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Nutritional value of whole coconut, coconut powder, and coconut fiber treated with sodium hydroxide for sheep

Valor nutritivo do coco integral, pó de coco e fibra de coco tratados com hidróxido de sódio para ovinos

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ABSTRACT

The growing consumption of green coconut — fresh and industrialized — in Brazil generates a large volume of wastes and coproducts that justifies the search for alternatives for their use in animal feeding. The most limiting factor to the inclusion of these coproducts in ruminant diets is their high fiber content, which may restrict intake and performance. The present study determined the composition and *in vitro* dry matter degradability of whole coconut, coconut powder, and coconut fiber treated with sodium hydroxide (0%, 3%, and 6%) and the effect of including whole coconut hydrolyzed with 6% sodium hydroxide at different concentrations (25%, 30%, 35%, and 40%) in the diet on apparent digestibility of nutrients, performance, and feeding behavior of sheep. Alkalinization decreased the hemicellulose, NDF, and ADF contents of the evaluated coproducts. Whole coconut and coconut powder provided greater *in vitro* degradation of DM compared with coconut fiber, with highest values obtained with the inclusion of 6% sodium hydroxide. Inclusion of whole coconut in the diets did not affect the intakes of DM, CP, NDF, and ADF, but influenced weight gain, feed conversion, and apparent digestibility of DM and NDF. Regarding the feeding behavior of the animals, the inclusion of whole coconut in the diet only affected their rumination time. Whole coconut hydrolyzed with 6% NAOH can be included in diets for feedlot sheep at up to 35% without reducing intake or weight gain.

Index terms: *Cocos nucifera*; NaOH; coproduct.

RESUMO

Avaliou-se a composição química e a degradação *in vitro* da matéria seca do coco integral, do pó de coco e da fibra de coco tratados com hidróxido de sódio (NaOH) e o efeito da inclusão do coco integral hidrolisado com 6% de NaOH sobre a digestibilidade aparente dos nutrientes, o desempenho e o comportamento ingestivo em ovinos - 0%, 3% e 6% - e o efeito da inclusão do coco integral hidrolisado com 6% de hidróxido de sódio em diferentes concentrações na dieta – 25%, 30%, 35% e 40% - sobre a digestibilidade aparente dos nutrientes, o desempenho e o comportamento ingestivo, em ovinos. A alcalinização diminuiu os teores de hemicelulose, FDN e FDA dos coprodutos avaliados. O coco integral e o pó de coco apresentaram maior degradação *in vitro* da MS em relação a fibra de coco, com maiores valores obtidos com a inclusão de 6% de hidróxido de sódio. A inclusão de coco integral nas dietas não afetou o consumo de MS, de PB, de FDN e de FDA, mas influenciou o ganho de peso, a conversão alimentar e a digestibilidade aparente da MS e da FDN. Quanto ao comportamento ingestivo dos animais, só houve efeito de inclusão do coco integral na dieta sobre o tempo de ruminação. O coco tratado com 6% de NaOH pode ser utilizado em até 35% na dieta de ovinos, pois não reduz o consumo e o ganho de peso desses animais.

Termos para indexação: *Cocos nucifera*; NaOH; coproduto.

INTRODUCTION

Brazil has more than 264 thousand hectares of land cultivated with coconut (Instituto Brasileiro de Geografia e Estatística - IBGE, 2015). Of this total cultivated area, over 80% are concentrated in the Northeast, and thus there has been an increase in consumption of both fresh and industrialized green coconut (*Cocos nucifera*) and in the production of wastes and coproducts in this region. Approximately 85% of the coconut structure consists of wastes that are not used by the agro-industrial chain for the generation of new products (Senhoras, 2004). Approximately 2.29 billion shells are produced annually in Brazil, which corresponds to 1.53 million tons of waste (Nunes et al., 2007). Also according to Nunes et al. (2007), most of the coconut shells are burned or discarded as waste;

upon being burned, they produce substances that pollute the environment, and when discarded they constitute a proper means for procreation of venomous animals and disease-vector insects, becoming an environment pollutant.

