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In natura residues from peach palm heart industry for ruminant feed

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ABSTRACT. Palm heart processing generates a large amount of residues like leaves, sheath and stems that have potential for ruminant feeding. This study aimed to evaluate the effect of *in natura* peach palm heart (*Bactris gasipaes* Khunt.) residues on performance, dry matter (DM) digestibility and intake of ruminants. External sheath was the most suitable residue for sheep, cattle and buffaloes feeding, although sheep presented rejection of 43.5 g kg^{-1}. Thereby, assays of apparent and *in vitro* dry matter digestibility were done under four feeding treatments, which were the exclusive peach palm sheath, and that one mixed with residues of banana and rice, besides citrus pulp. The experiment was carried out under randomized complete design, with five replications. Greater DM intake ($p < 0.05$) were observed in animals fed with peach palm sheath mixed with rice (1.12 kg day^{-1}) and mixed with citrus pulp (0.91 kg day^{-1}), however there were no difference among treatments regarding the sheep final weight ($p > 0.05$). Cattle and buffaloes accept different types of peach palm residues, unlike sheep that present a low rejecting for them. Citrus pulp and rice residue raise the roughage quality. Peach palm residues can be an alternative roughage source to feed ruminants.

Keywords: *Bactris gasipaes*; banana; buffalo; citrus pulp; digestibility; rice.

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Introduction

Peach palm (*Bactris gasipaes* Khunt.) is a perennial crop that presents high economic potential, mainly grown for palm heart processing, aiming human consumption. This processing generates a large amount of solid residues or by-products as bark, leaves, sheath and stem (Seben, Paula, & Viana, 2012), which represent 66% of total yield. This sub utilization worsens environmental degradation (Perignon, Vieux, Soler, Masset, & Darmon, 2017) jointly to slurry producing that is an important source of water table contamination.

Solid wastes are constantly produced along the year, and their final destination is the discarding at locations near to the peach palm heart processing, which occupies areas that could be used for own industrial activity, agriculture or either used for environmental conservation (Garcia, Modolo, Lagôa, Nomura, & Sáes, 2011).

Residue production has been increased due to population enhancing, industrial and technological development (Perignon et al., 2017). Law n° 12.305/10, which institutes the National Politic of Solid Wastes (NPSW), was created to allow necessary advances on coping of the main environmental problems in Brazil. This law previews both environmental conservation and reducing of residue production, and presents sustainable habits practices of consumption, recycling, reuse and final destination of solid wastes (Brasil, 2017). Beyond to institute NPSW, this law brings guidelines related to integrated solid wastes management.

Therefore, development of exploitation technologies is an alternative to minimize the environmental liability of peach palm heart industry, reduce environmental impact and rise the profits, thereafter. It worth pointing out that peach palm residues present great carbon and nitrogen contents, considering different activities related to the processing of agricultural products (Santos, Siqueira, Araújo, & Maia, 2014).

Innovation solutions to use the residues from palm heart industry are essential to reduce environmental impacts and provide ecological balance (Zenni, Helm, & Tavares, 2018). Moreover, these residues could be used as roughage source for ruminant feeding, mainly the peels (Rodrigues Neto et al., 2001; Zenni, Helm, &

Tavares, 2018). São Paulo state stands out like one of greatest Brazilian producers of palm heart, with 46 processing industries and 1700 farmers (LUPA, 2019).

Residues from peach palm could present following chemical composition: 260,0 g kg^{-1} dry matter (DM); 83,0 g kg^{-1} crude protein (CP); 560,4 g kg^{-1} neutral detergent fiber (NDF); 372,0 g kg^{-1} acid detergent fiber (ADF); 55,0 g kg^{-1} ether extract (EE) and 79,0 g kg^{-1} ash contents (Alves Júnior, Hernandez, Santos, & Lopes, 2004). There are some variations in literature related to the chemical composition of these by-products, likely due to variations on proportions of leaves, sheath and stems. Schmidt et al. (2010) analyzed palm heart and external sheath that presented 106.0 g kg^{-1} DM; 96.0 g kg^{-1} crude protein (CP); 616.0 g kg^{-1} neutral detergent fiber (NDF); 380.0 g kg^{-1} acid detergent fiber (ADF) and 74.2 g kg^{-1} *in vitro* DM digestibility, characterizing themselves as good roughage. However, authors found great contents of acid detergent fiber (ADF) and lignin, which may reduce their true digestibilities. On the other hand, Rombola et al. (2010) compared three replacement levels of peach palm sheaths and stem residues (0.0; 200.0 and 400.0 g kg^{-1}) by corn silage for lambs, and found that the replacement of 40% does not affect digestibility of dietary nutrients.

