Nutritional assessment of waste of cassava starch extraction dried in cattle feed

Avaliação nutricional do resíduo da extração do amido da mandioca seco na alimentação de bovinos

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Abstract

This study aimed to evaluate the digestive power of waste of cassava starch extraction dried (WCSEd) and corn, in addition to determining the appropriate level of WCSEd to replace corn in the diet of cattle. Studies to evaluate the *in vitro* digestibility and *in situ* degradability were performed. The study used four cattle with rumen cannula, individually fed with diets containing increasing levels (0, 33, 66 and 100%) of WCSEd to replace corn, to evaluate the dry matter and nutrient intake and digestibility, pH and ammonia concentration of rumen fluid. The WCSEd showed differences in the *in vitro* digestibility of DM, OM and NDF ($P < 0.05$) compared to corn, but did not change the NDT and *in situ* degradability. As for *in vivo* reviews, the DM and nutrient intake was influenced by treatments in decreasing order, resulting in changes in the digestibility of DM, OM and NDT of diet, and a decreased concentration of N-NH$_3$, but the pH was not affected. The residue from the extraction of cassava starch showed lower *in vitro* digestibility; however, ruminal degradability did not differ from corn. Their use in ruminant feed reduces the intake and degradation of feed, but improves the use of N-NH$_3$ in the rumen.
Key words: Degradability. Digestibility. Intake. Rumen parameters.

Resumo

Objetivou-se avaliar a degradabilidade potencial do REAMs e do milho e de determinar o nível adequado de REAMs, em substituição ao milho na ração de bovinos. Foram realizados estudos para avaliação da digestibilidade *in vitro* e degradabilidade *in situ*. Utilizou-se quatro bois castrados, canulados no rúmen, alimentados individualmente, com dietas contendo níveis crescentes (0%, 33%, 66% e 100%) de REAMs em substituição ao milho, para avaliação da ingestão e digestibilidade da matéria seca e nutrientes, avaliação do pH e nitrogênio amoniacal do líquido ruminal. O REAMs apresentou diferenças quanto à digestibilidade *in vitro* da MS, MO e FDN ($P < 0,05$), quando comparado ao milho, mas não apresentou alteração quanto ao NDT e a degradabilidade *in situ*. Quanto às avaliações *in vivo* a ingestão de MS e dos nutrientes foi influenciada de forma decrescente pelos tratamentos, resultando em redução na digestibilidade da MS, MO e no NDT das dietas *in vivo*, ocorrendo redução na concentração de

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N-NH3, mas o pH não foi influenciado. O resíduo da extração do amido da mandioca apresentou menor digestibilidade *in vitro* porem não diferiu do milho quanto a degradabilidade ruminal. Sua utilização na alimentação de ruminantes reduz a ingestão e degradação da ração, porém melhora o aproveitamento do N-NH3 no rúmen.

Palavras-chave: Degradabilidade. Digestibilidade. Ingestão. Parâmetros ruminais**.**

Introduction

The alternative foods may serve as a nutrient source for ruminants. However, they require frequent analysis regarding the nutritional composition (PEREIRA et al., 2008). It is important to know the characteristics of the feed, allowing the establishment of criteria for inclusion in animal feed (SOUZA et al., 2012).

The coproducts of cassava processing stand out as cheaper energy substitutes for feed formulation for ruminants (ZAMBOM et al., 2015; FERNANDES et al., 2015). This also enables the reduction of agribusiness waste, which would be discarded without treatment, resulting in damage to the environment (MELO et al., 2011).

The waste of cassava starch extraction dried (WCSEd) is obtained from the process used to extract starch from cassava by wetting and subsequently drying the co-product of this processing. According to Jasko et al. (2011), the moisture content of cassava bagasse exiting the process is often greater than 80%, making it difficult to transport and store, as the material is highly perishable. However, drying this by-product can facilitate its use.

Although ruminants have the ruminal environment which enables the efficient use of different foods, this same environment can be significantly affected by changes in diet. Therefore, the adoption of practices such as the nutritional characterization of foods can be a tool to enable the use of coproducts in animal nutrition. As a result, the aim of this study was to assess the potential of WCSEd and the degradability of corn and to determine the appropriate level of WCSEd as a substitute for corn in the diet of cattle.