The large volume of wastes generated by the agro-industry justifies the search for alternatives for the use of the green-coconut shell in the feeding of ruminants. The green-coconut waste can provide three coproducts: the whole coconut, the coconut fiber, and the coconut powder, which have different properties, especially regarding their particle size. Coconut fiber is obtained after the green-coconut shell is ground, and the powder is obtained after pressing and separation of the fibers. These wastes are rich in lignin and cellulose, with lignin content ranging from 37.2±0.8% to 43.9±0.7% and cellulose from 31.5±0.1% to 37.4±0.5% (Corradini et al., 2009).

Ruminants have the ability to use the fiber because of the activity of bacteria and protozoa present in their rumen that degrade the fibrous carbon to generate energy. However, when the percentage of fiber in the diet is increased, it can limit intake and affect the performance of animals. According to Mertens (1994), the neutral detergent fiber intake in ruminant diets should be 12 g/kg LW, varying by around 1 g/kg LW. The NDF digestibility is also an important forage quality parameter, since diets with high values for the rumen-undegradable fibrous fraction increase the rumen-fill effect of the NDF from this forage (Detmann et al., 2003).

Foods rich in cell wall and with low quality can be treated as alkaline products, e.g., urea, ammonium, calcium oxide, and sodium hydroxide, to improve the effective degradation of DM and cell wall, resulting in better nutritive value (Garcez et al., 2014; Silva et al., 2014). These treatments are aimed mainly at the delignification of the cell wall through the solubilization of lignin.

Although the alkaline treatment provides an improvement in the fiber use and digestibility, if used as the only roughage, the speed of degradation in the rumen should be observed so that intake is not reduced, especially in ruminants with medium and high production potential (Romão et al., 2013). In this case, these authors indicate the need for increasing the amount of concentrate feed in the diet. The evaluation of high-fiber roughages from the nutritional perspective should include measurements of particle size, of the feeding behavior of animals, since it can interfere with their feeding, rumination, and idle activities (Carvalho et al., 2014).

The dietary complementation for ruminants during the dry seasons in arid and semi-arid regions is a hard task to rural producers. The use of green coconut fiber can be a satisfactory alternative during this period, but the low digestibility and the little palatability might limit voluntary intake (Senhoras, 2004). The lack of information about improvement of the nutritive value of this waste with the use of relatively cheap, easy chemical treatments accessible to producers and of the performance of animals fed diets with inclusion of this fiber has limited its use in ruminant feeding.

In this regard, in the present study, different coconut coproducts were treated with sodium hydroxide and evaluated with regard to chemical composition and *in vitro* digestibility, and later selected as the only roughage source to determine performance, *in vivo* digestibility, and feeding behavior of sheep.

MATERIAL AND METHODS

Two experiments were conducted — one in the Laboratory of Animal Nutrition and another at the Department of Animal Science of Universidade Federal do Piauí (UFPI). The utilized material was collected in green-coconut processing industries located in Fortaleza, CE, Brazil. The coproducts whole coconut, coconut fiber, and coconut powder were obtained after collecting the green-coconut shells from the industries and the grinding, pressing, selection, fiber-sieving, and, lastly, partial natural dehydration procedures.

Chemical composition and *in vitro* digestibility

For the chemical hydrolysis, coproducts were sprayed with a solution of sodium hydroxide (NaOH) at three concentrations: 0%, 3%, and 6% at the rate of 1 kg of coproduct for 1 kg of solution, according to the treatment. Subsequently, the coproducts were homogenized and packed in plastic bags for 48 h at room temperature (Pires et al., 2006).

