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# Chemical composition and in vitro digestibility of concentrated containing sunflower crushed seeds

***Composição química e digestibilidade in vitro de concentrados contendo torta de girassol***

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**Abstract.** To evaluate the chemical composition and dry matter in vitro digestibility of concentrates with partial substitution of soybean meal with sunflower crushed, was used a randomized design with four treatments and four replications. The concentrates were composed of corn and soybean meal replaced by the sunflower crushes, in rates of 0, 20, 40 and 60%. The CP levels were not affected by the inclusion of sunflower crushed (P> 0.05), with mean of 28.1%, but the levels of EE, CF, NDF and ADF, where the replacement of 60% of soybean meal showed an average of 11.00, 14.78, 32.48 and 18.73% respectively. The increase in ADF, decreases total (TC) and non-structural (NEC) carbohydrates, DMIVD and TDN. The C00 had a higher IVDMD, 13.71% superiority of the C60, while C20 showed 8.96% of superiority. The TC and NEC reduced after 40% replacement, with an average of 57.62 and 26.15%. Concentrates with sunflower crushed presents average of NDT of 78.79%, reduction of 7.43% compared to the C00. Replacing up to 60% of soybean meal with sunflower crushed in concentrates; change the chemical composition and dry matter in vitro digestibility.

**Keywords.** Carbohydrates, cattle, ether extract, NDF, ration

**Resumo.** Para se avaliar a composição bromatológica e a digestibilidade *in vitro* de concentrados com substituição parcial do farelo de soja pela torta de girassol, foi utilizado um delineamento inteiramente casualizado, com quatro tratamentos e quatro repetições. Os concentrados eram compostos de milho e farelo de soja e este substituído pela torta de girassol, nas proporções de 0, 20, 40 e 60%. Os teores de PB não foram influenciados pela inclusão da torta de girassol (p>0,05), apresentando valores médios de 28,1%, porém os teores de EE, FB, FDN e FDA foram aumentados; onde a substituição de 60% do farelo de soja apresentou médias de 11,00, 14,78, 32,48 e 18,73%, respectivamente. Com o aumento dos teores de FDA, ocorreu diminuição nos valores de Carboidratos totais (CT) e não estruturais (CNE), DIVMS e NDT. O concentrado C00 apresentou maior DIVMS, superioridade de 13,71% ao C60; enquanto o C20 apresentou 8,96% de superioridade. O teor de CT e CNE reduziu após 40% de substituição, com valor médio de 57,62 e 26,15%. Os concentrados com torta de girassol apresentaram NDT médio de 78,79%, redução de 7,43% em relação ao C00. A substituição em até 60% do farelo de soja pela torta de girassol em concentrados altera a composição bromatológica e a digestibilidade *in vitro* da matéria seca.

**Palavras-chave.** Bovinos, carboidratos, extrato etéreo, FDN, ração

## Introduction

The productivity of the Brazilian herd of beef and milk is due to the quality of food provided; the low rates obtained annually are due to nutritional deficiency of animals. The rise in the cost of sources of energy and protein for animal feed increased production costs and reduced profit margin thus becomes necessary to evaluate the possibilities of using alternative foods of good quality, thereby maintaining the current level of livestock production. The main ingredients used to formulate rations are corn and soybean, as well as not having nutritional restrictions; their combination provides energy and protein. The processing of agroindustrial produce waste products that contribute to 2.9 trillion Mcal of metabolizable energy (ME) and the byproducts processed approximately 0.6 trillion Mcal of ME.

The sunflower (*Helianthus annuus L.*) is an annual dicotyledonous *compositae* family, originally from North American continent; stands out for high lipid content (> 35%), and the recommended cold extraction, preserving the quality of the oil, and yielding a product free of polar compounds. The sunflower crushed is an alternative source of protein and energy, with crude protein (CP) ranging from 240 to 333 g $kg^{-1}$, total digestible nutrients (TDN) around 790 g $kg^{-1}$ and 165 g $kg^{-1}$ of lipid (OLIVEIRA et al. 2007; GOES et al. 2008; GOES et al. 2010; DOMINGUES et al. 2010). The CP sunflower crushed is characterized by being widely degradable and non-degradable protein in the rumen of less than 10 g $100g^{-1}$ (BERAN et al., 2007); Goes et al. (2008 and 2010), found degradability of CP to the sunflower crushed , g $100g^{-1}$ of 36.65 and 50, respectively. The variation between these values may be due to the process of oil extraction, or the lack of uniformity of the crushed seeds according to the variety used, showing need for standardization of the product.

