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Protein and carbohydrate fractionation of Piata palisadegrass silage of brans from biodiesel industry

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ABSTRACT. This study aimed to determine the protein and carbohydrate fractionation of Piata palisadegrass silage of brans from biodiesel industry. The experiment was developed in the Federal Institute of Goiás State, Campus Rio Verde, with a completely randomized experimental design, four replications, in a 4 x 4 factorial scheme, with four oleaginous brans (cotton, sunflower, soybean and canola) and four levels of inclusion (0, 5, 10 and 15%). The results showed that brans from biodiesel industry are good sources of additives for ensiling the Piata palisadegrass, by considerably improving fractions of proteins and carbohydrates. However, the soybean meal proved to be more efficient by having higher fractions of proteins and carbohydrates A+B1 and lower fractions C, compared with other additives. It is recommended the addition of 15% of brans for providing better nutritional value of silage.

Keywords: additive, *Brachiaria brizantha,* CNCPS, silage.

Fracionamento de proteínas e carboidratos da silagem de capim-piatã com farelos da indústria do biodiesel

RESUMO. Objetivou-se determinar o fracionamento de proteínas e carboidratos da silagem de capim-piatã com farelos da indústria de biodiesel. O experimento foi conduzido no Instituto Federal Goiano, Campus Rio Verde. O delineamento experimental utilizado foi o inteiramente casualizado, com quatro repetições e em esquema fatorial 4 x 4, sendo quatro farelos oleaginosos (algodão, girassol, soja e canola) e quatros níveis de adição (0, 5, 10 e 15%). Os resultados demonstraram que os farelos da indústria do biodiesel constituem em boas fontes de aditivos para a ensilagem do capim-piatã, por trazer melhorias consideráveis nas frações de proteínas e carboidratos. No entanto, o farelo de soja mostrou ser mais eficiente, para melhorar a qualidade da silagem, por apresentar maiores frações proteícas e carboidratos A+B1 e menores frações C, quando comparado com os outros aditivos. Com relação aos níveis, recomenda-se a adição de 15% dos farelos, por proporcionar melhor valor nutritivo da silagem.

Palavras-chave: aditivo, *Brachiaria brizantha,* CNCPS, ensilagem.

Introduction

The difficulty to achieve good quality food at certain seasons in some localities is the main reason that leads the farmers to produce silage (CARVALHO et al., 2008). Under suitable climatic conditions, the Piata palisadegrass besides used for grazing, also has appropriate nutritional characteristics for making silage (COSTA et al., 2011). However, due to intrinsic characteristics at the ideal stage for cutting (moisture content, soluble carbohydrates, and low buffering capacity), tropical grasses silage may undergo losses of energy and dry matter ranging from 7 to 40%, due to secondary fermentation, producing effluents and aerobic deterioration (SANTOS et al., 2008; RIBEIRO et al., 2009).

In this way, the losses of silage must be reduced, and one way for this is by including additives, in order to increase the dry matter content and provide better fermentation. Thus, the incorporation of new nutrient sources becomes usual and some byproducts, like brans, have been evaluated (SANTOS et al., 2010; COSTA et al., 2011; OLIVEIRA et al., 2012), given their high nutritional value, enhancing silage quality.

Information on carbohydrate and protein fractions of silages produced with brans from biodiesel industry is very important, since according to Fox et al. (1992) besides enabling a more accurate estimate of animal performance, estimates of the fractions of carbohydrates and proteins help increasing the efficiency of nutrient utilization.

In order to evaluate the final silage, new systems and methods for assessing foods for ruminant are being used to maximize the use of nutrients by the animals. The *Cornell Net Carbohydrate and Protein System* (CNCPS) is a system that takes into account the dynamics of ruminal fermentation and potential loss of nitrogen, such as ammonia, in the evaluation of food (SNIFFEN et al., 1992), aiming to adjust the ruminal digestion of carbohydrate and protein to take full advantage of microbial production, reduce the loss of nitrogen, and estimate the ruminal loss of nutrient (BALSALOBRE et al., 2003).

Given the above, this study aimed to determine the protein and carbohydrate fractionation of Piata palisadegrass silage of brans from biodiesel industry.

Material and methods

The experiment was performed in the Federal Institute of Goiás State, Campus Rio Verde, at 748 m altitude, 17° 48' south latitude and 50º 55' west longitude, from September 2010 to July 2011. The area of pasture used to produce the silage had 180 m^2.