Samples of the hydrolyzed coproducts had their dry matter (DM), organic matter (OM), crude protein (CP), and ether extract (EE) contents determined according to methods described in Association of Official Analytical Chemists - AOAC (1995); and neutral detergent fiber (NDF), acid detergent fiber (ADF), using amylase, and hemicellulose, to Van Soest et al. (1991). A Dayse incubator was used for the estimate of the *in vitro* DM digestibility (IVDMD), in accordance with Santos et al. (2000), using a bovine rumen inoculum from a 5-year-old adult rumen-cannulated male animal weighing 600 kg that received a maintenance diet (National Research Council - NRC, 2001) containing whole coconut. After 48

h of incubation, samples were removed from the incubator and bags were washed in running water. Later, they were washed with an NDF solution to remove microorganisms adhering to the residual particles. The IVDMD was calculated as the ratio between the amount of residual DM and the initial DM: IVDMD (%DM) = 100 [(initialDM) – (residualDM – blank)/initialDM].

The concentrate was formulated based on ground corn, soybean meal, urea, and mineral premix. Diets were calculated to be isoproteic and to contain sufficient nutrients to provide gains of more than 150 g/day, according to NRC (2007) (Table 1).

Table 1: Proportion of ingredients and composition of experimental diets, in % DM.

Ingredient	Diet (% of $WC_{6\%NaOH}$)			
	25	30	35	40
Corn	55.3	51.3	50.9	50.5
Soybean meal	18.4	17.1	17.0	16.8
$WC_{6\%NaOH}$	25	30	35	40
Urea	0.2	0.6	1.1	1.6
Premix[1]	1	1	1	1
Composition				
Dry matter	87.3	87.3	87.4	87.5
Crude protein	14.3	14.4	15.1	14.6
Ether extract	3.3	3.3	3.2	3.2
Neutral detergent fiber	29.1	32.1	32.9	36.2
Acid detergent fiber	19.9	22.5	24.6	27.8
Mineral matter	5.5	6.2	6.4	6.8

$WC_{6\%NaOH}$: whole coconut hydrolyzed with 6% sodium hydroxide.
(1) Provides per kg of product: calcium 120 g, phosphorus 87 g, sodium 147 g, manganese 1,300 mg, zinc 3,800 mg, iron 18,000 mg, cobalt 40 mg, iodine 80 mg, chromium 20 mg, molybdenum 300 mg, sodium monensin 1,300 mg, fluorine 870 mg, and selenium 15 mg.

Performance, *in vivo* digestibility and feeding behavior of sheep

Twenty Santa Inês × Dorper crossbred male sheep with an average age of 90 days and average live weight of 20±2.9 kg were kept in individual 1m^2 stalls with concrete floor covered with wood shavings and provided with feeders and drinkers. Feed was provided in two daily meals, at 08h00 and 16h00, allowing for 10% as orts. The adjustment was made according to the consumption of the animals, by weighing the orts directly. Animals received water freely during the entire experimental period. Animals were weighed at the beginning of the performance trial and every 7 days, always before the first daily meal. Upon completing 47 days in the experimental period, sheep were weighed to determine final body weight. Approximately 10% of feed and orts were collected daily as a sample, packed, and stored for later analyses. To determine the DM, OM, CP, NDF, ADF, and hemicellulose contents, samples were initially pre-dried in a forced-air oven at 55 ºC±5 ºC and ground.

Two days before the end of the performance trial, the time spent feeding, ruminating, and on other activities (idleness, drinking, defecation, and urination) was recorded during 24 h straight, in five-minute intervals, according to Carvalho et al. (2007). During the night time observation, the environment was maintained under artificial illumination.

