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In situ degradability of elephant grass ensiled with acerola by-product

Degradabilidade *in situ* do capim elefante ensilado com subproduto da acerola

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Abstract

This study evaluated the inclusion of increasing contents (0; 35; 70; 105 and 140 g kg^{-1}) of dried acerola fruit (*Malpighia glabra*, Linn.) by-product (DABP) in the ensilage of elephant grass (*Pennisetum purpureum*, Schum.) considering the *in situ* degradability of dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and hemicellulose. Plastic drums with 210 L capacity were used as experimental silos. After 45 days of ensiling, silos were opened and silage samples were collected for the degradability trial and laboratory analysis. For the *in situ* degradability trial, was used one rumen-fistulated adult male cattle. The five by-product inclusion contents were tested in three replicates, with five incubation times, in a randomized complete split-plot design in which the contents of DABP were the treatments (plots), the different silos were the replicates and the incubation times were the sub-plots. Longer incubation times significantly increased ($P < 0.05$) the disappearance rates of DM, CP, NDF, ADF and hemicellulose. The effective degradability of the DM, NDF and hemicellulose was higher in the silages with 35 g kg^{-1} of DABP in the rumen passage rates of 0.02; 0.05 and 0.08 h^{-1}. Dried acerola fruit by-product can be added to elephant grass ensiling up to 35 g kg^{-1} without reducing the effective degradability of nutrients.
Key words: Agro-industrial by-product. Feedstuff evaluation. Nutritional value. Ruminal degradation. Tropical fruits.

Resumo

O presente estudo avaliou a inclusão de teores crescentes (0; 35; 70; 105 e 140 g kg^{-1}) do subproduto da acerola (*Malpighia glabra*, Linn.) desidratado (SPAD) na ensilagem do capim elefante (*Pennisetum purpureum*, Schum.) por meio da degradabilidade *in situ* da matéria seca (MS), proteína bruta (PB),

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fibra em detergente neutro (FDN), fibra em detergente ácido (FDA) e hemicelulose. Foram utilizados tambores plásticos de 210 L como silos experimentais. Após 45 dias da ensilagem, os silos foram abertos e coletadas amostras para realização do ensaio de degradabilidade e análises laboratoriais. Para o estudo de degradabilidade *in situ* foi utilizado um bovino adulto macho, fistulado no rúmen. Os cinco teores do subproduto foram testados com três repetições e cinco tempos de incubação, em delineamento inteiramente casualizado com parcelas subdivididas, sendo os teores de SPAD os tratamentos (parcelas), os diferentes silos as repetições e os tempos de incubação as subparcelas. Os maiores tempos de incubação aumentaram significativamente (P < 0,05) as taxas de desaparecimento da MS, PB, FDN, FDA e hemicelulose. A degradabilidade efetiva da MS, FDN e hemicelulose apresentou maiores valores nas silagens com 35 g kg^{-1} SPAD nas taxas de passagem ruminais de 0,02; 0,05 e 0,08 h^{-1}. O subproduto da acerola desidratado pode ser adicionado à ensilagem do capim elefante em até 35 g kg^{-1} sem reduzir a degradabilidade efetiva dos nutrientes.

Palavras-chave: Avaliação de alimentos. Degradação ruminal. Frutas tropicais. Subproduto agroindustrial. Valor nutritivo.

Introduction

The use of elephant grass (*Pennisetum purpureum*, Schum) in ensiling processes is an important strategy in ruminant production due the seasonal availability of forage in tropical regions. However, tropical grasses have high moisture content, low concentrations of soluble carbohydrates, and high buffering capacity, which may compromise the silage quality. Excessive moisture (80% or more) generates a favorable environment for the development of undesirable microorganisms, whereas the soluble-carbohydrate content of forage plants during ensiling is essential for adequate fermentation and preservation of the ensiled material (SANTOS et al., 2013).

Many authors have investigated the use of additives, mainly agro-industrial by-products, to the ensiled material as a way to improve the fermentation patterns (CARVALHO et al., 2008; MANERA et al., 2014; PIRES et al., 2009; VIANA et al., 2013; VIEIRA et al., 2017) by increasing the soluble carbohydrate and dry matter (DM) contents of the silage. The inclusion of additives with absorbent properties increases the DM content, providing better conditions for desirable fermentations, elevates soluble-carbohydrate content and improves the fermentation process, turning silage from tropical grasses into feed of adequate nutritional value (PINHO et al., 2008; REZENDE et al., 2008; TEIXEIRA et al., 2008; ZANINE et al., 2010).