Material and Methods

The experiment was conducted at the Universidade Estadual do Oeste do Paraná - UNIOESTE. The different foods used in the experiment were obtained 2013, sampled monthly for four months; corn (Dow 2B707) was produced at the UNIOESTE. The WCSEd was obtained from cassava processing industry, located in the city of Altônia-PR. The animal testing protocol was approved by the Ethics Committee on the use of Animals of UNIOESTE (49/13 Protocol).

The experimental design adopted for the evaluation of food, was completely randomized, with two treatments (WCSEd and ground grain corn) and four repetitions per treatment. Food samples to be evaluated were dried in an oven with forced air circulation to $55 \pm 5°C$ for 72 hours and ground using a mill with a 1 mm diameter sieve.

The levels of dry matter (DM), mineral matter (MM), crude protein (CP) and ether extract (EE) were determined according to methods described by AOAC (1990) and the determination of neutral detergent fiber (NDF) and acid detergent fiber (FDA) was performed according to Van Soest et al. (1991) (Table 1).

The carbohydrates were fractionated in A, B1, B2, and C as described by Sniffen et al. (1992). The percentage of total carbohydrates (TC) was obtained according to Sniffen et al. (1992). Fibrous carbohydrates (FC) were obtained from the NDF corrected to ashes and proteins (NDFcp); the NFC, corresponding to fractions A+B1, indicated the difference between the TC and the NDFcp (HALL, 2003). Fraction B2 was obtained by the difference between the NDFcp and the C fraction, determined by the NDF indigestible (CABRAL et al., 2004),

using 240 hours of *in situ* incubation. The crude protein was divided into five fractions: A, B1, B2, B3 and C, according to the method proposed by Licitra et al. (1996) (Table 1).

Table 1. Chemical composition of waste of cassava starch extraction dried (WCSEd), grain corn, soybean meal and corn silage.

Composition	Foods			
	WCSEd	Corn	Soybean Meal	Corn Silage
Dry Mater (g kg^{-1})	869.07	880.00	886.68	307.41
Organic Mater (g kg^{-1} de DM)	985.60	985.74	934.04	956.38
Crude Protein (g kg^{-1} de DM)[1]	14.91	95.73	514.83	81.49
A (g kg^{-1} de DM)	2.99	18.68	65.31	44.67
B1 (g kg^{-1} de DM)	1.06	3.49	22.44	6.12
B2 (g kg^{-1} de DM)	4.00	65.38	392.98	17.93
B3 (g kg^{-1} de DM)	2.35	1.90	31.92	3.89
C (g kg^{-1} de DM)	4.51	6.28	2.18	8.88
Ether Extract (g kg^{-1} de DM)	03.61	06.03	06.41	23.86
NDN (g kg^{-1} de DM)[2]	393.75	124.49	134.09	494.11
ADF (g kg^{-1} de DM)[3]	216.59	46.94	79.89	284.55
NFC (g kg^{-1} de DM)[4]	573.89	730.42	263.25	343.81
Total Carbohydrates (g kg^{-1} de DM)[5]	967.64	854.91	397.34	837.92
A+B1(g kg^{-1} de DM)	586.69	763.71	304.93	369.22
B2 (g kg^{-1} de DM)	303.32	76.32	71.55	294.86
C (g kg^{-1} de DM)	77.63	14.88	20.86	173.84

[1] Crude Protein Fractions, A: Soluble Fraction, B1: Fraction of rapid degradation, B2: Fraction of intermediate degradation, B3: Fraction of slow degradation, and C: indigestible Fraction; [2]NDF: Neutral Detergent Fiber; [3]ADF: Acid Detergent Fiber; [4]CNF: Non-fibrous carbohydrates; [5]TC: Total Carbohydrates Fractions, A + B1: Fraction of soluble carbohydrates and rapid degradable, B2: Potentially degradable Carbohydrates, C: Fraction of non-degradable carbohydrates.

Determination of *in vitro* dry matter digestibility (IVDMD) was performed using the technique described by Tilley and Terry (1963), adapted to the rumen, as described by Holden (1999). For the collection of ruminal fluid, we used three cattle, castrated males, fitted with a ruminal cannula. Then, 0.50 g of each food was weighed and placed in F57 filters (ANKON®). Two filters of each sample were packed into each jar, containing rumen fluid collected from different animals, plus buffer. The material was incubated for 48 hours with constant rotation at 39°C. At the end of this period, HCl-Pepsin (1:10,000) solution was added, and the material was incubated for a further 24 hours. After incubation, DM and OM were determined.