The use of sunflower byproduct in substitution for protein sources can be economically advantageous, releasing soybean meal, for other purposes, such as export. However studies that evaluate the levels and effects of inclusion of sunflower crushed in concentrates which comprise the diets fed to ruminants are few, which would be essential for efficient manipulation of diets. This work aimed to evaluate the chemical composition and in vitro digestibility of dry matter of concentrates made with replacement of soybean meal by sunflower crushed, obtained by cold pressing.

## Material and Methods

The experiment was conducted in the Food Sector Assessment and Laboratory of Animal Nutrition, Agricultural Sciences College of Federal University of Grande Dourados (UFGD) in Dourados, MS, Brazil. Were studied four types of concentrates, which were the treatments. Concentrates were made in feed manufactures and composed of corn and soybean meal and this replaced by sunflower crushed, in proportions of 0, 20, 40 and 60% (Table 1). The sunflower crushed was obtained by cold pressing, and processed into a 3 mm sieve before blending to occur. The chemical composition of the ingredients used for making the concentrates is presented in Table 2.

**Table 1**. Share the ingredients (g $kg^{-1}$ as fed)

| Ingredients | Concentrates# | | | |
|---|---|---|---|---|
| | C00 | C20 | C40 | C60 |
| Corn | 42,6 | 35,7 | 28,8 | 21,8 |
| Soybean meal | 52,4 | 41,9 | 31,5 | 21,0 |
| Sunflower crushed seed | -- | 17,4 | 34,8 | 52,2 |
| Mineral | 5,0 | 5,0 | 5,0 | 5,0 |

# C00 = Concentrate without sunflower crushed seed;
C20 = Concentrate with 20% of soybean meal replaced for sunflower crushed seed;
C40 = Concentrate with 40% of soybean meal replaced for sunflower crushed seed;
C60 = Concentrate with 60% of soybean meal replaced for sunflower crushed.seed.

**Table 2**. Chemical composition of ingredients used in concentrated for steers (%DM)

| | Chemical composition and in vitro digestibility | | | | | | |
|---|---|---|---|---|---|---|---|
| Ingredients | DM* | CP* | EE* | NDF* | ADF* | MM* | IVDDM* |
| Soybean Meal | 85,64 | 50,99 | 6,71 | 34,14 | 20,08 | 9,68 | 95,40 |
| Corn | 87,86 | 11,68 | 3,28 | 13,93 | 5,43 | 1,70 | 98,80 |
| Sunflower crushed | 95,05 | 30,93 | 16,76 | 42,69 | 31,27 | 4,72 | 64,54 |
| Mineral | 96,31 | - | - | - | - | - | - |

DM = dry matter, CP = crude protein, EE = ether extract, NDF = neutral detergent fiber, ADF = acid detergent fiber, MM = mineral matter and IVDMM = in vitro dry matter digestibility.

Contents were determined for of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), crude fiber (CF) and mineral matter (MM), according to methods described by AOAC (2006). Fractions neutral detergent fiber (NDF) and acid (ADF), hemicellulose (HCEL), and lignin (LIG), were determined by the method of Van Soest et al., (1991), in a sequential manner using 25 ml thermo stable amylase to 1% added in the beginning of the boiling, using the apparatus of Tecnal ® (TE-149), modifying the material of the bag used (5.0 x 5.0 cm) made of TNT -100 g $m^{-2}$). For the determination of lignin residue obtained from the FDA analysis, were transferred to filter crucibles, to continue the method by extracting by potassium permanganate ($KMnO_4$).

The TDN were estimated by Capelle et al. (2001), based on in vitro digestibility of dry matter (DMD), where% TDN = 9.6134 +0.829 DMS ($r^2$ = 0.98). The total carbohydrates (TC) and non-structural carbohydrates (NSC) as estimated Sniffen et al. (1992), in which they TC (% DM) = 100 - [CP (% DM) + EE (% DM) + Ash (% DM)] and CNE% = CT% -% NDF. The in vitro digestibility of dry matter was determined by the method described by Tilley & Terry (1963) in two steps of 48 hours, through the use of in vitro incubator (Tecnal ® TE-150), modifying the material of the bag used (5.0 x 5.0 cm), made with TNT -100 g/m2 (Casali et al., 2008). Were used 0.5 gram samples of the concentrates, previously dried and ground using a mill with a sieve containing sieves of 2 mm. The samples were placed in bags for further processing of fermentation in the fermentor rumen.