The production of juices or pulp from fruits generates by-products with a high potential to be used in ruminant feed (KARKOODI et al., 2012). The use of agro-industrial by-products has become an attractive alternative for animal feed in producing regions, given the quality of the ingredients, the environmental contamination reduction and low costs (HABIB et al., 2013). By-products generated from industrial processing or the discarded fruits are not frequently used in animal feeding and studies about their nutritional values are necessary. A alternative use of the waste from tropical fruit processing is silage making (HERRERA et al., 2009; LLANO et al., 2008). Many researches have been conducted to investigate the ensiling of pineapple, acerola, mango, cashew and other fruits by-products as additives to roughage in order to improve silage quality.

Acerola, as a natural source of vitamin C with numerous industrial uses, has great potential for the juice industry and has drawn the interest of fruit growers from several regions of Brazil, generating commercial crops in all states. As a result, the country has become the largest acerola producer and consumer, with a great economic importance of acerola cultivation (ASSIS et al., 2008). The industrialization of this fruit generates a by-product that can be used in animal feeding. However, it contains high contents of lignin and acid-detergent insoluble nitrogen (FERREIRA et al., 2010), which directly interfere in the digestibility of nutritional components, reducing energy values.

Thus, the objective of this study was to evaluate the *in situ* degradability of elephant grass ensiled with dried acerola by-product (DABP).

Material and Methods

The experiment was conducted in the Forage Crops Unit of Animal Science Department at the Federal University of Ceará (UFC), Fortaleza, CE, Brazil. Five contents of inclusion of dried acerola by-product (DABP) were used in the ensilage of elephant grass (0; 35; 70; 105 and 140 g kg^{-1}, as fed), which was harvested manually at approximately 70 days of growth and processed through a conventional forage shredder machine to a particle size of 1 to 2 cm (Tables 1 and 2). Afterwards, the chopped grass was mixed with the DABP from juice and pulp extraction, which was acquired from MAISA in Mossoró, RN, Brazil.

Table 1. Chemical composition of the feedstuffs.

Item	EG	DABP
Dry matter (g kg^{-1})	206.0	834.0
Crude protein (g kg^{-1} DM)	33.6	111.9
Neutral detergent fiber (g kg^{-1} DM)	736.9	734.7
Acid detergent fiber (g kg^{-1} DM)	488.5	549.4
Hemicellulose (g kg^{-1} DM)	248.5	185.3
Cellulose (g kg^{-1} DM)	344.8	284.1
Lignin (g kg^{-1} DM)	143.7	265.3
Neutral detergent insoluble nitrogen (g kg^{-1} of total nitrogen)	236.4	308.2
Acid detergent insoluble nitrogen (g kg^{-1} of total nitrogen)	139.1	183.8

EG - elephant grass; DABP - dried acerola by-product; DM - dry matter.

Table 2. Chemical composition of the silages.

Item	Dried acerola by-product				
	0	35	70	105	140
Dry matter (g kg^{-1})	197.5	232.0	249.1	268.3	308.5
Crude protein (g kg^{-1} DM)	54.5	74.3	79.8	87.3	100.1
NDF (g kg^{-1} DM)	730.4	738.2	749.0	757.5	762.5
ADF (g kg^{-1} DM)	444.6	442.4	478.3	501.2	536.4
Hemicellulose (g kg^{-1} DM)	285.8	295.7	270.8	256.3	226.1
Cellulose (g kg^{-1} DM)	314.5	287.6	307.3	313.8	297.8
Lignin (g kg^{-1} DM)	130.1	154.8	171.0	187.3	238.6
NDIN (g kg^{-1} of total nitrogen)	247.2	253.5	283.1	277.0	304.7
ADIN (g kg^{-1} of total nitrogen)	118.3	132.2	178.0	180.6	220.7

DM - dry matter; NDF - neutral detergent fiber; ADF - Acid detergent fiber; NDIN - neutral detergent insoluble nitrogen; ADIN - acid detergent insoluble nitrogen.

The acerola by-product was composed of seeds and small percentage of discarded fruits (300 to 400 g kg^{-1}). The product was dried in the sun on a cemented floor for 48 h, scattered in layers of approximately 7 cm thickness and stirred at least three times daily until it reached a moisture content of 130 to 160 g kg^{-1}. To avoid accumulation of moisture at night, the material was piled and covered with plastic canvas.