The IVDMD and *in vitro* digestibility of organic matter (IVDOM) were calculated by calculating the difference between the amount incubated and the residue after incubation. Determination of *in vitro* digestibility of NDF (IVDNDF) adopted the methodology described by Goering and Van Soest (1975), by removing the filters with 48 hours of incubation, subjecting them to NSF analysis. The IVDNDF was calculated by the difference between the NDF incubated food and the NDF of the residue of incubation. IVDOM values were used to estimate the TDN, as described by Kunkle and Bates (1998).

For the realization of *in situ* degradability of DM and OM, samples of WCSEd and corn were milled

with a 2 mm diameter sieve. For this, 7 grams of dry pre food was placed in each bag of nylon (10 x 20 cm), providing 10 to 20 mg of food per cm^2 of useful area of the bag (NOCEK, 1988); this was performed in triplicate for each incubation time and per animal. Three rumen cannulated cattle were used, with an average body weight of 533 ± 91.5 kg, consuming $1.71 \pm 0.05\%$ of BW. Incubation times were: 0, 2, 4, 8, 16, 24 and 48 hours (NRC, 2001); the average corn residue for these incubation times was 5.04 ± 0.1, 4.33 ± 0.3, 3.88 ± 0.3, 2.97 ± 0.4, 2.34 ± 0.6, $2.14 \pm 1.66 \pm 0.1$ and 0.6, respectively, and the WCSEd was 5.14 ± 0.2, 3.92 ± 0.3, 2.83 ± 0.3, 1.94 ± 0.4, 1.55 ± 0.5, $1.33 \pm 0.95 \pm 0.1$ and 0.4, respectively.

After incubation *in situ*, the bags went through the washing machine with constant renewal of the water until clear water appeared. After washing, the bags were dried in an oven with forced air ventilation to $55 \pm 5°C$ for 72 hours. The percentage degradation of DM and OM at each time was calculated by the amount that was left in the bag after incubation in the rumen. The non-linear parameters a, b and c were estimated via statistical analysis and genetic System, program (SAEG), developed by Universidade Federal de Viçosa (UFV, 2000). The effective degradability of dry matter (EDDM) and organic matter (EDOM) in the rumen was calculated using the equation described by Orskov and McDonald (1979), whereas the rate of passage of solids in the rumen of 2, 5 and 8%/h was calculated as suggested by ARC (1984) for low, medium and high rates of food intake. The data were subjected to analysis of variance and the differences were tested by Student's t test to 5% probability using SAEG (UFV, 2000).

For *in vivo* assessments, four male bovines were used, which were Jersey breed, castrated, with a cannulated rumen, and an average body weight of 533 ± 91.5 kg. The animals were distributed in the experimental design in Latin square (4 x 4) with four treatments and four experimental periods of 21 days each, using 14 days for adaptation to diet and seven for data collection, making a total of 84 days. The treatments consisted of levels of WCSEd (0%, 33%, 66% and 100%) instead of corn.

The diet was composed of 50% corn silage as a forage source, and 50% concentrated feed (fine ground corn, WCSEd, soybean meal, bicalcium phosphate and mineral supplement), formulated according to the recommendations of the NRC (1996) to meet the requirements of the animals in maintenance, providing 2% of body weight (Table 2).

The animals remained confined in stalls, with an individual trough for the control of dry matter intake. The feeding was carried out twice a day, with 70% of the total daily DM offered at 6:30 h and 30% at 16:30 h. During the seven days of each experimental period, the leftovers for each animal were weighed, and along with the samples of feed, were put in a freezer at -20°C.

For determination of the digestibility of dry matter and nutrients, from the 15th to the 20th day, the fecal samples were collected directly in the rectal ampulla at 8:00, 10:00, 12:00, 14:00, 16:00 and 18:00 h every day. Fecal excretion estimates were obtained, using NDF indigestible (NDFi) as an internal indicator, as proposed by Waller et al. (1980). The NDFi was estimated by incubation in the rumen of the F57 ANKOM® filters Technology Corporation, for 240 hours (LIPPKE et al., 1986), with samples of food, leftovers and feces assessed by NDF analysis.

Table 2. Ingredients and chemical composition of the rations, containing waste of cassava starch extraction dried (WCSEd) replacing the ground corn.

