carbohydrate profile. Although replacing the corn starch by NDF of the soybean hull or wheat bran did not affect the dry matter intake of the animals (Table 3), the animals fed corn had greater energy intake.

Assessing the total replacement of corn by wheat bran for dairy cows, Soares et al. (2004) found a reduction in the intake of NFC as the levels (0, 33, 67 and 100%) of wheat bran were increased in the diet because the bran is extremely rich in fiber (average 44.48% NDF), thus increasing the NDF and decreasing the NFC level of diets. In the study of Eifert et al. (2006), the apparent digestibility of NFC was not influenced by the sources of carbohydrates, even with the variation in the composition of NFC in the diets, with values of 294, 387 and 400 g/kg DM for wheat bran, corn and citrus pulp, respectively. However, the authors observed increased tendency of microbial synthesis in the corn diet compared with that with wheat bran (253.4 *vs*. 226.5 g N/day), whereas the citrus pulp was intermediary for both (237.5 g N/day), which may be explained by the difference between the contents of NFC of the diets.

The inclusion of different sources of carbohydrates significantly influenced the intake of digestible energy (DE) (Table 4), and for steers fed corn, the consumption of DE was higher by 16.2% and 21.9%, respectively, compared to animals that received soybean hull and bran in the diet. The same behavior occurs when consumption of DE was expressed in body weight. Unlike corn, which has lots of starch to meet the energy demand of cattle, the energy provided by soybean hulls is mainly associated with fermentation of pectin, which is extensive and rapidly degraded in the rumen. Furthermore, soybean hulls estimated 74-80% of corn nutritional value when included

Table 4 - Average daily intakes of non-fibrous carbohydrates and energy of steers fed different sources of carbohydrate in the diet

| Intake | Source of carbohydrate | | | P-value | CV (%) |
|---|---|---|---|---|---|
| | Corn | Soybean hulls | Wheat bran | | |
| Non-fibrous carbohydrates, kg/day | 6.38A | 2.82C | 3.52B | 0.0001 | 8.11 |
| Non-fibrous carbohydrates, g/kg of BW | 16.29A | 7.20C | 9.03B | 0.0001 | 8.04 |
| Digestible energy, Mcal/day | 45.92A | 39.53B | 37.66B | 0.0004 | 8.41 |
| Digestible energy, Mcal/100 kg BW | 117.23A | 100.89B | 96.51B | 0.0001 | 7.55 |

CV - coefficient of variation; BW - body weight.
Means in the same row followed by different letters differ (P<0.05) by the Tukey test.

in moderate to high amounts in the diet of finishing cattle (Ludden et al., 1995). Thus, the higher energy consumption in favor of the diet with corn is due to the higher starch content present in this carbohydrate source, corroborating studies of Mouro et al. (2007) and Dhakad et al. (2002).

The final live weight of steers did not differ (P>0.05) among sources of carbohydrates (Table 5) because the slaughter weight at the beginning of the experiment had been predetermined. It is observed that the time spent in confinement was greater for animals fed wheat bran due to less weight gain (Table 5). It is important to point out that the reduction in feedlot finishing period is economically important because it represents less energy for maintenance, higher turnover of animals and capital turnover, since that provides carcasses that meet the minimum requirements recommended by the slaughterhouses.

The average daily weight gain (ADG) was greater (P<0.05) for steers fed corn (1.57 kg/day) and soybean hulls (1.58 kg/day) compared with animals that received wheat bran (1.29 kg/day).

Ludden et al. (1995) observed a decrease in weight gain of steers with increasing level of soybean hulls (0, 20, 40 and 60%) in diets containing 95% concentrate and corn as the main ingredient, and reported that the inclusion of a small amount of soybean hulls in the diet (<20% DM) did not affect animal performance, probably because soybean hulls cause metabolic disorders, increasing energy availability of other feed ingredients. In another study, Pereira et al. (2007) found it possible to obtain satisfactory weight gains in cattle-finishing diets rich in byproducts, with values of 1.42, 1.38 and 1.30 kg/day, respectively, for corn, wheat bran and corn gluten meal.

The literature review showed that in the few studies where corn was replaced by wheat bran, the weight gain of finishing cattle was slightly reduced when this substitution was greater than 10% of the feed grains (Dalke et al., 1997; Dhuyvetter et al., 1999). The lower weight gain for steers fed wheat bran can be explained, at least in part, by the lower energy intake from the diet containing wheat bran (Table 2), since in this study the correlation between the consumption of TDN and ADG was r = 0.54 (P = 0.0062), which could have limited the rumen organic matter digestibility of the diet containing wheat bran.

The difference of ADG between carbohydrate sources used in the diet (Table 5) had no effect (P>0.05) on the final body condition (FBS) and gain in body condition (GBC) of the animals, with average FBS of 3.78 points, which is a condition close to fat. With the advance of the feeding period in the feedlot, there are changes in the rate of gain composition, making the fat deposition slow because it is a process to be energetically more costly as compared with muscle deposition. It is worth noting that in short feeding periods, the higher fat deposition rate is, in practice, a positive outcome to achieve the minimum level of fat cover required by slaughterhouses, which is 3 to 6 mm backfat thickness on the carcass, decreasing the time spent in confinement and feeding costs. Although in this study there was no significant difference in fat thickness among treatments (Table 6), it was observed that animals fed soybean hulls presented fat cover degree of 2.88 mm, which is slightly lower than the recommended by slaughterhouses. In accordance with Luchiari Filho (2000), subcutaneous fat in small quantities causes shortening of the muscle fiber and darkening of the superficial muscles of the carcass during cooling.