After the silage was homogenized and weighed, the material was placed into the silos (126 kg of silage at a density of 600 kg m^{3-1}) and compressed. The silos were made of plastic drums with a 210 L capacity and closed with plastic canvas secured with rubber bands.

The material was kept ensiled for 45 days, after which the silos were opened and silage samples were collected for trial. Samples were pre-dried in a forced-air oven at 60ºC for 72 h, processed through a 5 mm sieve mill and homogenized for subsequent incubation. For the *in situ* degradability trial, was used one rumen-fistulated adult male cattle (TOMICH; SAMPAIO, 2004) fed corn silage and supplemented with 1 kg of concentrate daily, at 07h00 and 16h00. The feeds were incubated in 9 × 20 cm nylon bags with 50 µm porosity containing 10 g of the pre-dried material. Bags were inserted in the rumen at 08h00 and removed in sequential order at 6; 24; 48 and 96 h, and then washed manually in running water. To determine zero time (t = 0), three nylon bags were used per treatment with the same amount of sample utilized for the other incubation times; these were sealed and washed manually in the same manner as the other times. A randomized complete experimental design with split-plots was adopted, in which the five contents of DABP were the treatments (plots), the three different silos were the replicates, and the five incubation times were the sub-plots.

Afterwards, the samples were dried in a forced-air oven at 60ºC, weighed, and analyzed to determine the dry matter (DM; Official Method 934.01; AOAC, 1990) and crude protein (CP; Official Method 984.13; AOAC, 1990) contents. The fiber fraction was analyzed according to Van Soest et al. (1991). Concentrations of neutral detergent fiber (NDF) were determined using 1 g of sample treated with heat-stable alpha-amylase, solubilized with 100 mL of neutral detergent solution, and expressed without correction for residual nitrogen and ash. Acid detergent fiber (ADF) contents were determined by the sequential method and expressed without correction for residual nitrogen and ash. Lignin content was determined by cellulose solubilization with sulfuric acid (72% H_2SO_4). Neutral (NDIN) and acid (ADIN) detergent insoluble nitrogen contents were determined according to the methodologies described by Licitra et al. (1996).

The model was evaluated by Akaike's information criterion (AIC), in which: L is the likelihood function, n is the sample size and p is the number of free parameters of the model. The SAS software (Statistical Analysis System, version 9.2; 1990) was used to compare the means and coefficients of the model proposed by Ørskov and McDonald (1979). After determining the model parameters, effective degradability (ED) was estimated by adopting the rumen passage rates of 0.02; 0.05 and 0.08 h^{-1} (McDONALD, 1981).

Results and Discussion

Rumen incubation time and DABP addition significantly influenced ($P<0.05$) the disappearance rates of DM and CP from the ensiled material (Table 3). The soluble fractions of DM ranged from 194.3 to 210.2 g kg^{-1} for silages of elephant grass only and with addition of 35 g kg^{-1} DABP (as fed), respectively. These values were similar to those observed when the elephant grass was ensiled with dried pineapple byproduct (194.3 to 240.1 g kg^{-1} for silages of elephant grass only and with pineapple byproduct addition of 105 g kg^{-1}, as fed; FERREIRA et al., 2016) and with dried cashew apple (194.3 to 221.6 g kg^{-1} for silages of elephant grass only and with dried cashew apple addition of 35 g kg^{-1}, as fed; FERREIRA et al., 2015).

Table 3. Average disappearance (g kg^{-1}) of the nutrients from silages at time zero and at different rumen-incubation times.

Time (h)	Dried acerola by-product				
	0	35	70	105	140
			Dry matter		
0	194.3bE	210.2aE	205.7abE	205.0abE	203.0abE
6	225.9cD	264.5aD	249.5abD	233.0bcD	241.6cD
24	341.8bC	384.5aC	354.7bC	342.0bC	312.1cC
48	454.5abB	474.5aB	457.5abB	440.4bB	456.6abB
96	610.4baA	622.2aA	580.8bA	557.6bcA	550.1cA
			Crude protein		
0	173.0cE	181.1bcE	216.3aE	186.0bE	190.0bE
6	249.9cD	272.4aD	266.3abD	243.6cD	256.3dC
24	370.6bC	390.0abC	380.6abC	377.1bC	392.2aC
48	470.1bcB	493.1abB	514.5aB	510.0aB	452.2bC
96	645.7aA	652.0aA	645.2aA	637.1aA	628.8aA

[a,b,c,d] Means followed by different letters in the row are different by t test (P<0.05). [A,B,C,D,E] Means followed by different letters in the column are different by t test (P<0.05). * Significant at 1% probability content by t test. Coefficient of experimental variation (CV) of dry matter = 1.59% and of crude protein = 6.10%.