The apparent digestibility coefficients of DM, CP, NDF, and ADF were calculated soon after the performance trial by the total feces collection method, using metabolic cages, lasting eight days, which consisted of three for adaptation and five for feces collection (Bueno et al., 2005). Animals were fed twice daily, at 09h00 and 16h00, allowing 10% as orts. Orts, feces, and urine were collected daily, per animal, and a 10% aliquot was taken, packed, and stored for later analyses. For the laboratory analyses, samples were pre-dried and ground. The apparent digestibility coefficients of the nutrients (DC) were determined according to the equation described by Schneider and Flatt (1975), as follows: DC = 100 [(nutrient consumed – nutrient excreted)/ nutrient consumed].

The total digestible nutrients (TDN) were determined based on the apparent digestibility coefficient of DM (DMD), according to the equation proposed by Cappelle et al. (2001): TDN = 1.064 × DMD – 3.84.

To analyze the chemical and IVDMD data, a completely randomized design was adopted, in a 3 × 3 factorial arrangement (three coproducts and three concentrations of NaOH, with nine treatments and four replicates. After the interaction between coproducts and levels of inclusion of NaOH was detected, the regression analysis was performed considering the inclusion levels within each by-product. Data were subjected to analysis of variance, using the PROC GLM procedure of Statistical Analysis System – SAS (2009), statistical software, and means were compared by least significant differences of Tukey's test at 5% significance. Performance, feeding behavior, and apparent-digestibility data were analyzed in a randomized-block design with four treatments, using

SAS (2009) software, with means compared by Duncan's test at 5% probability level.

RESULTS AND DISCUSSION

There was no interaction ($P > 0.05$) between coproducts and percentages of inclusion of NaOH for OM, CP, or hemicellulose. Therefore, the effects were studied separately for each one of these variables (Table 2).

Among the coproducts, the coconut fiber displayed the highest ($P > 0.05$) concentration of OM and hemicellulose and the lowest ($P < 0.05$) amount of CP. The decrease ($P < 0.05$) in the percentage of OM as the concentration of NaOH was increased was expected due to the higher addition of Na. The higher CP content obtained with the higher NaOH concentration ($P < 0.05$) was a result of the release of protein bound to the plant cell wall or the fiber. This effect was associated with the reduction of NDF, ADF, and hemicellulose contents, which proves the solubilization of the plant cell wall.

No interaction occurred ($P < 0.05$) between coproducts and the hydrolysis level for NDF, ADF, or IVDMD, and thus the regression analysis was performed considering the inclusion levels within each coproduct (Figures 1, 2, and 3). The decrease in NDF contents for the three coproducts with the alkalinization can be attributed to the partial solubilization of the cell wall. The magnitude of this effect was more expressive in the treatment with the highest concentration of NaOH. Gomes et al. (2015) also found that sodium hydroxide was efficient in delignifying the cell wall of sugarcane bagasse. Addition of NaOH to whole coconut and coconut powder resulted in a greater reduction of the NDF content when compared with that observed by Pires et al. (2006) with sugarcane, who obtained a decrease of only 1.15 units of NDF per unit of NaOH added.

Table 2: Mean values for organic matter (OM), crude protein (CP), and hemicellulose of whole coconut, coconut powder, and coconut fiber and of the coproduct treated with different percentages of sodium hydroxide (NaOH).

Variable %	Coproduct			NaOH (%)		
	Whole coconut	Coconut powder	Coconut fiber	0	3	6
OM	92.0 b	90.8 c	94.5 a	96.0 a	92.4 b	88.9 c
CP	3.9 b	4.9 a	3.3 c	3.3 b	3.3 b	4.0 a
Hemicellulose	14.0 b	15.6 b	19.0 a	18.4 a	15.5 ab	14.6 b

*Different lowercase letters in the same row indicate a significant difference (Tukey's test, $P < 0.05$).