The soil was classified as distroferric Red Latosol (Oxisol), with 530 g kg^{-1} clay; 250 g kg^{-1} silt and 220 g kg^{-1} sand. The chemical characteristics of the soil at the layer 0-20 cm, before planting were: pH in water: 5.6; Ca: 4.04 $cmol_c$ dm^{-3}; Mg: 2.0 $cmol_c$ dm^{-3}; Al: 0.0 $cmol_c$ dm^{-3}; Al+H: 6.6 $cmol_c$ dm^{-3}; K: 65 mg dm^{-3}; CTC: 7.05 $cmol_c$ dm^{-3}; P: 8.07 mg dm^{-3}; Cu: 3.7 mg dm^{-3}; Zn: 1.8 mg dm^{-3}; V: 48.4 %; M.O: 35.6 g kg^{-1}.

The area was prepared with harrowing followed by leveling. By the planting of forage it was applied 80 kg ha^{-1} P_2O_5, using the super triple phosphate. Then, the Piata palisadegrass was broadcast seeded with 9 kg viable pure seeds per hectare. The standardization cut was held at 40 days after planting, and the topdressing included 80 kg ha^{-1} nitrogen and 40 kg ha^{-1} potassium, as urea and potassium chloride, respectively.

The experimental design was the completely randomized with four replications in a 4 x 4 factorial scheme, being four brans from biodiesel industry (cotton, sunflower, soybean, canola) and four levels of inclusion (0, 5, 10, and 15%). The brans were obtained from mechanical extraction of oil, where the amount applied was based on the natural material of Piata palisadegrass.

For the ensilaging process, the Piata palisadegrass was harvested at 45 days after maintenance fertilization, at 20 cm from ground level, using backpack crush cutter. Afterwards, the forage was minced into 10-30 mm-particles, with a stationary shredder, and ground. Then, the material was homogenized with the brans, according to the different levels determined, and stored in PVC experimental silo, with 10cm diameter and 40 cm length.

The silage was compacted with iron pendulum and the silos were sealed with PVC caps and adhesive tape to preclude the entry of air. Immediately after, they were stored at room temperature and protected from rain and sunlight.

After 60 days of fermentation, the silos were opened, discarding the top and bottom portion of each. The central portion was homogenized and placed into plastic trays. About 1 kg was weighed and taken to a forced air oven at 55ºC for 96 hours to determine the pre-drying matter. Later, the samples were ground in a Willey type mill, with 1mm-sieve, to be analyzed.

Non-protein nitrogen (NPN), neutral and acid detergent insoluble nitrogen (NDIN and ADIN) were determined according to Licitra et al. (1996), and the soluble nitrogen (SN), according to Krishnamoorthy et al. (1983).

The protein fractionation was calculated by the CNCPS system (SNIFFEN et al., 1992). The protein was analyzed and calculated for the five fractions, A, B1, B2, B3 and C. The fraction A, made up by NPN compounds, was determined by the difference between total N and trichloroacetic acid (TCA) insoluble nitrogen with the formula: A (%Nt) = Nt - N1 / Nt x 100, where Nt = total nitrogen of the sample, and N1 = content of trichloroacetic acid insoluble nitrogen. The fraction B1 refers to soluble protein, rapidly degraded in the rumen, obtained by the difference between the borate phosphate buffer (TBF) insoluble nitrogen minus the NPN, by the formula: B1 (%Nt) = N1 - N2 / Nt x 100, where: N2 = borate phosphate buffer insoluble nitrogen. The fractions B2 and B3 consist of insoluble protein with intermediate-slow degradation rate in rumen, determined by the difference between the borate phosphate buffer insoluble nitrogen and NDIN, the NDIN minus the ADIN, respectively. The value of B2 is achieved with B2 (%Nt) = N2 - NIDN / Nt x 100 and the fraction B3, with B3 (% Nt) = NDIN - ADIN / Nt x 100. The fraction C is formed by insoluble protein indigestible in the rumen and intestine, and was determined by the content of residual nitrogen of the sample after treated with acid detergent and expressed in percentage of Nt of the sample.