As donors of rumen fluid were used four crossbred steers with 285 kg of body weight, fitted with rumen cannula, kept in individual paddocks of *B. Brizantha* cv Marandu, with drinkers and supplemented with concentrates described in Table 1. During the first fourteen days proceeded to adaptation of animals to supplements and treater. The harvest of the rumen contents was performed in the morning, on the 15th day of early adaptation, before the first meal. The material was packed in thermos bottles preheated to 39°C. After removal of the required amount was injected with $CO_2$ gas, forming a blanket in order to maintain anaerobiosis. Subsequently, was filtered into cotton by hand pressure. The liquid obtained was used for inoculation into jars of rumen fermentor.

In each jar were placed in the incubator artificial 1200 ml of buffer (g per liter - 9,8 of $NaHCO_3$; 7 of $Na_2HPO$ x $7H_2O$ ; 0,57 of KCl; 0,47 de NaCl; 0,12 of $MgSO_4$ x $7H_2O$ and 0,04 de $CaCl_2$) and 400 ml of rumen fluid. Previously, prior to incubation, was added to each 1200 ml of buffer, 20 mL of urea solution (5.5 g urea 100 $ml^{-1}$ $H_2O$) and glucose solution (5.5 g glicose100 $ml^{-1}$ $H_2O$). After preparation of the solution, it was flushed with $CO_2$ gas in order to lower the pH to 6.9 and then incubation was performed for 48 hours of concentrates. After this time the fermentation was stopped and added 40 mL of 6N HCl and 8 g of pepsin (1:10000) in each jar to the second stage of the technique of Tilley & Terry (1963). Pepsin was previously dissolved in 34 ml $H_2O$ and distilled at 39°C for 5 minutes in magnetic stirrer and then controlled the pH (2.0-3.5).

After the incubation period, the jars were removed from the incubator artificial opened and the bags TNT bags containing the digestion residues were washed under running water and then placed in an oven at 55 ° C for 72 hours, cooled in a desiccator and weighed.

The experimental design was completely randomized with four treatments and five replicates, and the data submitted to analysis of variance and regression, using the statistical package SAEG 9.1 (SAEG, 2007); according to the model: $\hat{Y}_{ij} = \mu + t_i + e_{ij}$, where: $\hat{Y}_{ij}$ = value observed in the experimental unit that received the concentrate i, in j repetition $\mu$ = overall average; $t_i$ = effect of replacing i, where i = 1, 2, 3 and 4 and eijk = random error associated with each observation.

## Results and Discussion

The protein levels of concentrated decreased by 0.028% for each 1% of replacement of soybean meal by sunflower crushed seeds (Table 3), and the sunflower crushed increased levels of EE, CF, NDF, ADF and lignin. Oliveira et al. (2007) evaluated concentrates with inclusion of sunflower crushed of 25 and 50% reported an increase EE, FB and FDA, but not to NDF, with the substitution of 50% showed the highest levels (2.98, 5.13 and 27.03%), lower than the values found in this work to levels above 20% substitution. The increase presented to these fractions is due to the greater participation of sunflower crushed in concentrates, since it has a high concentration of these nutrients (Table 2); which according to the authors, sunflower crushed featuring wide variation in their composition which can be explained by lack of standard presented, in this work the sunflower crushed had higher fiber content.

The addition of sunflower crushed elevated the content of FB, concentrates, by highlighting the substitution levels of 40 and 60% that were 29% higher than the level of 20%, compared to control (C00) the increase was significant (Table 3). The sunflower crushed comes from crushing the grain, with the presence of the hulls that has a high concentration of FB. The same behavior can be explained to the lignin, since FB is constituted largely by lignin. According to Pereira et al. (2000), the sunflower hulls stands out for its high cell wall content, this is highly lignified.

**Table 3**. Contents of organic matter (OM), dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), neutral (NDF) and acid (ADF) detergent fiber, hemicellulose (HCEL), cellulose (CEL), lignin (LIG), total carbohydrates (TC), non-structural carbohydrates (NSC), no nitrogen extraction (ENN), mineral matter (MM) and total digestible nutrients (TDN) of concentrates