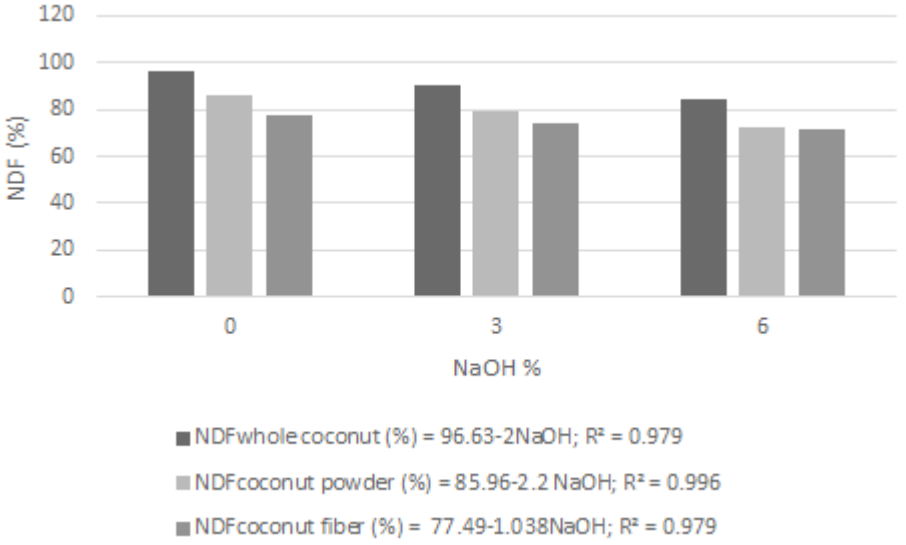

Figure 1: Neutral detergent fiber (NDF) contents of whole coconut, coconut powder, and coconut fiber hydrolyzed with sodium hydroxide (NaOH).

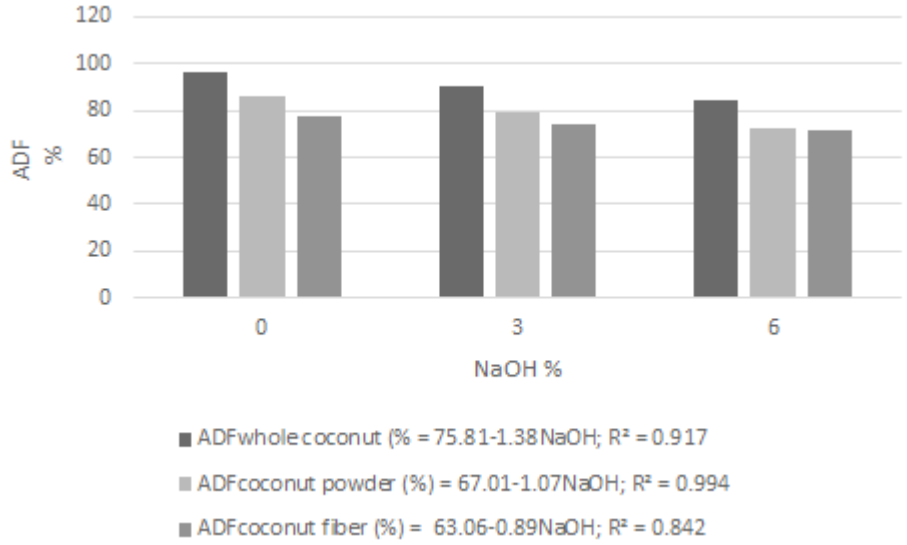

Figure 2: Acid detergent fiber (ADF) contents of whole coconut, coconut powder, and coconut fiber hydrolyzed with sodium hydroxide (NaOH).