Silages DM disappearance increased up to 96 h of incubation. By this time, the silages had already reached their maximum DM disappearance rate. However, considering the contents of DABP in every time of incubation individually, no consistent variations were obtained in the values of DM disappearance. Rêgo et al. (2009) evaluated the inclusion of dehydrated cashew apple in the ensilage of elephant grass (0; 40; 80; 120 and 160 g kg^{-1}, as fed) and observed similar disappearance rate of DM up to the content of 141 g kg^{-1}. Rêgo et al. (2010) evaluating the DM degradability of elephant grass silage with five contents of annatto grain by-product (0; 40; 80; 120 and 160 g kg^{-1}, as fed) observed increase in the disappearance of DM up to the by-product addition of 340 g kg^{-1} to 96 hours of incubation time, differently from that observed in the present study.

At the highest inclusion content of 140 g kg^{-1}, there was no influence of the by-product inclusion content on the disappearance of CP, probably due to the fact that this silage has a higher content of lignin, NDIN and ADIN (Table 2) with lower availability of nutrients to ruminal microorganisms.

At 0 h incubation time, the silages with 35; 70; 105 and 140 g kg^{-1} DABP (as fed) showed higher ruminal NDF disappearance rates than those observed in the silage with elephant grass only (Table 4). Considering the other incubation times, the disappearance of NDF was not constant. Rêgo et al. (2010) evaluated NDF degradability of elephant grass silage with five contents of annatto grain by-product (0; 40; 80; 120 and 160 g kg^{-1}, as fed) and observed increase of NDF disappearance up to 160 g kg^{-1} of by-product addition.

Table 4. Average disappearance (g kg^{-1}) of the nutrients from silages at time zero and at different rumen-incubation times.

Time (h)	Dried acerola by-product				
	0	35	70	105	140
			Neutral detergent fiber		
0	96.6cE	125.7bE	143.4abE	126.7bE	158.9aE
6	164.5aD	177.7aD	169.1aD	154.8aD	174.6aD
24	295.3bC	329.7aC	279.9bcC	270.9bcC	263.5cC
48	362.2bB	414.5aB	404.9aB	374.8bB	410.5aB
96	527.1bcA	582.0aA	553.4abA	520.4cA	550.5bA
			Acid detergent fiber		
0	100.7cD	109.0cD	175.9bD	151.0bD	222.7aD
6	123.3cD	141.4cD	201.7abD	190.0bD	234.2aD
24	252.3bC	293.9aC	316.3aC	285.9abC	310.7aC
48	338.3cB	403.3abB	423.3aB	379.4bB	434.6aB
96	529.5abA	565.4aA	525.2bA	532.4abA	547.5abA
			Hemicellulose		
0	81.6cD	174.7aC	104.5bcD	134.7abD	86.2bcD
6	82.0bcD	174.3aC	110.7bD	120.6abD	65.6cD
24	128.9cC	449.1aB	215.2bC	241.9bC	129.1cC
48	373.4aB	423.6aB	371.0aB	366.0aB	354.8aB
96	494.8bA	602.1aA	557.0abA	561.5abA	526.2abA

[a, b, c] Means followed by different letters in the row are different by t test ($P<0.05$). [A, B, C, D, E] Means followed by different letters in the column are different by t test ($P<0.05$). * Significant at 1% probability content by t test. Coefficient of experimental variation (CV) of Neutral detergent fiber = 8.77%, Acid detergent fiber = 9.41% and Hemicellulose = 2.86%.

Acid-detergent fiber disappearance rates at 0 and 6 h of incubation were similar ($P>0.05$; Table 4), demonstrating low microbial activities in the first hours of incubation. This only changed at 24 h, when ADF disappearance rates increased, reaching the highest values at 96 h of incubation ($P<0.05$). The ADF disappearance rates were similar to those of NDF in the incubation period after 24 h. This observation is related to the proportions of fibrous fractions in DABP, which provided a reduction of NDF digestibility since the by-product presented close concentrations of NDF and ADF (734.7 and 549.4 g kg^{-1} DM, respectively; Table 1) and, consequently, low hemicellulose content (185.3 g kg^{-1} DM) and fiber quality.