| | Concentrates# | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | C00 | C20 | C40 | C60 | Average | CV (%) | SEM** | P<F |
| OM | 88,26 | 84,27 | 83,67 | 85,76 | 85,49 | 1,06 | 1,99 | 0,0676 |
| DM | 91,51 | 87,46 | 87,97 | 91,03 | 89,49 | 1,03 | 2,02 | 0,0000 |
| CP | 29,35 | 27,87 | 27,91 | 27,46 | 28,15 | 3,15 | 1,08 | 0,0144 |
| EE | 3,68 | 5,65 | 8,82 | 11,00 | 7,29 | 12,66 | 3,02 | 0,0000 |
| CF | 4,41 | 11,09 | 13,73 | 14,98 | 11,06 | 7,03 | 4,27 | 0,0000 |
| NDF | 26,98 | 29,32 | 30,44 | 32,48 | 29,81 | 7,51 | 2,86 | 0,0021 |
| ADF | 5,51 | 13,86 | 17,16 | 18,73 | 13,82 | 7,03 | 5,34 | 0,0000 |
| HCEL | 21,46 | 15,45 | 13,27 | 13,75 | 15,98 | 11,56 | 3,75 | 0,0004 |
| CEL | 1,93 | 6,07 | 9,44 | 14,28 | 7,93 | 5,85 | 4,69 | 0,0000 |
| LIG | 5,18 | 9,25 | 13,75 | 19,55 | 11,93 | 9,23 | 5,51 | 0,0000 |
| TC++ | 63,71 | 63,28 | 58,97 | 56,26 | 60,56 | 2,13 | 3,40 | 0,0000 |
| NSC++ | 36,74 | 33,97 | 28,53 | 23,77 | 30,75 | 6,47 | 5,45 | 0,0000 |
| ENN+ | 59,30 | 52,20 | 45,23 | 41,28 | 49,50 | 2,30 | 7,17 | 0,0000 |
| MM | 3,25 | 3,19 | 4,30 | 5,28 | 4,00 | 11,59 | 0,97 | 0,0000 |
| TDN* | 85,12 | 82,00 | 78,38 | 76,00 | 80,35 | 0,97 | 3,68 | 0,0000 |

#C00 = Concentrate without sunflower crushed seeds; C20 = Concentrate with 20% of soybean meal replaced for sunflower crushed seeds; C40 = Concentrate with 40% of soybean meal replaced for sunflower crushed seeds; C60 = Concentrate with 60% of soybean meal replaced for sunflower crushed seeds.

OM: $Y=90,94 – 0,18x$ ($r^2=0,93$); DM: $Y=91,40 – 0,27x + 0,004x^2$ ($r^2=0,82$) ;CP: $Y=28.99 – 0,03x$ ($r^2=0,77$); EE: $Y=3,52 – 0,13x$ ($r^2=0,92$) ; CF: $Y=5,90 – 0,17x$ ($r^2=0,86$) ;NDF: $Y=27,16 – 0,09x$ ($r^2=0,50$); ADF: $Y=7,37 – 0,21x$ ($r^2=0,86$); HCEL: $Y=19,78 – 0,13x$ ($r^2=0,61$); CEL: $Y=1,86 + 0,20x$ ($r^2=0,98$); LIG: $Y=4,79+0,23x$ ($r^2=0,99$); TC: $Y=64,56 – 0,13x$ ($r^2=0,82$); NSC: $Y=37,40 – 0,22x$ ($r^2=0,88$); ENN: $Y=58,68 – 0,31x$ ($r^2=0,96$); MM: $Y=0,29 + 0,04x$ ($r^2=0,72$); TDN: $Y=85,00 – 0,15x$ ($r^2=0,94$).

+ ENN = 100 - (% CP +% EE +% FB + %MM), CT ++ = 100% - (% CP +% EE +% MM) and %NSC =%CT-%NDF

**SEM = standard error of mean.

Similarly the levels of EE were increased with the addition of sunflower crushed, averaging 8.49%, up from 2.98% presented by Oliveira et al., (2007). Commonly attributed to a limit of EE in the diet of ruminants values between 6.0 and 7.0% of dry matter (Vasconcelos & Galyean, 2007; Marin et al., 2010), higher values may alter the rumen degradation of fiber, however this limit is variable because it depends on the type of basal diet (forage vs. concentrate) the degree of unsaturation of fatty acids of lipid source, or even the physical protection of lipids, as with whole grain or oilseed crushed (Dhiman et al., 2000). With the presence of EE dietary ruminal biohydrogenation occurs, a measure "self-protective" performed by the microorganisms against the harmful effects of unsaturated fatty acids, especially polyunsaturated (Marin, et al, 2010). The sunflower has around 66% of polyunsaturated fatty acids, which could compromise the microbial activity in the rumen. Involvement of microbial activity is due to interaction between fatty acids (mainly polyunsaturated) and the microbial cell membrane phospholipids, which tends to undermine its stability and permeability, a fact that inhibits the growth of microorganisms (Kim et al., 2009).