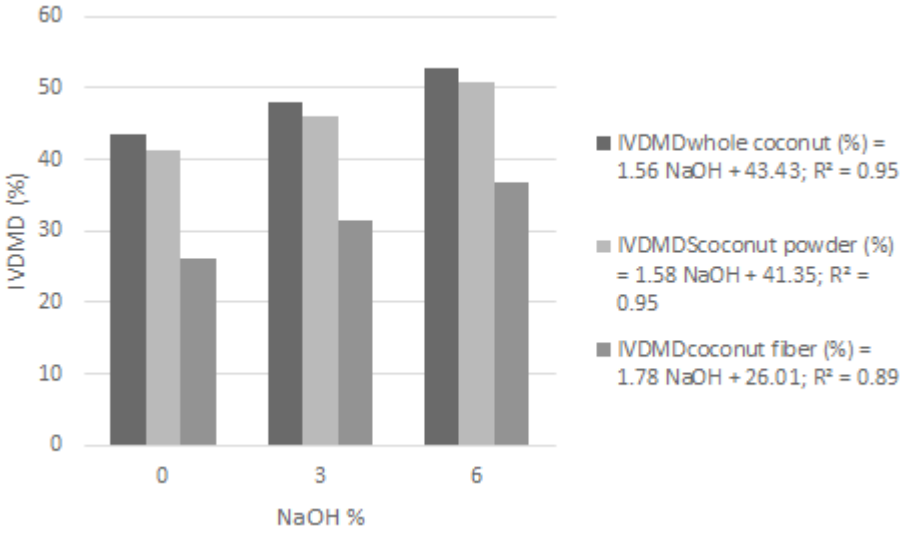

Figure 3: *In vitro* dry matter degradation (IVDMD) of whole coconut, coconut powder and coconut fiber hydrolyzed with sodium hydroxide (NaOH).

Likewise, the ADF content was reduced with the alkaline treatments. The whole coconut showed a lower ($P < 0.05$) percentage of ADF relatively to the coconut powder and coconut fiber. The magnitude of the decrease in the concentration of ADF depended on the dose of NaOH utilized. Murta et al. (2011) observed that the treatment of sugarcane bagasse with increasing levels of sodium hydroxide decreased its NDF and ADF concentrations linearly, and that a dose greater than 2% increased the availability of cell wall due to its partial solubilization.

The whole coconut and the coconut powder showed a higher IVDMD ($P < 0.05$) compared with the coconut fiber; irrespective of the coproduct, the inclusion of 6% NaOH resulted in a higher IVDMD. This is the result of the delignification and partial solubilization of hemicellulose and the expansion of hemicellulose — a

linear decrease observed in the NDF and ADF contents — which facilitated the attack of the cell wall by fibrolytic microorganisms.

The addition of one unit of NaOH provided an increase of 1.56, 1.58, and 1.78 units in the IVDMD of the whole coconut, coconut powder, and coconut fiber, respectively. The IVDMD of the whole coconut and of the coconut powder treated with 6% NaOH were higher than 50%, but the highest increase in IVDMD was obtained with coconut fiber, 41.1%. It is thus observed that alkaline hydrolysis benefited the nutritional value of these coproducts and can predispose animals to satisfactory performances when included in diets. Gomes et al. (2015) also obtained an elevation of more than 50% in the IVDMD of hydrolyzed sugarcane bagasse and attributed this effect to the partial solubilization of lignin; it also reduced the effect of this physical barrier for the degradation of the structural carbohydrates by the rumen microorganisms.

For the performance, apparent digestibility, and feeding behavior trials, the whole coconut treated with 6% NaOH ($WC_{6\%NaOH}$) was used as the only roughage in the sheep diets, as it presented the best chemical and fermentation characteristics compared with the coconut fiber, and also because of its lower cost relatively to the coconut powder.

Daily dry matter intake in percentage and per unit of metabolic size in the diets did not differ ($P > 0.05$) from each other despite the increase in the concentration of NDF, which is one of the main factors controlling DMI (Table 3). It is believed that the intake was not affected by the inclusion of $WC_{6\%NaOH}$ due to the improvement in the fiber digestion with the alkaline agent. The DMI in g/day were higher than the 82.37 g/unit of metabolic weight found by Azevedo et al. (2012) with sheep fed a diet containing 30% roughage and 70% concentrate.