The percentage of total carbohydrate (TC) was obtained by the equation (SNIFFEN et al., 1992): TC = 100 – (%CP + %EE + %ash); of fiber carbohydrate (FC) from the NDF corrected to the content of ash and protein (NDF_{CP}); of non-fiber carbohydrate (NFC), which correspond to fractions A+B1, through the difference between total carbohydrate and (NDF_{CP}); and of the fraction C, by the indigestible NDF after 144 hours *in situ* incubation (CABRAL et al., 2004). The fraction B2, which corresponds to the available fiber fraction, was obtained by the difference between (NDF_{CP}) and the fraction C.

Data were tested by an analysis of variance, considering as sources of variation the additives and levels, and interaction thereof. Mean values were compared by a Tukey's test at 5% probability, using the software SISVAR® (FERREIRA, 2011). The levels of additives were evaluated by a regression analysis, based on the value of the coefficient of determination, and from the equations were generated graphs using Sigma Plot.

Results and discussion

The fractions A, B1, B2, B3 and C were significantly influenced ($p < 0.05$) by the additives, inclusion levels and interaction between these factors (Tables 1 e 2).

The fraction A or non-protein nitrogen (NPN) increased linearly with increased levels of brans in the silage. For all the brans, the level of 15% was the most effective in increasing the fraction A. This is an outstanding result because this soluble fraction has rapid ruminal degradation owed the higher content of CP in the brans (EPIFANIO et al., 2014), improving thus the degradation rate. According to Russell et al. (1992), non-protein nitrogen sources are essential for the proper functioning of the rumen, since ruminal microorganisms fermenting structural carbohydrates use ammonia as a nitrogen source.

At level zero and 5%, the fraction A was similar between the additives. At the level 10 and 15%, the soybean meal had the highest values of fraction A, differing from cotton, sunflower and canola brans, with similar fractions. Therefore, the higher the increase in fraction A, the greater the need for carbohydrates of rapid degradation for a suitable synchrony of fermentation of carbohydrate and protein in the rumen (RUSSELL et al., 1992).

Andrade et al. (2010) evaluated the silage of elephant grass with cassava and cocoa brans and coffe husk, and observed a downward linear trend as increased the additive levels. According to these authors this was due to the low content of dry matter (18.7%) interfering with the availability of degradable protein.

Table 1. Protein fractionation of Piata palisadegrass with different levels of additives.

Additive	Level of Additive (%) 0	5	10	15	Equation	R^2
	Fraction A (%)					
Cotton	32.48 a	36.32 a	42.79 b	51.40 b	$Y = 31.2630 + 1.2646x^*$	0.97
Sunflower	31.88 a	36.49 a	41.71 b	50.99 b	$Y = 30.8850 + 1.2510x^*$	0.97
Soybean	33.68 a	35.43 a	43.27 a	54.59 a	$Y = 31.1570 + 1.4114x^*$	0.91
Canola	32.82 a	37.85 a	41.35 b	50.06 b	$Y = 32.2370 + 1.1044x^*$	0.96
CV (%)	3.23					
	Fraction B1 (%)					
Cotton	7.38 b	8.12 a	9.98 b	11.12 b	$Y = 7.1880 + 0.2616x^*$	0.97
Sunflower	8.48 ab	8.81 a	10.38 b	11.61 b	$Y = 8.1760 + 0.2192x^*$	0.94
Soybean	8.57 ab	9.07 a	11.07 a	12.00 a	$Y = 8.3340 + 0.2458x^*$	0.95
Canola	8.89 a	8.80 a	9.72 b	11.13 b	$Y = 8.8640 - 0.0722x + 0.0150x^{2*}$	0.99
CV (%)	8.23					
	Fraction B2 (%)					
Cotton	10.80 a	12.55 b	13.56 b	14.69 a	$Y = 10.9980 + 0.2536x^*$	0.98
Sunflower	11.87 a	14.87 a	16.47 a	15.94 a	$Y = 7.2070 + 1.8284x - 0.0840x^{2*}$	0.98
Soybean	12.07 a	13.42 a	14.96 ab	14.97 a	$Y = 11.9840 + 0.4058x - 0.0134x^{2*}$	0.97
Canola	11.16 a	12.99 b	15.57 a	14.62 a	$Y = 10.9460 + 0.6762x - 0.0278x^{2*}$	0.91
CV (%)	8.07					
	Fraction B3 (%)					
Cotton	16.26 a	15.36 a	10.26 ab	7.33 a	$Y = 17.0860 - 0.6378x^*$	0.94
Sunflower	15.52 a	13.25 a	10.17 c	7.90 a	$Y = 15.6010 - 0.5188x^{2*}$	0.99
Soybean	15.04 a	14.81 a	10.23 ab	7.29 a	$Y = 16.0170 - 0.5566x^*$	0.91
Canola	16.68 a	14.47 a	12.49 a	7.55 a	$Y = 17.2030 - 0.5874x^*$	0.94
CV (%)	9.93					
	Fraction C (%)					
Cotton	33.06 a	27.63 a	23.41 a	15.46 ab	$Y = 33.4430 - 1.1404x^{2*}$	0.98
Sunflower	32.24 a	26.58 b	21.23 b	13.52 b	$Y = 32.6190 - 1.2302x^{2*}$	0.99
Soybean	30.61 b	27.26 a	20.44 b	11.11 c	$Y = 32.1530 - 1.3064x^{2*}$	0.95
Canola	30.45 b	25.86 b	20.85 b	16.61 c	$Y = 33.4430 - 1.1404x^{2*}$	1.00
CV (%)	5.52					