Ingredients	Replacement levels			
	0%	33%	66%	100%
Corn silage (g kg⁻¹)	500.00	500.00	500.00	500.00
WCSEd (g kg⁻¹)	0.00	119.13	226.96	320.07
Corn (g kg⁻¹)	376.22	237.76	109.96	0.00
Soybean Meal (g kg⁻¹)	110.94	131.17	150.52	166.55
Mineral Supplement[1] (g kg⁻¹)	11.27	9.02	8.96	8.92
Dicalcium Phosphate (g kg⁻¹)	1.57	2.93	3.58	4.46
Nutrients				
Dry Matter (g kg⁻¹)	593.03	593.60	593.49	593.41
Organic Matter (g kg⁻¹ of DM)	952.32	950.11	947.00	946.83
Crude Protein (g kg⁻¹ of DM)	141.24	149.83	158.28	150.19
Ether Extract (g kg⁻¹ of DM)	15.78	14.87	14.58	14.33
Total Carbohydrates (g kg⁻¹ of DM)	791.94	794.46	792.14	796.68
NDF[2] (g kg⁻¹ of DM)	325.05	343.24	365.44	390.20
ADF[3] (g kg⁻¹ of DM)	183.72	199.00	209.64	225.85
TDN[4] estimated (g kg⁻¹ of DM)	774.50	751.10	729.70	710.90

[1]Composição Chemistry (kg-¹ of product): Ca - 260 g, P - 40 g, Co - 13 mg, Mg - 15 g, Mn – 1,100 mg, Zn – 3,000 mg, Se – 20 mg, I - 40 mg, S - 12 g, F – 170 mg e F - 400 mg (commercial product); [2]NDF: Neutral Detergent Fiber; [3]ADF: Acid Detergent Fiber; [4]TDN: Total Digestible Nutrients (Estimed by: TND= OM (%) /100 [26,8 + 0,595 (IVDOM (%))]).

Samples of food, leftovers and feces were analyzed as to the levels of DM, ash, EE, CP, NDF, ADF, OM and TC. The TDN was estimated according to the equations described by Sniffen et al. (1992).

For the determination of pH and ammonia nitrogen (N- NH$_3$), rumen fluid collection was performed on the 21st day of each experimental period, via ruminal cannula, at the following times: 0, 2, 4, 6 and 8 hours after feeding in the morning. Immediately after collecting, the samples were filtered in cotton fabric and proceeded to the measurement of the pH, using a digital potentiometer. A rate of 50 mL was added to 1 ml of sulfuric acid (1:1) and frozen for the later determination of N-NH$_3$, as described by Fenner (1965).

For the values for ruminal parameters, plots subdivided by time analysis were used. For the variables concerning the intake of DM and nutrients, as well as *in vivo* digestibility, data were interpreted by analysis of variance using the SAEG (UFV,

2000), and submitted to polynomial regression, considering the levels of WCSEd (0%, 33%, 66% or 100%) at the 5% level of probability.

Results and Discussion

On *in vitro* digestibility of DM, OM, and NDF, the grain maize has higher digestibility (Table 3), closer to the values observed by Hashimoto et al. (2007), who reported 95.38% for IVDMD values. This digestibility, as well as the IVDOM, is consistent with the fractionation of carbohydrates and nitrogen (Table 1); it should be noted that a small amount matches fraction C, which is indigestible. The IVDMD of WCSEd was 88.92%, differing statistically from corn, which is admittedly a high digestibility food, and is one of the most frequently used energy supplements in animal feed (RIBEIRO FILHO et al., 2012); however, it still has a high value of IVDMD, because it is a residue of the agro-industry.

The NDF digestibility showed significant differences between food items tested, the grain maize showed a higher percentage of degradation of the NDF in comparison to the WCSEd (P = 0.047). This can be explained by variation in the fractionation of carbohydrate (Table 1), where it can be observed that the corn showed a lower quantity of fraction B2 (8.93%) compared to WCSEd (31.35%). It can be observed that despite the high content of NDF and ADF and the fractionation of carbohydrate in WCSEd (Table 1), this has the potential to be degraded in the rumen, and be used as an energy source in feed for ruminants, even showing a lower digestibility of corn. This high content of NDF and ADF is due to the extraction of starch during processing, resulting in concentration of the fibrous fraction of cassava (FELIPE et al., 2013). The WCSEd TDN showed no significant differences when compared to the grain corn, demonstrating its potential use in feeds for ruminants in place of maize.