Regarding it, the inclusion of regional residues or agricultural co-products in the own peach palm residues may improve nutritional quality of roughage, with technical and economic viability (Bayão et al., 2014). Rice (*Oryza sativa* L.) residue is largely used in ruminant nutrition (Negrão et al., 2016), which is obtained from harvesting and processing of this cropping. Rice residues should be used fresh, or either stabilized by antioxidant due to its great fatty content (Lana, 2000). These residues present potential traits to be used as lipids source of diets. Thereby, co-products as rice bran allow the laboring of high-density diets that could improve animal performance.

On the other hand, banana (*Musa* spp.) is one of the most consumed fruits all over the world, and grown in most of all tropical countries. Regarding it, Brazil is the second largest producer of the world, processing 11.2% of total yield. Banana cropping generates one of the largest amount of residues and co-products due to post-harvesting decomposition, because banana is quite perishable. Considering these characteristics and the great availability of banana, its residue could be used in animal feeding. However, improvements on conservation and processing techniques that allow safety to animals and economic viability are necessary.

Furthermore, citrus pulp is a well-known co-product of orange crops (*Citrus sinensis* L. Osbeck), specifically a co-product of juice processing. Nowadays, the citrus pulp is usually sold under pellet form, which is largely used in different replacement levels in animal diets (Vargas & Ramirez, 2019). This dietary source has a fiber fraction of great digestibility. However, several intake restrictions were found when substitution of citrus pulp overtaken 30% of dry matter of total diet (Coan, 2008). According to Teixeira, Ciacco, Tavares, and Bonezzi (1998), citrus pulp is a co-product of orange industrial processing, which is constituted by discarded peels and pulps of whole fruits. Citrus pulp may present an average CP content of 6 g kg^{-1}, besides 110.0 g kg^{-1} of crude fiber content, and total digestible nutrient (TDN) content varying from 700.0 g kg^{-1} to 750.0 g kg^{-1}.

Based on this context, this study aimed to assess acceptability of *in natura* peach palm residues for ruminants, besides apparent and *in vitro* dry matter digestibility of these exclusively offered residues, or mixed with residues from rice, banana and orange processing industries.

Material and methods

Present study was carried out in two phases, according to criteria for each species (Conselho Nacional de Controle de Experimentação Animal [CONCEA], 2013) and protocol 134/10 of ethic committee. First phase consisted of the acceptability trial of peach palm residues for ruminants (cattle, buffaloes and sheep), and the second one, consisted of assays of apparent and *in vitro* dry matter digestibility (IVDMD) of *in natura* peach palm residues, only for sheep.

First phase was carried out in a farm located at Pariquera-Açú municipality, São Paulo State. Five crossbred Nellore cattle (average of one year-old and 340.0 kg); besides five buffaloes of Murrah breed (average of one year-old and 390.0 kg) and five Texel sheep (average of one year-old and 38.5 kg) were evaluated. Residue acceptability was evaluated according to dry matter intake and management facility. Thereafter, these residues were supplied to sheep, buffaloes and cattle.

Three different residues from peach palm were supplied to animals for three consecutive days, which were external sheath, palm heart tip and a basal portion known like 'head' (Silva & Leão, 1979). Intake behavior were assessed, from 7:00 a.m. to 4:00 p.m., by a same observer. Sheep received hay, and the buffaloes and the cattle occupied Marandu grass (*Brachiaria brizantha* Syn. Cv. Marandu) pastures. Thus, there were no fasting

of water or feed. All peach palm heart residues were accepted by all species, but because of its availability and easy processing, external sheath was the selected one for next experiment.

Second phase was carried out at Animal Science Institute, Nova Odessa, at São Paulo State. Apparent and *in vitro* dry matter digestibility of external sheath were assayed using sheep. Regarding intake evaluating and apparent digestibility, *in natura* peach palm residue was corrected for 250.0 g kg^{-1} DM. Crossbred Texel sheep that averaged 38.45 kg of body weight were previously treated with vermifuge. Animals were weighed before adaptation period, at the beginning and in the end of experimental period. These animals were individually housed into metabolic cages that contained feces and urine separators, which minimizing contamination by hair and urine.