Means followed by different letters, lower case in the columns (additive), are significantly different by Tukey's test ($p < 0.05$). *significant at 5% level.

Considering the fraction B1, a linear increase was observed for the brans of cotton, sunflower and soybean according to the addition in the silage, and a quadratic increase for canola meal, estimated the minimum point at the level of 12.4% (Table 1). The highest fractions B1 were obtained at 15% level for all brans, with increase of 3.74, 3.13, 3.43, and 2.24 percentage units compared to level zero, for cotton, sunflower, soybean and canola, respectively. Importantly, the contribution of 15% in the ensiling process increased the fraction B1, favoring the degradation in the rumen, since it can ensure a better synchrony of fermentation between carbohydrate and protein in the rumen, and consequently, favor the microbial growth, which results in better use of nutrients (PEREIRA et al., 2010). These results are relevant, once the fraction B1 is also considered the soluble fraction with rapid degradation in the rumen (SNIFFEN et al., 1992).

Comparing the additives, the fraction B1 was similar between the brans at the level of 5%. At zero level, a significant difference was found between the brans of cotton and canola. And at levels 10 and 15%, the soybean meal had the highest value of the fraction

B1. This result is correlated with the high content of CP of the soybean meal (42.0%).

Some authors reported the deficiency of the fraction B1 in the protein of tropical forage (RUSSELL et al., 1992; SNIFFEN et al., 1992), with values below 10% of total crude protein (BALSALOBRE et al., 2003). Nevertheless, with the addition of 15% of both brans, the fraction B1 was enhanced, with values higher than 11.12%.

On the silage of tifton-85, Pereira et al. (2007) verified a value of 2.97% for the fraction B1 for the control silage, while when added the waste from corn processing and corn meal, the fractions were 2.11 and 1.91%, respectively.

The fraction B1 + B2, by having a rapid degradation rate in the rumen in relation the fraction B3, tends to be extensively degraded in the rumen, contributing to meeting the requirements of nitrogen of the ruminal microorganism, but the rapid ruminal proteolysis of these fractions may lead to the accumulation of peptides and allow their loss to the intestine, once the use of peptides is limiting for protein degradation (SNIFFEN et al., 1992).

There was a linear increase of the fraction B2 for the cotton meal with the addition of the brans in the silage, being this increase more expressive at the 15% level. But, for the brans of sunflower, soybean, and canola, a quadratic increase was found with the maximum point at the levels of 0.8, 14.1, and 12.2%, respectively.

Among the brans within each level, observed in the Table 1, at the level zero and 15%, the fractions B2 were similar between the brans. At the 5% level, the sunflower and canola brans presented greater fractions B2 and at the level of 10%, only the cotton meal was different from the sunflower and canola brans.

In this way, Andrade et al. (2010) studied the elephant grass ensiled with different additives and verified that when added 30% of the levels, the silage with cassava meal presented the highest fraction B1 + B2 (45.6%), whereas the coffee husk had intermediate values (33.3%) and the cocoa meal achieved lower fractions B1 + B2 (30.0%).