The hemicellulose disappearance rates followed the same trend observed for ADF. Silages at 0 and 6 h of incubation did not differ from each other ($P>0.05$; Table 4), whereas after 24h, the rate of disappearance of this nutrient increased, ending at 96 h with the highest values ($P<0.05$). The disappearance rates were similar between the treatments without inclusion and in the highest content for all incubation times.

The soluble fraction readily available to the rumen microorganisms presented higher values when the by-product was added to ensilage of elephant grass, varying for DM from 187.3 to 215.4 g kg^{-1}, respectively for silage without DABP and with inclusion of 35 g kg^{-1} and for CP from 177.2 to 215.4 g kg^{-1}, respectively for silage without DABP and with inclusion of 70 g kg^{-1} (Table 5). The fraction a, which is composed of carbohydrates and soluble nitrogenous compounds, increased in the treatments with DABP probably due the higher CP content of the by-product (Table 1). Ferreira et al. (2016) also observed increase in the soluble fraction when elephant grass was ensiled with five contents of dried pineapple by-product (0; 35; 70; 105 and 140 g kg^{-1}, as fed), with fraction a values for DM varying from 187.3 to 249.7 and for CP from 178.9 to 233.0 g kg^{-1}, respectively for silage without and with by-product inclusion of 140 g kg^{-1}. The rumen microbial flora transforms non-protein nitrogen and degradable protein into microbial protein, when energy is available, and this availability for microorganisms is determined by the rates of degradation and passage through the rumen, which will influence the efficiency and quantity of microbial protein synthesized (SANTOS et al., 2012).

Table 5. Parameters of degradability and effective degradability and coefficient of determination (R^2) of the nutrients of silages for the passage rates of 0.02, 0.05 and 0.08 h^{-1}.

DABP	Parameters			Effective degradability			
	a	b	c	0.02 h^{-1}	0.05 h^{-1}	0.08 h^{-1}	R^2
				Dry matter			
0	187.3	520.0	15.7	416.0	312.0	273.0	0.99
35	215.4	520.0	15.4	441.0	338.0	299.0	0.99
70	206.5	490.9	15.0	417.0	320.0	284.0	0.99
105	200.1	475.0	14.6	401.0	307.0	273.0	0.97
140	198.8	482.5	14.0	397.0	304.0	271.0	0.97
				Crude protein			
0	177.2	633.4	13.8	436.0	314.0	270.0	0.98
35	198.7	564.1	16.5	454.0	339.0	295.0	0.98
70	215.4	558.2	15.4	458.0	347.0	306.0	0.98
105	185.5	544.4	18.5	447.0	333.0	288.0	0.98
140	204.0	563.0	14.1	437.0	328.0	288.0	0.97

DABP- dried acerola by-product; a - soluble fraction (g kg^{-1}); b - potentially soluble fraction (g kg^{-1}); c - degradation rate of b (g kg^{-1}h^{-1}). R^2 - coefficient of determination.

In our study, the DABP addition contents decreased fraction b degradation rates (c) for DM (Table 5). Low c indicates a longer feed permanence time in the rumen and may lead to a reduce in feed intake due gastrointestinal tract distention. Tomich and Sampaio (2004) reported that degradation rates below 20 g kg^{-1} h^{-1} suggest low-quality feedstuffs, since they require a longer rumen permanence time to be digested. Therefore, it is possible that the addition of DABP to the ensilage of elephant grass compromised the nutritional quality of this feed because of its reduced use by rumen microorganisms.

The effective degradability (ED) of the DM was higher in the silages with 35 g kg^{-1} of DABP considering the rumen passage rates of 0.02; 0.05 and 0.08 h^{-1}. Probably, this difference, as previously discussed, are related with protein, lignin, NDIN and ADIN contents in the silages, where the highest inclusion contents might have negatively influenced the potentially soluble fraction (b) and degradation rate (c). The DM effective degradability at 0.05 h^{-1} rumen passage rate was lower than the observed by Rêgo et. al. (2011) evaluating the ruminal degradation of silages of elephant grass (*Pennisetum* *purpureum*) cutting in 70 days after regrowth (394.1 g kg^{-1}).

The CP fractions a and b presented the same behavior of DM. The CP effective degradability showed improvement in the addition contents of 35 and 70 g kg^{-1}. Despite the increase in CP content in the silages with the by-product inclusion (Table 2), these values are still considered low. According to Van Soest (1994), the nitrogenous compounds requirements of ruminal microorganisms would not be met at CP dietary contents lower than 6-8%, compromising the use of available energy substrates. Therefore, the difference in the effective degradability can be attributed to low CP contents of the silages.