This experimental phase was conducted under complete randomized design, with four treatments and five replications (animals). Four experimental diets were composed by 850.0 g kg^{-1} DM of *in natura* external sheath of peach palm, added to 150.0 g kg^{-1} DM of rice (PP + R) or banana (PP + B) residues, or either citrus pulp (PP + C). Moreover, *in natura* external sheath was assessed without any additive (PP). Feeds used in the present study was chosen because of great residue variety used for ruminant feeding in this region. Agroindustry Palmitos Selva S.A., from Registro municipality, donated the peach palm residue for the research project. Moreover, banana bunches were collected at Polo Vale do Ribeira – APTA – SAA. Lastly, Rice Processing Company of Pariquera-Açú donated the rice residues, and COALMA Company (Com. Prod. For Animal Nutrition), from Paulínia municipality, donated the pelletized citrus pulp. All residues were obtained from São Paulo state. Nutritional value (Silva & Queiroz, 2009; Tilley & Terry, 1963) of all these by-products was evaluated (Tables 1 and 2).

Experimental diets were daily adjusted according to the intake of previous day, then the orts approximately represented 100.0 g kg^{-1} of total supplied to provide voluntary intake, and not to alter the ingredients proportion (Silva & Leão, 1979). Dry matter intake was daily quantified by difference of supplied feed amount and orts. These orts were daily collected in the morning. Urine samples were collected with aid of appropriate containers that had 6N HCl (hydrochloric acid), which were added in necessary amount to maintain pH below 3.0, and avoid losses of nitrogen by volatilization. Daily volume was measured, and an aliquot of 10% was collected and stored under refrigeration for later analysis of urine nitrogen by Kjeldahl method, according to Silva and Queiroz (2009). Assays were composed by three periods, and the first one occurred for animal adapting to metabolic cages, which during 11 days. The second one during seven days, with the daily dry matter intake assessment. The last one had five days with the sampling of orts, feces and urine. In that period, animals received 90% of total supplied feeding compared to the previous phase (Silva & Leão, 1979).

Samples of feed, orts and feces were partially collected each day (about 10%). In the end of the five-day collecting, these daily samples formed a composite one, per animal. The composite samples were dried in forced air ventilation oven, at 55°C for 72 hours. Thereafter, samples were properly mowed at 1 mm, immediately conditioned into plastic bags and taken to the laboratory. Dry matter (DM), crude protein (CP), ether extract (EE), ashes, crude fiber (CF) and non-nitrogenous extract (NNE) contents were determined according to Silva and Queiroz (2009).

Coefficient of apparent digestibility of DM, neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined with the aid of total fecal collecting method. Dry matter intake (DM), neutral detergent fiber (NDF), acid detergent fiber (ADF), total carbohydrates (CHO), non-fibrous carbohydrate (NFC) and total digestible nutrient (TDN) were determined, and the calculation of apparent digestibility was obtained by following equation (Silva & Leão, 1979):

[(Nutrient intake in grams - amount in grams of nutrient in stool)/ Nutrient intake in grams)]/100

Dry matter *in vitro* digestibility (IVDMD) of external sheath from *in natura* peach palm was determined at Bromatology Laboratory of Animal Science Institute, Nova Odessa, São Paulo state, according to Tilley and Terry (1963). Collecting data were submitted to analysis of variance with the aid of SAS (1999) statistical package. In case of significant difference, means were compared by Tukey test at 5% of probability.

Results and discussion

Residues from peach palm are roughages with limited nutrients and have great moisture content (Table 1), which must be considered on the estimating cost of this feed (Schmidt et al., 2010).

Bromatological composition in the present study pointed out that external sheath presented higher protein, fiber and mineral contents (Table 2). Schmidt et al. (2010) classified palm heart peel residue as

fibrous, with 616.0 g kg^{-1} NDF, 96.0 g kg^{-1} CP, 742.0 g kg^{-1} *in vitro* digestibility and 106.0 g kg^{-1} DM, characteristics of an adequate roughage.