The fraction B3 has a very slow degradation rate, once it is associated with the cell wall. This fraction is represented by extensive cell-wall-bound proteins, thus slowly degraded, and mainly digested in the guts (BALSALOBRE et al., 2003).

The inclusion of the brans promoted a linear reduction of the fraction B3 for all brans, whose reductions were estimated at 8.93, 7.62, 7.75, and 9.13 percentage units, when comparing the level zero with 15%, for the brans of cotton, sunflower, soybean and canola, respectively. These results are assigned to the lowest content of CP of Piata palisadegrass in relation to the brans thus (EPIFANIO et al., 2014), higher fractions B3 are achieved in the control, with a slower degradation.

As the fraction B3 is represented by cell-wall-bound proteins with slow degradation rate and mainly digested in the guts (CABRAL et al., 2004), it seems that without the addition of the brans in the Piata palisadegrass silage, the ruminal non-degraded protein increases, once greater values of B3 and sharp reduction of the fraction A were observed in the control silage.

In relation to the brans within each level, the fraction B3 was similar between the brans at the level zero, 5 and 15%. Only the level 10% was influenced, presenting a greater fraction B3 for the canola meal.

Pires et al. (2009) evaluated the fractionation of proteins of the elephant grass silage, and verified fractions B3 of 10.7, 11.6, 21.5, and 19.5% for the control, with addition of coffee husk, cocoa meal, and cassava meal, respectively.

The fraction C has linearly reduced for all used brans, as increased the levels of additives in the ensiling process, with a reduction of 17.6, 18.7, 19.5, and 13.8 percentage units, comparing the level zero with the level 15%, for the brans of cotton, sunflower, soybean and canola, respectively. This is a remarkable result because the fraction C corresponds to unavailable nitrogen and consists of protein and nitrogen compounds associated with lignin (SNIFFEN et al., 1992). Krishnamoorthy et al. (1983) reported that this fraction is not degraded by bacteria in the rumen and does not provide amino acids for the post-ruminal digestion. This shows that an expressive protein portion from silages is not used for microbial growth or even as a true protein source in the post-ruminal digestive tract.

Our findings are satisfactory considering the silage added with additives, since according to Sniffen et al. (1992), the increase in the fraction C is complicated by the formation of Maillard products caused by the heating inside the silo by the undesirable fermentation owing the high moisture content of forage. In this case, the decreased fraction C when added the levels, mainly at the 15% level, can be ascribed to the brans' quality, being considered good additive for ensiling process.

Carvalho et al. (2008) examined the protein fractionation of the elephant-grass ensiled with cocoa meal, and observed a quadratic behavior for the fraction C as a function of the inclusion levels, estimating the maximum value of 33.0% for the level of 19.6%.

Regarding the brans within each level, at the level zero, the cotton and sunflower brans presented similar values of the fraction C, differing from soybean and canola brans. At 5% level, the lowest fractions were detected for the sunflower and canola brans. At 10%, the cotton meal had the highest fraction, different from the other brans. And at the 15% level, the soybean meal was the most effective in reducing the fraction C, with a value of 11.1%.

By assessing the silage of elephant grass with cassava meal, coffee husk and cocoa meal, Andrade et al. (2010) observed a downward linear effect of including the cassava meal to the silage, with a reduction estimated at 0.13 percentage unit for every 1% of cassava meal added. Higher results were found in the present study, with contents varying between 11.11 and 16.61% when added 15% of soybean and canola brans, respectively.

When evaluated the fractionation of carbohydrate, in Table 2 is observed that with the addition of the levels studied there was a linear reducion in the content of total CHO for all brans, with an increase in levels in the silage (Table 2). This reduction can be related with higher content of CP and EE at the level of 15%. Sniffen et al. (1992) reported that higher levels of CP and EE can interfere with the estimation of the content of total CHO, causing its reduction, as a function of the high levels of these fractions.

Table 2. Carbohydrate fractionation of the Piata palisadegrass silage with different levels of additives.

