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Review article

# Rumen parameters of sheep fed cassava peel as a replacement for corn

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ABSTRACT

We hypothesized that cassava peel, high in energy, could replace corn and used as energy resource for animal feed in the tropics. This study assessed the intake, total apparent digestibility of nutrients, rumen parameters (pH, $NH_3$-N, and volatile fatty acids), and rumen dynamics of NDF of sheep fed with different corn replacement levels with cassava peel (0, 25, 50, 75, and 100%). Five castrated Santa Ines sheep with an initial average weight of 42.0 ± 4.44 kg were fistulated in the rumen and distributed in a 5 × 5 Latin square design, divided into five 14-d periods. Cassava peel levels had no effect on the DM intake (1364 g/d), DM digestibility (691 g/kg), pH (6.45), and N-$NH_3$ concentration (20.7 mg/100 mL). Collection time after feeding showed effect in both ruminal pH and N-$NH_3$ concentration. A quadratic effect was found for propionate concentration and acetate:propionate ratio. There was no effect of cassava peel levels on the ruminal pool of NDF (504 g) and NDFi (285 g), as well on the rate of ingestion (0.060%/h), digestion (0.033%/h), and passage of NDF (0.026%/h). Thus, we recommend the total replacement of corn with cassava peel in the diets of sheep.

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## 1. Introduction

To meet the nutritional requirements of the animals and to sustain their productivity and profitability, alternative feed sources have been researched (Wadhwa and Bakshi, 2013). This alternative feed could replace cereal grains when production is impaired due to prolonged drought, and when there are a great competition in the market associated with elevated prices. Therefore, alternative energy sources such as cassava tubers and agroindustry residues could rationally be used in ruminant feeding (Baiden et al., 2007) to supplement the energy of animals during seasons when feed is scarce and to reduce feeding costs.

Among the feedstuffs that have been tested as alternative ingredients, cassava is highlighted as a high energy resource for animal feed in the tropics. It demonstrates versatility in its use, agricultural characteristics that allow for the exploration of cassava in high or low conditions of technology, and can be produced throughout the year to guarantee a constant supply for the animals.

The cassava peel result from stripping the roots, represent around 20% of the total weight of the fresh root, and can be utilized in fresh, hay, or ensiled forms in animal feeds (FAO, 2013). The cassava peel have a total carbohydrate content of 86.2%, and thus become an alternative for the replacement of corn. However, due to the reduced crude protein content (4.51%) (Ferreira et al., 2007), it is necessary to correct the nitrogen source, which did not decrease the use of cassava in the finishing of animals (Abrahão et al., 2005). Based on this, the cassava peel is a potential ingredient in the diets of growing sheep (Baah et al., 2011). Moreover, using the residue in the animal feed could help to reduce ambient impacts, since cassava wastes discarded, in most cases without any treatment, into water bodies near to the manipulation places, increase the biochemical oxygen demand (BOD) reducing the oxygen availability in river waters (Souza et al., 2014).

In the most of works carried out with cassava peel, the waste is coming from cassava industrialization for flour production (Santos et al., 2015; Prado et al., 2006; Marques et al., 2000), and the residues (cassava peels) obtained mechanically are characterized by high fiber content (Baah et al., 2011; Caldas Neto et al., 2000; Baah et al., 1999), varying between 33 and 50% of NDF, in a function of a better processing efficiency for peel removal. Santos et al. (2015) using cassava peel acquired from the starch industry for lactating cows, verified linear decrease on the intake and digestibility of DM, due to increase in the NDF and ADF contents in the rations. However, there are few studies with cassava peel obtained from Family Farming. In this study, the purpose was work out with cassava waste obtained by manual cutting by Rural Family Houses, in

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**Table 1**
Chemical composition of the diet ingredients based on dry matter (g/kg DM).

| Nutrients | Cassava peel | Ground corn | Soybean meal | Tifton hay |
|---|---|---|---|---|
| Dry matter (g/kg) | 883 | 899 | 909 | 887 |
| Organic matter | 927 | 977 | 931 | 910 |
| Crude protein | 49.5 | 105 | 507 | 85.9 |
| Ether extract | 20.9 | 40.0 | 34.7 | 33.1 |
| Neutral detergent fiber | 229 | 116 | 148 | 738 |
| Acid detergent fiber | 148 | 41.4 | 68.4 | 332 |
| Non-fiber carbohydrates | 628 | 715 | 241 | 53.6 |
| Starch | 561 | 693 | 184 | 19.0 |
| Indigestible neutral detergente fiber | 171 | 28.6 | 17.7 | 236 |

which this residue consisted of the root tip, peel and pulp, different from those obtained for agroindustry.

Therefore, the aim of this study was to evaluate the effects of replacing corn with cassava peel and to test the hyphothesis that cassava peel obtained from Rural Family Farming can partially or totally replace corn for sheep without affecting intake and digestibility of nutrients, rumen parameters (pH, N-$NH_3$, and volatile fatty acids), and rumen dynamics of NDF.

## 2. Material and methods

The experiment was conducted in the Feed Evaluation Laboratory for Small Ruminants II of the Universidade Federal Rural de Pernambuco, Recife, Brazil. All animal handling practices followed the recommendations of the National Council of Animal Experimentation Control (CONCEA), under process number 23082.006199/2012 and licence number 009/2015.