Likewise, the percentage increase in $WC_{6\%NaOH}$ in the diets did not affect ($P > 0.05$) the crude protein intake (CPI), possibly due to the low CP content of $WC_{6\%NaOH}$ and because the diets were isoproteic. The intakes of NDF (NDFI) and ADF (ADFI) did not differ ($P > 0.05$) between the diets; the lack of effects for DM intake might have contributed for this effect not to occur.

The DWG of the animals fed the diet containing 25% $WC_{6\%NaOH}$ was higher than that observed with 40% of inclusion, which resulted in a better ($P < 0.05$) feed conversion. For the diet with 25% $WC_{6\%NaOH}$, DWG was higher than the 205 g observed by Azevedo et al. (2012) using tropical grasses as roughage with a roughage:concentrate ratio of 30:70 in the diet. The low NDF content and the higher energy uptake with the increased level of concentrate in this diet contributed to this result. Overall, the performance data observed with the diets containing $WC_{6\%NaOH}$ were close to those observed with diets containing tropical grasses, between 104 and 194 g/d (Carvalho et al., 2006), or agro-industrial coproducts, from 195 to 228 g/d (Murta el al., 2011). This demonstrates this coproduct's capacity of being used as a roughage source in high-concentrate diets. Feed conversion ranged from 4.7 to 7.7 and was negatively ($P < 0.05$) influenced ($P < 0.05$) by the $WC_{6\%NaOH}$ inclusion levels, showing that the animals will need to consume greater amounts of feed to convert it to 1 kg LW. The same response was found by Azevedo et al. (2012), who detected a linear increase in feed conversion values as they increased the levels of macauba palm (*Acrocomia aculeata*) cake in finishing-sheep diets, with values ranging from 5.5 to 6.4.

Table 3: Intakes of dry matter (DMI), crude protein (CPI), neutral detergent fiber (NDFI), and acid detergent fiber (ADFI), daily weight gain (DWG), and feed conversion (FC) in sheep fed diets containing four levels of whole coconut hydrolyzed with 6% sodium hydroxide ($WC_{6\%NaOH}$).

Parameter	$WC_{6\%NaOH}$ (%)				CV %
	25	30	35	40	
DMI (g/day)	1,008	985	1,039	892	16.5
DMI (g DM/$kg^{0.75}$)	92.2	105.7	81.0	90.9	20.6
CPI (g/day)	146	145	162	135	16.7
NDFI (g/day)	283	298	314	296	14.9
ADFI (g/day)	190	205	232	225	16.5
DWG (g/day)	220 a	168ab	170ab	131b	33.1
FC (kg feed/LWG)	4.7 a	5.9ab	6.2ab	7.7b	24.4

[a,b] Different letters in the same row indicate a significant difference (Duncan's test, $P < 0.05$).

The apparent digestibility of DM (DMD) differed ($P < 0.05$) between the diets with 25% and 35% or 40% $WC_{6\%NaOH}$ (Table 4); between the diets with 25% and 40% $WC_{6\%NaOH}$, this difference was 7.3%. The apparent digestibility of OM (OMD) was higher ($P < 0.05$) in the diet with 25% $WC_{6\%NaOH}$. Addition of whole coconut did not interfere ($P < 0.05$) with CPD because the diets were isoproteic and because the concentrate contributed with the largest part of the dietary protein, since the whole coconut has a low CP content.

For NDF, the diet treated with 25% $WC_{6\%NaOH}$ showed higher values than that treated with 40%, but this effect was not sufficient to cause a rumen-fill effect, since it did not affect intake. This difference may be attributed to the lower percentage of NDF in this diet due to the lower proportion of roughage. For ADFD, however, no difference was detected ($P > 0.05$) between the diets, possibly due to the action of the sodium hydroxide on the cell wall, facilitating its attack by rumen microorganisms. In an experiment with sheep fed 50% sugarcane treated with 2.25% calcium oxide and 50% concentrate, Murta et al. (2011) obtained values close to those observed here with whole coconut for DMD, NDFD, and ADFD: 72.9%, 32.3% and 30.7%, respectively. The diet with the highest ($P > 0.05$) TDN content was that with 25% of inclusion of whole coconut, which can be explained by the higher proportion of concentrate. The DWG obtained with this diet was higher than that found by Xenofonte et al. (2008) using a diet containing 71% TDN.