Additive	Level of Additive (%)				Equation	R^2
	0	5	10	15		
	Total CHO (%)					
Cotton	79.4 a	74.3 b	70.9 b	67.7 b	Y = 78.8810 - 0.7688x*	0.98
Sunflower	78.2 a	73.1 b	71.8 b	69.7 b	Y = 77.2590 - 0.5342x*	0.91
Soybean	78.6 a	73.0 b	68.1 b	66.5 b	Y = 77.7940 - 0.8272x*	0.95
Canola	80.6 a	78.6 a	78.6 a	70.2 a	Y = 81.6480 - 0.6274x*	0.87
CV (%)	3.03					
	Fraction A + B1 (%)					
Cotton	25.8 a	35.3 ab	40.0 ab	44.7 ab	Y = 27.2400 + 1.2280x*	0.96
Sunflower	26.9 a	33.5 b	39.2 b	45.1 ab	Y = 27.1300 + 1.2060x*	0.99
Soybean	26.7 a	37.3 a	43.1 a	47.8 a	Y = 28.3600 + 1.3820x*	0.96
Canola	26.5 a	34.7ab	39.3 b	43.3 b	Y = 27.7000 + 1.1000x*	0.96
CV (%)	4.88					
	Fraction B2 (%)					
Cotton	44.0 a	42.8 a	40.0 a	37.4 a	Y = 44.4400 - 0.4520x*	0.97
Sunflower	44.4 a	42.7 a	40.1 a	38.8 a	Y = 44.4100 - 0.3880x*	0.98
Soybean	45.0 a	40.7 a	38.9 b	38.5 a	Y=44.9450-1.0110x +0.0390x2*	0.99
Canola	45.6 a	43.1 a	40.5 a	38.4 a	Y = 45.5300 - 0.4840x*	0.99
CV (%)	3.26					
	Fraction C (%)					
Cotton	30.5 a	21.8 a	20.0 a	17.8 a	Y=30.1350-1.7730x + 0.0650x2*	0.97
Sunflower	28.7 a	23.7 a	20.6 a	15.8 ab	Y = 28.4700 - 0.8360x*	0.99
Soybean	28.5 a	21.8 a	18.0 b	13.6 b	Y = 27.7500 - 0.9700x*	0.98
Canola	28.0 a	22.1 a	20.3 a	18.1 a	Y=27.7750-1.1850x + 0.0370x2*	0.98
CV (%)	7.98					

Means followed by different letters, lower case in the columns (additive), are significantly different by Tukey's test ($p < 0.05$). *significant at 5% level.

Similar results were registered by Carvalho et al. (2007) who evaluated the elephant grass silage with cocoa meal and found a linear decrease in the content of total CHO, decreasing 0.22 percentage at each unit meal added. The same was observed by Andrade et al. (2010), when analyzing the silage of elephant grass and observed a reduction of 9.21% in the content of CHO of the cocoa meal compared to other additives.

At zero level, total CHO contents were similar between the brans. At levels 5, 10 and 15%, cotton, sunflower and soybean brans had similar results, differing from the canola meal, which showed the highest levels of total CHO.

Considering the carbohydrate fraction A + B1, Table 2 shows that the addition of increasing levels linearly increased for all brans studied. The greater fractions A + B1 were obtained at the level of 15% for all brans studied, with increase of 1.26, 1.21, 1.40, and 1.12 percentage units for each 1% of additives added to the Piata palisadegrass silage, compared with the zero level for cotton, sunflower, soybean and canola brans, respectively. These results are relevant because the fraction A + B1 are food sources for increased content of rumen microorganisms and the synchrony between the rate of digestion of proteins and carbohydrates, can have important effects on the end products of fermentation and on animal production, since the fraction A + B1 represents the soluble fraction with rapid ruminal degradation (SNIFFEN et al., 1992).

However, Carvalho et al. (2007) verified that food with high fraction A+B1 is good sources of energy to increase rumen microorganisms that use non-fiber carbohydrates. Therefore, the higher the elevation of values of the fraction A + B1, the greater the need to supply rapidly degradable carbohydrates for the proper synchrony between fermentation of carbohydrates and protein in the rumen, with the purpose of synchronizing the release of energy and nitrogen (RUSSELL et al., 1992).

Increased fraction A + B1 with additive in the silage was also recorded by Andrade et al. (2010), who found that the addition of cassava and cocoa meal in elephant grass silage promoted a linear increase in the fraction A + B1 of carbohydrates, with increases of 1.5 and 0.8 percentage unit every 1% addition of these additives.