Table 1. Chemical-bromatological composition and *in vitro* dry matter digestibility of *in natura* peach palm (*Bactris gasipaes*) residues, banana bunch, broken rice and pelleted citrus pulp.

Variables	Feeds*			
	In natura RP	Banana	Rice	Citrus pulp
DM (g kg^{-1})	250.0	176.2	840.8	877.8
CP**	67.0	77.8	129.4	76.6
CF**	366.1	29.6	103.2	120.3
NDF**	649.7	181.5	87.0	225.6
ADF**	432.1	149.2	21.0	166.6
Lignin**	61.4	64.5	05.2	18.1
Cel**	370.7	85.0	16.6	228.5
Hem**	209.1	32.3	66.0	59.0
EE**	5.8	16.4	25.1	26.8
NNE**	554.3	803.9	722.6	699.9
Ash**	36.6	72.3	19.7	76.4
CF**	649.1	181.5	87.0	225.6
NFC**	57.9	652.0	738.8	594.6
NDF/NFC	11.22	0.28	0.12	0.38
IVDMD	534.8	859.9	896.5	884.2

**in natura* RP = *in natura* peach palm residue; Banana = bunch with stem; Rice = broken rice without classification ; citrus Pulp = pelleted. ** Results expressed as a g kg^{-1} of the dry matter.

Table 2. Chemical-bromatological composition of *in natura* peach palm (*Bactris gasipaes*) residues.

Peach palm residues	DM	CP	CF	EE	NNE	Ash	NDF
				(g kg^{-1})			
Heart of palm tip	219.6	46.0	296.8	12.2	601.5	43.9	627.4
External sheath	129.6	93.1	375.3	11.8	441.9	78.1	600.0

Bayão et al. (2014) studied chemical composition of the residue from Real palm heart production, and found greater DM, CP and EE contents in leaf residue than sheath ones. On the other hand, NDF and CP contents were greater for the sheath, which were more viable for ruminant feeding, because of CP content above 7%, as was found in present study. Thereby, external sheath of peach palm may guarantee an adequate ruminal fermentation (Sampaio et al., 2009).

Sheep presented average rejection of 43.5 g kg-1 in the first day of feeding (Table 3). However, buffaloes and cattle had acceptance of 100%, which can be explained by great selectivity of sheep compared to cattle and buffaloes, because of intrinsic differences about the dental arch and the form of forage seizure between sheep (lips) and bovines (tongue) (Milne, 1991) that likely affected their intakes. Presence of thorns in different residues of peach palm (palm heart tip, external sheath and basal portion) also may have influenced the results.

Analysis of variance indicated significant effect ($p < 0.05$) of feeding treatment on DM, CP, CF, NDF, ADF, lignin, cellulose, hemicellulose, EE, NNE, ash and NFC contents, besides FDN/NFC and IVDMD (Table 4).

Results of chemical composition of *in natura* peach palm residues in literature vary. Rodrigues Neto et al. (2001) found 260.0; 83.0; 79.0; 55.0; 564.0; and 372.0 g kg^{-1} of DM, CP, ash, EE, NDF and ADF contents of that residue, respectively. On the other hand, Andrade et al. (2002) observed 340.0; 75.0 and 650 g kg^{-1} of DM, CP and NDF contents of leafs from peach palm.

Table 3. Acceptability (%) of different *in natura* peach palm (*Bactris gasipaes*) residues by ruminants.

Peach palm residues	Sheep		Buffalos		Cattle	
	Feeding schedule – hours					
	7:00	16:00	7:00	16:00	7:00	16:00
Heart of palm tip	95.65	100.0	100.00	100.00	100.0	100.00
External sheath	95.65	95.65	100.00	100.00	100.0	100.00
Basal portion – head	95.65	95.65	100.00	100.00	100.0	100.00

*NA = not evaluated – unviability of the residue.

Table 4. Nutritional value of *in natura* peach palm (*Bactris gasipaes*) sheath exclusively supplied, or mixed with other agricultural residues.