### 2.1. Animals and experimental diets

Five castrated male Santa Ines sheep, fistulated in the rumen, with an average initial body weight of $42.0 \pm 4.44$ kg were used. They were distributed across a $5 \times 5$ Latin square design, with five experimental periods lasted 14 days and were divided as follows: seven days for adaptation to the diets and seven days to collect data and samples. The animals were housed in individual slatted floor pens and given ad libitum access to water and feed.

The cassava peel was acquired from the Rural Family Houses, located in Glória do Goitá, Pernambuco state, Brazil. To obtain this byproduct, cassava roots were washed and manually peeled. The cassava peel was characterized by a residue composed by peel, fiber, and pieces of cassava pulp (root tip). Cassava peels were dried on concrete floors under direct sunlight for 2 days, reaching DM content of about 88%, and stored in plastic bags. After, the cassava peel was processed in forage machine, and milled in similar size to corn particle. The mixture, urea+ammonium sulfate, was used to correct the cassava peel protein. The experimental diets consisted of five replacement levels of corn with cassava peel (0, 25, 50, 75, and 100%) (Tables 1 and 2).

**Table 2**
Ingredient proportion and chemical composition of the experimental diets.

| Ingredients (g/kg) | Replacement levels (cassava peel replacing corn, %) | | | | |
|---|---|---|---|---|---|
| | 0 | 25 | 50 | 75 | 100 |
| Cassava peel | 0 | 46.1 | 93.3 | 140 | 186.6 |
| Ground corn | 190 | 143 | 95 | 47.5 | 0 |
| Soybean meal | 165 | 165 | 165 | 165 | 165 |
| Tifton hay | 630 | 630 | 630 | 630 | 630 |
| Urea/ammonium sulfate[a] | 0 | 0.90 | 1.70 | 2.50 | 3.40 |
| Mineral mix | 15 | 15 | 15 | 15 | 15 |
| Total | 1000 | 1000 | 1000 | 1000 | 1000 |
| Chemical composition (g/kg DM) | | | | | |
| Dry matter (g/kg) | 894 | 894 | 893 | 892 | 892 |
| Organic matter | 913 | 909 | 906 | 903 | 899 |
| Crude protein | 158 | 158 | 157 | 157 | 157 |
| Ether extract | 33.8 | 32.9 | 32.0 | 31.1 | 30.1 |
| Neutral detergent fiber | 511 | 516 | 521 | 527 | 532 |
| Acid detergent fiber | 228 | 233 | 238 | 243 | 248 |
| Non-fiber carbohydrates | 212 | 208 | 203 | 198 | 194 |
| Starch | 174 | 167 | 161 | 154 | 147 |
| Digestible organic matter | 683 | 656 | 659 | 642 | 640 |
| NDFi[b] | 157 | 164 | 170 | 177 | 183 |

[a] Nine parts of urea to one part of ammonium sulfate mixed in the concentrate of diet.
[b] Indigestible neutral detergente fiber.

### 2.2. Intake and digestibility of nutrients

Diets were offered as total mixed ration twice daily in two equal meals at 8 h and 16 h. During all experiment, the offerings and orts were weighed daily to calculate the voluntary intake and to adjust the offered feed in order to guarantee 10% of orts.

Animals were kept in metabolism cages fitted with plastic feeders for supply of hay and concentrate, and plastic bucket for water supply. The fecal dry matter output was estimated using the total collection of feces, which was realized using collection bags adapted to each animal from the 1st to the 3rd day of each period. The bags remained attached for 24 h in animals and the feces collection was performed twice daily (07:00 and 17:00 h) in each experimental period. Immediately after collection, samples were placed in plastic bags properly identified, weighed and frozen at −18 °C. At the end of each experimental period, fecal samples were unfrozen at room temperature for elaboration of composite samples. Fecal composite samples were elaborated by homogenizing all the samples obtained by the same animal in the period, and sampled a portion of, approximately, 500 g/animal/period. Immediately after this procedure, fecal samples were ovendried (60 °C; 72 h). Afterwards, samples were ground to 2 mm through a Willey mil, packed in plastic bags and stored for further analysis.

The direct method was used for the determination of apparent digestibility of the nutrients, by evaluating the levels of nutrients in feed samples and feces. The apparent digestibility (AD) was obtained using the equation described by Coelho da Silva and Leão (1979): $AD = ((Nf - No - Nfc)/(Nf - No)) \times 100$, where: Nf = nutrient in feed (g); No = nutrient in orts (g); and Nfc = nutrient in feces (g).

### 2.3. Rumen parameters

On the last day of each collection period, ruminal contents were sampled at 0, 2, 4, and 6 h post morning feeding to determine the pH, ammonia nitrogen (N-$NH_3$), and concentration of volatile fatty acids (VFA). Rumen contents (~100 mL) were collected once at each sampling time from the ventral sac by using a stomach tube, and the composite samples taken from each sheep were strained through 4 layers of cheesecloth. The pH was immediately measured after collection using a pH metre. After, 1 mL of 1:1 sulfuric acid ($H_2SO_4$) was added to the sample, which was then stored in the freezer at −18 °C for later ruminal N-$NH_3$ concentration analysis, according to

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