When comparing the additives within each level, it is observed that at level zero the fraction A + B1 was similar between the brans. At the level 5 and 10%, a significant difference was only between sunflower and soybean brans. And at the level 15% the soybean meal was different from the canola meal, with higher fraction A + B1. This result is due to the lower content of fiber fraction (NDF:

18.07%; ADF: 10.24% and lignin: 3.78%) and high content of crude protein (42.0%) in the soybean meal.

In agreement with Sniffen et al. (1992), the fraction A is made up of sugars and the fraction B1, of starch, pectin and glucans. Pectin, although located in the cell wall, can be included in the fraction comprising cellular content since it meets the requirements of non-starch polysaccharide and is rapidly digested in the rumen (VAN SOEST et al., 1991).

For the fraction B2, a linear reduction (Table 2) was verified for cotton, sunflower and canola brans with increasing levels of additives in the silage. Nevertheless, for the soybean meal a quadratic reduction was detected, with minimum values estimated in this fraction of 38.39% for the level 12.96% of this additive.

This reduction for all brans can be explained by lower contents of NDF in oleaginous brans in relation to Piata palisadegrass (68.35), which explains the lower content of this fraction when brans were added to the silage, and according to Carvalho et al. (2007) the NDF content influences the results of the fraction B2.

Besides that, the decrease of the fraction B2 coincided with an increase of fractions A+B1, which reinforces the hypothesis of natural cell wall decomposition caused by fermentation in the silo, which contributes to increase the fractions of high availability (BARCELOS et al., 2001).

When compared the brans within each level, it is observed in Table 2, at zero, 5 and 15%, fractions B2 were similar between the brans. At the level 10% the soybean meal showed greater fraction B2, thus differing from cotton, sunflower and canola brans.

According to Oliveira et al. (2012), forage foods usually have higher NDF content and therefore, have higher values of the fraction B2 of carbohydrates. This component provides energy slowly in the rumen and can affect the efficiency of microbial synthesis and animal performance. In such cases, the forage must be supplemented with energy sources readily available in the rumen, when not having protein limitations in quantity and quality. In this sense, the oleaginous brans used in this study proved to be effective in reducing this fraction, which sets them as an alternative source of potentially digestible carbohydrates.

Pires et al. (2009) examined the fractionation of carbohydrates in silages of elephant grass with addition of by-products, and verified that the control silage showed the highest fraction B2 (68.9%), followed by silages with coffee husks (58.7%), cassava meal (54.4%) and cocoa meal (50.9%). The authors reported that the highest value of hemicellulose in elephant grass before ensiling resulted in a higher fraction B2 in the control silage. This result was similar to the present study, when compared the control silage of Piata palisadegrass in relation to the reduction of this fraction with addition of brans at the time of ensiling.

There was a linear decrease in the fraction C with increased levels of additives for sunflower and soybean brans, the decrease was estimated at 0.86 and 0.99 percentage unit every 1% of meal added in the silage, respectively. For the cotton and canola brans there was a quadratic reduction, with minimum values estimated at 18.04% and 8.29% of this fraction for the levels of 13.64 and 15.01% with the inclusion of these additives, respectively.

It is possible that the reduction of the fraction C with the addition of energetic oleaginous brans is due to the low lignin content of these additives (cotton: 4.39%; sunflower: 4.18%, soybean: 3.78% and canola 4.16%) compared with the Piata palisadegrass (4.91%).

Regarding the brans within each level, in Table 2 is verified that the at zero and 5% level the brans showed similar fractions C. In the level of 10% the smallest fraction C was obtained for soybean meal. While at the level of 15%, canola and cotton brans presented the highest fraction C, differing from the soybean meal, which had the lowest fraction C. Jobim et al. (2010) reported that soybean can be an alternative for use in silage and presents indisputable nutritional value because it contains high protein and energy. This result demonstrates that soybean meal can be a great option of additive to silages of tropical grasses.

Opposite result to the present study were observed by Carvalho et al. (2007) that registered a linear increase in the fraction C, with increased by 0.2 percentage units for each unit of cocoa meal added to elephant grass silage.

Conclusion

Brans from biodiesel industry are good sources of additives for ensiling Piata palisadegrass, by considerably improving fractions of proteins and carbohydrates. However, the soybean meal was more efficient due to the higher carbohydrate and protein fractions A + B1 and C fractions smaller, compared with other additives. It is recommended the addition of 15% of brans for providing better nutritional value of silage.

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