As for the rumen degradability of NDF from the silages, the soluble fraction (a) ranged from 109.4 g kg^{-1} in the silage with elephant grass only to 142.5 g kg^{-1} in the silage containing 140 g kg^{-1} DABP (as fed) (Table 6). Similar to DM degradation rates (c), NDF degradation rates decreased with the addition of the by-product. Tropical grasses present high productivity, but during their growth cycle accumulate a high percentage of cell wall (NDF), which has slow and incomplete digestion, occupying space in the gastrointestinal tract, besides influencing the consumption and digestibility (MERTENS, 1996).

The low degradation rates (c) observed for the rumen degradation of ADF with increase in inclusion of DABP (Table 6) may reflect in lower digestibility of the feed and, consequent, a reduction of voluntary intake. The ED did not show significant differences after inclusion of DABP, agreeing with the results obtained in the apparent-digestibility trial for this fraction (FERREIRA et al., 2010). Thus, feed with higher fiber and lignin contents will have lower nutritional value, characterizing it as a low availability to rumen microorganisms, such as DABP, when at high contents of inclusion. We observed that the effective degradability of the NDF and hemicellulose was higher in the silages with lower inclusion content of DABP (35 g kg^{-1}, as fed), to the rumen passage rates of 0.02; 0.05 and 0.08 h^{-1}.

The low values recorded for ADF degradation parameters may be related mainly to the lignin contents found in the silages (Table 2). Lignin is the primary factor limiting the digestion potential of fibrous carbohydrates, which are the nutrients to which it is chemically linked. Its negative effects are due to the physical barrier formed as well as to the characteristics of its chemical links with structural polysaccharides, resisting the action of microbial enzymes, the inhibition of enzymatic activity, or even the inter-relationship among all of these factors (KRAUSE et al., 2013).

Table 6. Parameters of degradability and effective degradability and coefficient of determination (R^2) of the nutrients of silages for the passage rates of 0.02, 0.05 and 0.08 h^{-1}.

DABP	Parameters			Effective degradability			
	a	b	c	0.02 h^{-1}	0.05 h^{-1}	0.08 h^{-1}	R^2
				Neutral detergent fiber			
0	109.4	536.0	15.2	341.0	234.0	195.0	0.98
35	129.3	577.6	15.6	382.0	266.0	223.0	0.99
70	134.1	590.0	12.6	363.0	253.0	215.0	0.99
105	122.1	588.2	11.8	340.0	234.0	198.0	0.96
140	142.5	590.0	11.9	362.0	256.0	219.0	0.96

continue

continuation

				Acid detergent fiber			
0	120.0	565.0	11.6	328.0	227.0	192.0	0.97
35	120.0	565.0	15.1	363.0	251.0	210.0	0.92
70	168.0	444.6	17.2	373.0	282.0	247.0	0.97
105	151.5	565.0	11.3	355.0	256.0	221.0	0.97
140	190.0	535.9	11.6	387.0	291.0	258.0	0.94
				Hemicellulose			
0	95.0	590.0	10.6	299.0	198.0	164.0	0.91
35	156.9	465.4	25.8	419.0	315.0	270.0	0.63
70	95.0	590.0	13.3	331.0	219.0	179.0	0.97
105	104.3	590.0	13.1	338.0	227.0	188.0	0.93
140	95.0	590.0	10.9	303.0	202.0	166.0	0.87

DABP- dried acerola by-product; a - soluble fraction (g kg^{-1}); b - potentially soluble fraction (g kg^{-1}); c - degradation rate of b (g $kg^{-1}h^{-1}$). R^2 - coefficient of determination.

The rumen degradability parameters of hemicellulose from the silages containing DABP were low, compared with other by-products (FERREIRA et al., 2016). The low degradation rates (c) obtained in the silages for this component explain the reduced voluntary intakes observed (FERREIRA et al., 2010), because the maximum ruminant forage intake depends primarily on the rate of ruminal emptying of hemicellulose and cellulose. These rates, in turn, depend upon several factors that interfere with the rumen microflora activity, like the lignification and absence of nutrients for adequate growth of the rumen microflora.

Conclusion

Dried acerola fruit by-product can be added to elephant grass ensiling up to 35 g kg^{-1} without reducing the effective degradability of nutrients.

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