Variables	Treatments*				Mean	CV
	PP	PP+B	PP+R	PP+C		(%)
DM (g kg^{-1})	250.0	250.0	250.0	250.0	250.0	-
CP**	67.0 b	72.0 b	91.0 a	69.0 b	74.7	11.1
CF**	366.1 a	329.1 b	258.2 d	302.0 c	312.9	0.51
NDF**	649.7 a	567.0 b	451.2 d	489.2 c	539.8	0.20
ADF**	432.1 b	460.7 a	310.4 d	355.3 c	390.1	0.46
Lignin**	61.4 b	65.1 a	44.7 d	54.2 c	56.5	0.90
Cel**	370.7 a	335.9 b	266.6 d	298.3 c	317.7	0.18
Hemi**	209.1 a	106.3 d	140.8 b	133.9 c	147.5	0.62
EE**	05.8 c	05.7 c	12.6 a	11.6 b	09.1	1.69
NNE**	554.3 d	576.2 c	660.6 a	619.8 b	602.1	0.23
Ash**	36.6 b	48.2 a	26.9 c	49.6 a	39.9	2.08
NFC**	57.9 d	129.1 c	259.3 a	199.6 b	161.3	2.41
NDF/NFC	112.2 a	43.9 b	17.4 d	24.5 c	49.3	4.99
IVDMD	534.8 b	529.1c	594.5 a	584.9 a	560.8	0.22

Means followed by different letters in same row differ from each other by Tukey test at 5% *PP = Peach palm sheath without additives; PP+B = Peach palm sheath + banana residue; PP+R = Peach palm sheath + rice residue; PP+C = Peach palm sheath + citrus pulp residue. ** Results expressed as a g kg^{-1} of the dry matter.

Peach palm sheath mixed with broken rice provided better CP content than exclusive peach palm sheath one, with an increase of 358.2 g kg^{-1}. In this sense, there were no difference among the other treatments. Crude protein contents observed in exclusive residue additives (Table 1) had same tendency observed in CP contents of those residues added to *in natura* peach palm sheath (Table 4).

Difference among treatments was found regarding cell wall constituents. Exclusive *in natura* peach palm sheath presented the greatest NDF content (649.7 g kg^{-1} of DM), unlike that one of peach palm sheath mixed with broken rice, which had the lowest NDF content (451.2 g kg^{-1} of DM). On the other hand, ADF content ranged from 310.4 g kg^{-1} (peach palm sheath mixed with broken rice) to 460.7 g kg^{-1} (sheath mixed with banana bunch). The greatest lignin content was obtained from peach palm sheath mixed with banana bunch. Broken rice inclusion on the peach palm sheath quite reduced NDF, ADF, cellulose and lignin contents, factors that improved quality of that roughage.

Exclusive peach palm sheath presented the greatest cellulose content (330.7 g kg^{-1} DM), followed by those ones mixed with banana bunch, broken rice and citrus pulp. *In natura* peach palm residue mixed with broken rice stood out due to lowest lignin content (44.7 g kg^{-1} in DM). Exclusive peach palm sheath also had greatest contents of NDF and cellulose (649.7 g kg^{-1}). Inclusion of banana bunch to *in natura* peach palm sheath raised ADF and lignin contents (460.7 and 65.1 g kg^{-1}, respectively). However, the banana residue presented lower ADF content than peach palm residues and citrus pulp (Table 1), although the peach palm sheath mixed with banana residue presented greatest lignin content.

Exclusive peach palm sheath had greatest hemicellulose content (209. g kg^{-1}), while the lowest one occurred when banana bunch was added (106.3 g kg^{-1}). This difference represents reducing of 102.9 g kg^{-1} on hemicellulose content. Others treatments presented intermediate values. These results could be explained by great hemicellulose contents presented in banana peels and stems.

There was no difference between treatments of banana bunch (48.2 g kg^{-1}) and citrus pulp (49.6 g kg^{-1}) added to peach palm sheath, but they were greater ($p < 0.05$) than exclusive peach palm sheath (36.6 g kg^{-1}) and that one mixed with broken rice (26.9 g kg^{-1}). These results likely occurred because of greater ash contents of banana bunch and citrus pulp, compared to the other residues (Table 1).

Non-fibrous carbohydrate contents varied from 57.9 to 259.3 g kg^{-1}. The lowest observed value occurred on the exclusive sheath of *in natura* peach palm heart, while the greatest one was observed on peach palm sheath mixed with broken rice. Although the NFC content of banana bunch had been greater than citrus pulp one (Table 1), when added to external sheath, it provided a lower NDF content compared to that peach palm residue added to citrus pulp (Table 4).