Table 3. In vitro digestibility and degradability in situ waste of cassava starch extraction dried (WCSEd) and corn grain.

	WCSEd	Corn	SE[9]	P *value*
	in vitro Digestibility			
DM[1] %	88.92	93.64	1.552	0.003
OM[2] %	90.93	95.92	2.447	0.028
NDF[3] %	81.52	84.88	1.219	0.047
TDN[4] %	80.47	82.86	1.545	0.845
	in situ DM Degradability			
a[5]	24.145	24.684	1.059	0.831
b[6]	70.066	81.602	5.096	0.306
c[7]	0.146	0.067	0.026	0.131
ED[8] (2%)	84.782	83.929	0.602	0.541
ED (5%)	74.890	67.712	2.273	0.117
ED (8%)	67.929	58.738	2.905	0.116
	in situ OM Degradability			
a[5]	24.293	24.186	1.030	0.966
b[6]	69.511	82.735	5.367	0.257
c[7]	0.150	0.066	0.026	0.114
ED[8] (2%)	84.715	84.111	0.630	0.684
ED (5%)	75.074	67.635	2.358	0.117
ED (8%)	68.230	58.542	3.018	0.108

Values in the same row, followed by letters differ by analysis of variance at 5% of significance.
[1]DM: Dry Matter; [2]OM: Organic Matter; [3]NDF: Neutral Detergent Fiber; [4]TDN: Total Digestible Nutrients; [5]A: Fraction of rapid degradation; [6]B: Potentially degradable fraction; [7]C: Constant rate of degradation of fraction B; [8]ED: Effective Degradability in different rates of passage (2, 5 and 8%); [9]SE: Standard Error.

The parameters 'a', 'b' and 'c' of DM and OM and the DMDEG and OMDEG, for rates of 2%, 5% and 8%, did not present significant differences between WCSEd and corn (Table 3), indicating that WCSEd can be an alternative to the use of corn in feed for ruminants, as it is as efficient as corn in the supply of energy to the ruminal microorganisms.

The WCSEd presented a fraction that was 24.15% lower than that observed by Martins et al. (1999), who assessed the degradability of the

MS of the zest of cassava, obtaining a result of 55.6%. These differences are due to the higher starch content, present in the cassava zest, once the WCSEd is subjected to the starch extraction process. However, the values of DMDEG in 2%, 5% and 8% obtained in this study were similar to those seen by the same authors: 81.9%, 75.0% and 71.4%, respectively.

For DMDEG, values higher than those observed by Cação et al. (2012) were obtained, of 66.0%, 50.9% and 43.4% for the same rates of passage. With increased passage rate for the reduction of degradation of both food and corn there is increased susceptibility to degradation, with an increased rate of passage, as a function of the WCSEd presenting a numerically higher degradation rate than corn.

The WCSEd and maize did not show any differences (P ≥ 0.05) for the OMDEG. For corn, the values obtained were higher than those observed by Fortaleza et al. (2009), which were 51.81% and 46.84% and the rates were 5% and 8%.

Dry matter intake was influenced in descending order, by increasing the level of WCSEd in place of maize (Table 4). These results corroborate with those presented by Fernandes et al. (2015), in which cows fed with corn-based animal feed showed a higher intake of 10.27% compared to those that were fed with rations based on WCSEd. The reduction of intake may be associated with increased levels of NDF in diet, since the period for feeding the animals was limited to 8 hours a day, increasing the effect of NDF on ingestion (SILVA, 2011).

Table 4. Daily intake and apparent digestibility of dry matter and nutrients of cattle, receiving diets containing waste of cassava starch extraction dried (WCSEd) replacing the feed corn.