The efficiency with which the animal feed consumed is transformed into weight gain is presented in the form of feed conversion (FC), which followed the same behavior of weight gain of animals (Table 5). The animals fed corn and soybean hulls had better (P<0.05) FC: 18.8% and 23.1%, respectively, compared with cattle that received wheat bran in their diet. Evaluating the substitution of sorghum

Table 5 - Average performance of feedlot steers fed different sources of dietary carbohydrates

| Variable | Source of carbohydrate | | | P-value | CV (%) |
|---|---|---|---|---|---|
| | Corn | Soybean hulls | Wheat bran | | |
| Initial weight, kg | 357.69 | 352.56 | 349.40 | 0.8593 | 8.43 |
| Final weight, kg | 429.81 | 433.19 | 430.47 | 0.9761 | 7.51 |
| Feeding time in confinement, days[1] | 46 | 51 | 63 | - | - |
| Average daily weight gain, kg | 1.57A | 1.58A | 1.29B | 0.0323 | 15.24 |
| Initial body score, scores | 3.15 | 3.07 | 2.99 | 0.1199 | 4.69 |
| Final body score, scores | 3.80 | 3.76 | 3.80 | 0.7289 | 2.84 |
| Body condition gain, scores | 0.65 | 0.69 | 0.81 | 0.0793 | 19.12 |
| Feed conversion, kg of DM/kg of gain | 6.85B | 6.61B | 8.14A | 0.0157 | 13.78 |
| Energy conversion, Mcal of DE/kg of gain | 29.42 | 25.70 | 29.64 | 0.0967 | 13.45 |

CV - coefficient of variation; DM - dry matter; DE - digestible energy.
Means in the same row followed by different letters differ (P<0.05) by the Tukey test.
[1] Not analyzed statistically.

Table 6 - Means for hot carcass weight and yield and fat thickness of feedlot steers fed different sources of carbohydrate in the diet

| Variable | Source of carbohydrate | | | P-value | CV (%) |
|---|---|---|---|---|---|
| | Corn | Soybean hulls | Wheat bran | | |
| Hot carcass weight, kg | 244.76 | 253.31 | 246.87 | 0.6149 | 7.15 |
| Hot carcass yield, kg/100 kg BW | 56.97 | 58.53 | 57.40 | 0.3156 | 3.56 |
| Fat thickness, mm | 3.25 | 2.88 | 3.17 | 0.6726 | 28.31 |

CV - coefficient of variation; BW - body weight.
Means in the same row followed by different letters differ (P<0.05) by the Tukey test

grain (0, 25, 50, 75, 100%) for soybean hulls in finishing steers, Restle et al. (2004) observed an improvement in feed conversion when soybean hulls were included in all diets. The same authors reported that using moderate levels of concentrate for cattle fed soybean hulls, one can expect better performance, according to the better conditions of the rumen for digestion of the diet compared with animals fed sorghum. Other studies (Ezequiel et al., 2006a; Pereira et al., 2007) show that replacing corn with other energy sources does not alter the feed conversion of finishing cattle.

There was no difference (P>0.05) for energy conversion (EC) between sources of carbohydrates, with an average 28.25 Mcal DE/kg gain (Table 5). Restle et al. (2006) fed beef calves weaned at 80 days of age corn, soybean hulls, rice bran and its mixtures in diets with 50% concentrate and no found significant difference for EC (average 12.23 Mcal/kg gain). In the present study the correlation between EC and ADG was r= - 0.76 (P<0.0001). However, it is noteworthy that the animals at the beginning of confinement had high weight and body condition score above 3, indicating uniform body development.

Hot carcass weight and yield and subcutaneous fat thickness did not differ (P>0.05) among sources of carbohydrates (Table 6), presenting values of 248.3 kg, 57.63 kg/100 kg BW and 3.1 mm, respectively. Lower results were observed by Ezequiel et al. (2006a), who evaluated the effect of the supply of soybean hulls or corn germ meal to replace 70% of corn in the diet of steers and reported average carcass yield of 54.51 kg/100 kg BW. Carcass yield may be influenced by factors inherent to animal variations (genotype, rumen fill, fasting and transport) and it can also be influenced by the slaughter facility, due to the greater or lesser degree of rigor in the process of carcass emptying (Prado et al., 2000). The data highlight that within the boundaries of strategic planning, the choice of carbohydrate source to be fed to finishing steers must consider both the economic factor and associative effect of all the ingredients of the diet so as not to compromise animal performance.

## Conclusions

Soybean hulls can completely replace corn in diets containing approximately 60% concentrate for steers in the finishing phase without affecting dry matter intake and average daily gain, also providing improvement in feed conversion. The inclusion of wheat bran as the main ingredient in the concentrate in diets for feedlot steers results in less weight gain and lower feed conversion. The use of corn, soybean hulls or wheat bran as a source of carbohydrate in the diet of finishing steers does not affect hot carcass yield and subcutaneous fat thickness.

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