Diets with high NDF/NFC ratios often provide low digestibility. Exclusive *in natura* peach palm sheath presented the greatest observed ratio (112.2), while that roughage mixed with broken rice presented the lowest one (17.4). High NDF/NFC ratios characterize predominance of slow-digestion carbohydrates that cause filling effect in the rumen (Mulligan, Quirke, Rath, Caffrey, & O'Mara, 2002).

Greater *in vitro* dry matter digestibilities were observed on treatments of peach palm sheath mixed with citrus pulp (584.9 g kg^{-1}) and rice (594.5 g kg^{-1}). Lowest IVDMD was observed on treatment of banana bunch adding (529.1 g kg^{-1}). This value even was lower than IVDMD of exclusive peach palm sheath (534.8 g kg^{-1}). These results could be explained by the quality of each residue. Despite banana bunch presents great total carbohydrate contents, it presents a large amount of resistant starch. This amount could represent 84% of the total starch (Freitas & Tavares, 2005).

According to Rodrigues Neto et al. (2001), potential of the peach palm residues for dry matter (DM), crude protein (CP) and neutral detergent fiber (NDF) yield, as roughage source, is similar to that one of corn and sorghum hybrids (Almeida Filho, Fonseca, Garcia, Obeid, & Oliveira, 1999; Ferreira, Neiva, Rodriguez, Lôbo, & Vasconcelos, 2004), besides elephant grass and sugarcane (Botrel & Xavier, 1998). These facts pointing out possibilities of by-products exploitation from after-extracting of peach palm heart.

Inclusion of residues from rice and orange cropping increased IVDMD of *in natura* peach palm sheath, and thereby, these treatments were considered roughages of good nutritional value. On the other hand, peach palm sheath mixed with banana bunch had great ADF and lignin contents, besides lower IVDMD (Table 4), which decreased nutritional value of that roughage. This fact could worsen the animal performance.

Among all treatments, *in natura* peach palm sheath mixed with broken rice presented the best nutritional value, with 91.0 g kg^{-1} of CP content; 258.2 g kg^{-1} of CF content; 451.2 g kg^{-1} of NDF content; 44.7 g kg^{-1} of lignin content; and 594.5 g kg^{-1} of IVDMD. Regarding it, this treatment was the best final obtained by-product.

Considering the nutritional value, peach palm sheath mixed with citrus pulp was the second best one roughage, which presented 69.0 g kg^{-1} of CP content; 302.0 g kg^{-1} of CF content; 489.2 g kg^{-1} of NDF content; and 54.2 g kg^{-1} of lignin content. Moreover, IVDMD was 584.9 g kg^{-1} and considered average.

There was no effect of feeding treatment ($p > 0.05$) on initial and final weight, or else on average daily gain, during observed period (Table 5). These type of results usually occurs in digestibility assays, when periods of data collecting are relatively short (21 days) and animals are under maintenance status (Silva & Leão, 1979).

Apparent digestibility coefficient of DM, CP, EE, NDF, hemicellulose, ADF, total CHO, NFC, TDN had significant difference ($p < 0.05$) regarding the feeding treatments (Table 6).

The greatest coefficient of apparent DM and CP digestibilities were obtained in peach palm sheath mixed with broken rice and citrus pulp (Table 6). There were significant difference ($p < 0.05$) on the EE apparent digestibility among all treatments, and that one mixed with broken rice presented the greatest value, followed by peach palm sheath mixed with citrus pulp. These results could be a consequence of the great EE and the lower structural carbohydrates contents of rice residue (Araújo et al., 1998).

Table 5. Initial weight, final weight, daily weight gain of sheep consuming *in natura* peach palm (*Bactris gasipaes*) sheath exclusively supplied, or added to other agricultural residues.

Variables	Treatments*				Means	CV (%)
	PP	PP+B	PP+R	PP+C		
Initial weight (Kg)	38.40	39.10	38.66	38.50	38.67	11.30
Final weight (Kg)	37.60	37.20	40.50	37.75	38.26	9.30
ADG** (Kg day^{-1})	-1.96	-5.18	4.64	-1.52	-1.00	10.40

*PP = Peach palm sheath with no additives; PP+B = Peach palm+ banana bunch; PP+R = Peach palm+ broken rice; PP+C = Peach palm+ citrus pulp. **Average daily gain.