With the inclusion of sunflower crushed was a linear increase in ADF content, and reduced concentrations of ENN, CT and CNE, where levels of 60% showed the lowest values for these yields, and hence falling IVDM (Table 4) and NDT. Oliveira et al. (2007) noted that increases in ADF content in the diet can harm the digestibility in function of lignin, undegradable fraction, representing a higher proportion of the ADF, which is consistent with the values presented in Table 3. Tomlinson et al. (1991), have suggested that the alteration of the level of ADF is associated with the change of dietary TDN; since most of NDT is linked to the carbohydrate content of the food. The sunflower crushed has a high content of FDA, and possibly high lignin content. Although there was an increase in the ADF and NDF, with average values of 29.81 and 13.82%, these values are higher than those reported by Oliveira et al. (2007), with the inclusion of 25 and 50% of sunflower crushed , but are below the limit harmful suggested by Tomlinson, et al. (1991) in cattle.

According Detmann et al. (2003) is decreased dietary TDN with increasing NDF; such behavior demonstrates the possibility of the value of NDF indicate with good precision, the energy level of a food / diet in static models for predicting consumption, but there is a strong correlation between TDN and organic matter digestibility, which may infer the data presented in Table 3. The characteristics of NDF vary from fiber sources, which facilitate distinction between slow degradation of food components and that soluble rapid degradation (Detmann et al., 2003).

The change in the content of hemicellulose (HCEL) and cellulose (CEL) is associated with NDF and ADF, and become interesting since ruminants deploy these components in short-chain fatty acids (SCFA), mainly acetic, propionic and butyric, which represent the largest source of energy, but the cell wall polysaccharides (cellulose, hemicellulose and pectates), when isolated, have a higher degradation by rumen microorganisms or enzymes (Pariz et al., 2010). However, the degradation of these polysaccharides in the cell wall composition, it is rarely complete and varies according to the lignin content, type and age of the plant (Silva & Queiroz, 2002).

The TC and NNE are considered the main components of the diet of cattle. Teixeira & Santos (2001) report that the nonstructural carbohydrates (NSC) include starch and sugars (rapid fermentation in the rumen), which should provide a minimum to promote microbial growth and a maximum to prevent acidosis in ruminants. In this case, NSC concentrations can vary from 20% to 45%, the value of 40% to 45% of diets with typical forage: concentrate of 40% to 60% or less of forage. In the present work, the NSC concentrations ranged from 36.74% to 23.77% considering all concentrates.

The replacement of soybean meal decreased by 12.06% in vitro digestibility of dry matter concentrates (Table 4), behavior similar to that shown for the TDN. Despite the decrease the digestibility of the concentrates with sunflower crushed was similar, with an average of 83.44% which is 8.39% lower than concentrated control (C00). Oliveira et al. (2007) also found a reduction in IVDM as it increases the inclusion of sunflower crushed in concentrates, with treatment composed of soybean meal and corn upper at 8.28%. However for all treatments the digestibility kept above 80%. The reduction in digestibility may be associated with increased EE and NDF of concentrates. Depending on the content of EE, NDF, dry matter intake can be affected. In this study the concentrations of EE and NDF increased according to the substitution levels, however the amount of sunflower crushed used was adequate, at least in terms of IVDM.

According to Oliveira et al. (2007), depending on the category animal, the levels of EE, ADF and NDF, beyond the carbohydrate content, to be provided by concentrated, are important because of their direct influence on intake and digestibility of nutrients mainly in animal performance. Despite the higher level of replacement, IVDM was maintained above 80.0%, and considering the overall average, the figure was 85.35%.

**Table 4**. Values of *in vitro* digestibility of dry matter (IVDM) in percentage of concentrates evaluated

| | C00 | C20 | C40 | C60 | Media | CV (%) | SEM | P<F |
|---|---|---|---|---|---|---|---|---|
| IVDM | 91,08a | 87,27b | 82,95b | 80,09b | 85,35± | 1,41 | 4,45 | 0,0000 |

IVDM: Y=90,94 – 0,18x ($r^2$=0,93).

C00 = Concentrate without sunflower crushed seeds; C20 = Concentrate with 20% of soybean meal replaced for sunflower crushed seeds; C40 = Concentrate with 40% of soybean meal replaced for sunflower crushed seeds; C60 = Concentrate with 60% of soybean meal replaced for sunflower crushed seeds.

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## Conclusion

Under these experimental conditions can replace partially the soybean meal by the sunflower crushed seeds until the content of 60%.

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