	Replacement levels				Regression Equation	SE[16]	P *value*	
	0%	33%	66%	100%			L	Q
DMI[1] (kg dia^{-1})	9.75	9.40	9.45	8.98	1	0.426	0.0177	0.7338
DMI (%PV)	1.76	1.69	1.76	1.65	$\hat{Y}$ =1.714	0.030	0.2151	0.6355
OMI[2] (kg dia^{-1})	9.28	8.93	8.94	8.50	2	0.406	0.0146	0.7817
CPI[3] (kg dia^{-1})	1.42	1.48	1.55	1.39	3	0.067	0.9758	0.0065
EEI[4] (kg dia^{-1})	0.27	0.23	0.21	0.18	4	0.022	0.0048	0.6766
TCI[5] (kg dia^{-1})	7.67	7.43	7.44	7.15	5	0.331	0.0278	0.8132
NDFI[6] (kg dia^{-1})	3.06	2.98	3.28	3.37	6	0.153	0.0495	0.4882
ADFI[7] (kg dia^{-1})	1.74	1.81	1.90	1.99	7	0.096	0.0013	0.8749
DMD[8] (%)	69.24	68.01	66.91	59.28	8	1.346	0.0288	0.2398
OMD[9] (%)	73.07	72.52	71.58	64.94	9	1.219	0.0320	0.1907
CPD[10] (%)	70.60	71.43	71.47	61.66	$\hat{Y}$= 68.789	1.552	0.1107	0.1517
EED[11] (%)	79.72	74.51	76.88	70.26	$\hat{Y}$= 75.342	1.681	0.0780	0.8073
TCD[12] (%)	73.55	73.43	72.50	66.50	12	1.150	0.0383	0.1710
NDFD[13] (%)	48.72	42.02	49.33	38.09	$\hat{Y}$= 44.541	2.171	0.4047	0.4321
ADFD[14] (%)	43.41	45.95	52.49	41.38	$\hat{Y}$= 45.806	2.309	0.2225	0.3264
TDN[15] (%)	73.05	73.33	72.73	65.79	15	1.1783	0.0494	0.1306

[1,2]DMI: Dry Matter Intake; [2]OMI: Organic Matter Intake; [3]CPI: Crude Protein Intake; [4]EEI: Ether Extract Intake; [5]TCI: Total Carbohydrate Intake; [6]NDFI: Neutral Detergent Fiber Intake; [7]ADFI: Acid Detergent Fiber Intake; [8]DMD: Dry Matter Digestibility; [9]OMD: Organic Matter Digestibility; [10]CPD: Crude Protein Digestibility; [11]EED: Ether Extract Digestibility; [12]TCD: Total Carbohydrate Digestibility; [13]NDFD: Neutral Detergent Fiber Digestibility; [14]ADFD: Acid Detergent Fiber Digestibility; [15]TDN: Total Digestible Nutrients; [16]SE: Standard Error.

[1]$\hat{Y}$ = 9.72737-0.00672802x (R^2 = 0.85); [2]$\hat{Y}$ = 9.25919-0.00700936x (R^2 = 0.89); [3]$\hat{Y}$ = 1.40716+0.00487148x-0.0000487491x^2 (R^2 = 0.79); [4]$\hat{Y}$ = 0.261268-0.000793626x (R^2 = 0.98); [5]$\hat{Y}$ = 7.65297-0.00465462x (R^2 = 0.88);
[6]$\hat{Y}$ = 2.98694+0.00373408 (R^2 = 0.76); [7]$\hat{Y}$=1.73492+0.0024833x (R^2=0.80); [8] $\hat{Y}$ = 70.5044-0.0933549x (R^2 = 0.80); [9] $\hat{Y}$ = 74.3284-0.0764213x (R^2 = 0.76); [12]$\hat{Y}$ = 71.49586 - 0.06662044x (R^2 = 0.73); [15]$\hat{Y}$= 74.5911-0.0676469 (R^2= 0.64).

The DM intake as a percentage of BW was not influenced by diet, corroborating with the effects observed by Fernandes et al. (2015), using the wet residue of cassava in place of maize, in the feeding of lactating cows. The animals showed no weight gain throughout the experiment.

The intake of OM and EE decreased linearly with increasing substitution of corn for WCSEd. This variation is due to the variation observed for the intake of DM. In the ingestion of CP, quadratic variation was observed, while for NDF and ADF, an increase was observed (P ≤ 0.05) as a result of the levels of these nutrients in WCSEd, in response to increasing levels of WCSEd in the diet (Table 2).
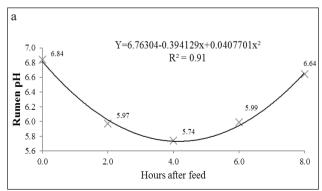
The digestibility coefficients of DM, OM and TC, as well as TDN, were influenced (P ≤ 0.05) by an increase in WCSEd in place of maize. However, the other nutrients were not influenced by the treatments (P ≥ 0.05). There was a reduction in the coefficient of digestibility of DM, and, consequently, reduced digestibility coefficient of OM and TC. The values observed in this study are similar to those obtained in a study 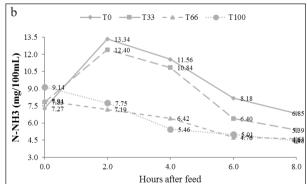evaluating the substitution of corn for wet residue of cassava (0%, 25%, 50%, 75% and 100%) in the diet of lactating cows (ZAMBOM et al., 2015), obtaining mean values of 65.42% for IVDMD.