Table 6. Apparent digestibility coefficient of nutrients of *in natura* peach palm sheath exclusively supplied, or else added to other agricultural residues.

Parameters of Digestibility (g kg^{-1})	Treatments*				CV (%)
	PP	PP+B	PP+R	PP+C	
DM	607.0 b	589.0 b	668.0 a	656.0 a	4.67
CP	626.0 b	541.0 c	673.0 a	663.0 a	4.02
EE	609.0 d	587.0 c	769.0 a	744.0 b	6.31
NDF	523.0 a	481.0 b	526.0 a	528.0 a	9.44
Hemicellulose	492.0 b	513.0 a	517.0 a	446.0 c	5.12
ADF	453.0 b	442.0 b	449.0 b	558.0 a	6.99
Total CHOs	563.0 b	559.0 b	682.0 a	673.0 a	5.32
NFC	548.0 b	581.0 b	711.0 a	667.0 a	7.14
TDN	535.0 b	529.0 b	595.0 a	585.0 a	5.13

Means followed by different letters in same row differ from each other by Tukey test at 5% probability. *PP = Peach palm sheath with no additives; PP+B = Peach palm+ banana bunch; PP+R = Peach palm+ broken rice; PP+C = Peach palm+ citrus pulp.

There were difference among feeding treatments regarding the cell wall constituents. Peach palm sheath mixed with banana bunch had the lowest NDF apparent digestibility. Banana bunch and broken rice as additives improved hemicellulose apparent digestibility, compared to exclusive peach palm sheath (Table 6). Likewise, citrus pulp improved ADF apparent digestibility.

Apparent digestibility of total CHO was greater on the peach palm sheath mixed with broken rice and citrus pulp. Roughages composed by exclusive peach palm sheath, or added to banana bunch had lower results. In the present study, obtained total CHO contents were down below than those ones observed by Rodrigues Neto et al. (2001).

Apparent digestibility of NCF from roughages mixed with broken rice and citrus pulp were superior to the exclusive peach palm sheath, or either mixed with bunch banana. Same pattern of responds occurred for TDN apparent digestibility, and residues of rice and orange cropping stood out again, compared to exclusive peach palm sheath and residue of banana cropping.

There were feeding treatment effect ($p < 0.05$) on daily dry matter intake (kg day^{-1} DM), and this intake considering body (%BW) and metabolic weight (g kg^{-1} $BW^{0,75}$) . Broken rice and citrus pulp added to the peach palm sheath provided greater daily intake, and consumption per kilogram of metabolic weight. (Table 7).

Table 7. Dry matter intake estimating in days (Kg day^{-1} DM), percentage of body weight (%BW) and grams per kilogram of metabolic body weight (g kg^{-1} $BW^{0.75}$) of *in natura* peach palm sheath exclusively supplied, or else added to other agricultural residues.

Intake parameters	Treatments*				CV
	PP	PP+B	PP+R	PP+C	(%)
Kg DM day^{-1}	0,60 c	0.82 b	1.12 a	0.92 a	14.11
% BW	1.89 c	2.63 b	3.11 a	2.74 b	16.22
g kg^{-1} $BW^{0,75}$	50.8 b	59.9 b	85.7 a	82.4 a	18.23

Means followed by different letters in same row differ from each other by Tukey test at 5% . *PP = Peach palm sheath with no additives; PP+B = Peach palm+ banana bunch; PP+R = Peach palm+ broken rice; PP+C = Peach palm+ citrus pulp.

These treatments also had greater dry matter intake per kilogram of body weight, compared to the exclusive peach palm sheath and that roughage mixed with banana bunch (Table 7). Broken rice and citrus pulp inclusion provided a dry matter intake beyond the nutritional requirement for maintenance status of sheep, which varies from 1.5 to 3.0% of body weight (National Research Council [NRC], 2007). These results demonstrated that inclusion of different agricultural residues considerably modified the amount of ingested feed by animals.

Conclusion

External sheath of peach palm can be an alternative source of roughage for ruminant feeding, because of its nutritional value and dry matter intake. This residue using can add value for peach palm heart industry, considering the possible reducing of environmental impact and decreasing of operational costs due to the irregular disposal.

Rice residues and citrus pulp inclusion increase the quality of peach palm external sheath, despite it do not improve sheep performance. Regarding it, further studies are necessary, mainly about other ruminant species like buffaloes and cattle.

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