As regards the feeding behavior, there was no effect ($P < 0.05$) of treatment on the time spent feeding (Table 5). The equal intakes of DM, CP, and NDF may explain the similarity between the times. Sá et al. (2015) evaluated the feeding activity of sheep fed diets with increasing inclusion levels of babassu (*Attalea speciosa*) cake and also did not find differences between feeding times. These authors attributed this result to the fact that the diets were isonitrogenous and isofibrous, along with the equal DM intakes.

Table 4: Apparent digestibility of dry matter (DMD), organic matter (OMD), crude protein (CPD), neutral detergent fiber (NDFD), and acid detergent fiber (ADF), and total digestible nutrients (TDN) in sheep fed diets containing four levels of whole coconut hydrolyzed with 6% sodium hydroxide ($WC_{6\%NaOH}$).

Parameter	$WC_{6\%NaOH}$ (%)				CV %
	25	30	35	40	
DMD (%)	69.8 a	66.7ab	65.1b	64.7b	3.3
OMD (%)	71.3a	67.3b	65.4b	64.9b	3.3
CPD (%)	63.9	61.8	64.2	64.8	4.7
NDFD (%)	36.3a	34.6ab	35.4a	27.5b	16.8
ADFD (%)	23.9	20.7	21.1	21.1	14.4
TDN	71.3a	67.2b	65.5b	65.0b	3.4

[a,b]Different letters in the same row indicate a significant difference (Duncan's test, $P < 0.05$).

Table 5: Feeding behavior of sheep fed diets containing four levels of whole coconut hydrolyzed with 6% sodium hydroxide ($WC_{6\%NaOH}$).

Parameter	$WC_{6\%NaOH}$ (%)				CV %
	25	30	35	40	
Feeding (% in 24 h)	15.5	13.2	13.3	14.5	21.8
Rumination (% in 24 h)	31.6b	36.2ab	40.3a	33.9ab	13
Other activities (% in 24 h)	52.9	50.6	46.4	51.6	12.8

[a,b]Different letters in the same row indicate a significant difference (Duncan's test, $P < 0.05$).

Rumination time was longer (P<0.05) by the animals fed the diet containing 35% whole coconut as compared with those consuming the diet with 25% of that ingredient, likely due to the greater NDF content of the diet (Carvalho et al., 2014). Sá et al. (2015) also found an effect of the NDF from babassu cake on the feeding behavior of lambs; with the inclusion of babassu cake in the diet, the sum of the times spent feeding and ruminating resulted in a longer chewing time. However, Cardoso et al. (2006) evaluated diets for sheep with increasing NDF levels — between 25% and 43% — and did not observe an effect on the time spent feeding, ruminating, and on other activities. When the rumination and chewing times are limited, saliva production is decreased, which may lead to a decline of the rumen pH and consequently a reduction of the fiber digestibility (Macedo et al., 2007). This reduction was not observed, since the DNDF in the diet with 25% $WC_{6\%NaOH}$ did not differ from that with 35% of this ingredient, despite the shorter rumination time.

The time spent on other activities did not differ (P < 0.05) between treatments, though differences were found in rumination time between the treatments with 25 and 35% $WC_{6\%NaOH}$. As stated by Gonçalves et al. (2001), the longer times spent feeding or ruminating may lead to a reduction of the time spent on other activities, such as idleness.

CONCLUSION

Coconut treated with 6% NaOH can be used at up to 35% in sheep diets, as it does not decrease the intake or weight gain of these animals.

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