In this study, an increase in the content of NDF and ADF in feed (Table 2) was observed due to the greater concentration of these nutrients in WCSEd, and lower digestibility of NDF from WCSED in comparison to corn (Table 3) which may have influenced the reduction of digestibilities of DM and OM, causing a decrease in TDN of the feed with the increased levels of replacement of WCSEd, since TDN is influenced by DM and digestibility of OM and reduces with the increase in levels of NDF (BERCHIELLI et al., 2011).

No difference (P ≥ 0.05) between the NDF digestibility in experimental rations was obtained, corroborating the absence of ruminal pH change between treatments (Figure 1). According to Kozloski (2016), NDF digestibility can be influenced by changes in rumen pH, reducing the grip to fiber, and modification of microbial metabolism, when there is an excessive reduction in the rumen pH.

Figure 1. Concentration of (a) pH and (b) ammonia nitrogen (NH3-N) in the rumen liquid of bovine animals receiving diets containing waste of cassava starch extraction dried (WCSEd) replacing the feed corn during the hours after feeding.

◆ T0: $\hat{Y} = 8.30059+2.0399x-0.292536x^2$ ($R^2 = 0.70$); ◙ T33: $\hat{Y} = 8.7399+1.46432x-0.2511x^2$ ($R^2 = 0.74$); ● T100: $\hat{Y} = 8.78044-0.603697x$ ($R^2 = 0.92$).

For the ruminal pH, no interaction was observed between treatments and hours after feeding, as variation only occurred for the hours after feeding, thus obtaining a minimum pH of 4.83, 4:50 hours

after feeding. The use of WCSEd, substituting corn, made the maintenance of an adequate, ruminal environment possible once the ruminal bacteria are adapted to maintain its growth in this medium with varying pH of 5.5 to 7.0 (BERCHIELLI et al., 2011).

A significant interaction was observed between the hours after feeding, and the treatments for NH_3-N levels. A significant effect was observed between treatments at 2 hours ($\hat{Y} = 13.75038 - 0,782854x$; R2 = 0.81) and 4 hours ($\hat{Y} = 11.9605 - 0,0681741x$; R2 = 0.91) after feeding, decreasing with the increased levels of WCSEd in the substitution. According to Santos and Pedroso (2011), the pool of NH_3-N tends to increase between 2 and 4 hours after feeding, depending on the degradability of crude protein in the diet and the conditions for growth of the microbiota.

For 0% and 33% treatments for the replacement of corn for WCSEd, the maximum values of NH_3-N occurred at 3.48 (3:29) and 2.92 (2:55) hours, respectively, after feeding, corroborating with the results, obtained by Zeoula et al. (2002), who obtained a higher quantity of NH_3-N (12.5 mg/100 ml) 2 hours after feeding; this treatment contained corn, and was compared to the treatment of cassava with chips in the feed.

Using 66% substitution, no significant variation was observed (P $\geq$ 0.05) during the hours after feeding, while for the treatment with 100% substitution, an effect was observed (P $\leq$ 0.05), descending linearly in the concentration of ruminal liquid NH_3-N, which lowered as more WCSEd was added to the feed.

It is possible that the low concentrations of NH_3-N observed for these treatments, as a result of the increased microbial synthesis and depending on the need for increased isoproteic maintenance of soybean meal diets, along with the increased levels of WCSEd in the diet (Table 1 and 2), may have caused a reduction in the number of protozoa as a function of the greatest amount of EE from

the soybean meal. This may have led to a higher consumption of NH_3-N by ruminal bacteria (MARTINELE et al., 2008), as protozoa ingest bacteria as the main source of amino acids and nucleic acids (KOZLOSKI, 2016).

Conclusions

The residue of cassava starch extraction showed lower *in vitro* digestibility but did not differ from the corn with regard to rumen degradability. Their use in ruminant feed reduces feed intake and degradation, but improves the use of NH_3-N in the rumen.

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