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Values of Cassava Tuber Peels Produced in the Farms and Home-Scale Snack Food Industries as Feed Based on Yield Rate, Crude Nutrient, and Mineral Composition

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ABSTRACT

The Payakumbuh region is an important tourist destination in West Sumatra. They produce various snack food made from cassava tubers, producing a large cassava peel as a by-product. The research aimed to study the meal yield rate, crude nutrient, fiber fraction, and mineral composition of cassava peels as by-products of cassava farm and snack food industries. Twenty cassava farms and ten snack food industries were visited, and the owners were interviewed for data on the type of cassava used, products, and handling of cassava peel. The quantity of cassava peel produced and potentially used as feed was recorded. Samples of fresh peels from three different varieties and tuber sizes were collected, weighed, dried, and ground in meal form to determine the meal yield rates and analyze for dry matter (DM) content, crude nutrient, fiber fraction, and mineral composition. Results found three cassava cultivars used to produce snack foods, i.e., black, bread, and sticky cassava. The percentage of fresh peel and meal yield rates ranged from 16.4-16.7% and 21.9-26.9%, respectively. DM and crude protein content varied between 23.8 to 27.0% and 9.3 to 11.2%, respectively. Bread cassava peels showed the highest DM, ash, and ADF content. Cassava peel contained considerably high Fe and was a good source of K, Mg, P, Na, Mn, and Zn.

Key words: Cassava peel, crude nutrient, fiber fraction, mineral composition.

INTRODUCTION

The Payakumbuh which cover Payakumbuh city and Limapuluh Kota district, is known as beef cattle and goat breeding centre in West Sumatra (Khalil *et al*., 2019, Kurnia *et al*., 2015). Beef cattle and goat farming are dominated by smallholders and supported by an agricultural system in which annually small-scale crop estates dominate as potential sources of forages, green fodder, and agricultural and agro-industrial by-products. One potential agro-industrial by-product is cassava tuber peel as a by-product of cassava tuber processing to produce various snack food. Cassava peel is available in the cassava farming land and snack food industries. Many outlets along the main road direct to the Riau province offer a variety of snack food made from cassava tuber as typical West Sumatra souvenirs for retailers, travelers, and tourists. The region of Payakumbuh is located along the main road connecting West Sumatra to Riau province, traversed by many types of inter-provincial vehicles. Payakumbuh is also an important tourist destination in West Sumatra. Many exciting tourist objects, such as Ngalau, Harau Valley, Kelok Sembilan, and Padang Mengatas Beef Cattle Breeding Center, encourage tourists to come to Payakumbuh.

In the snack food home industries, processing and peeling of the cassava tuber are carried out almost every day to produce various types of chips, crackers, and ready-to-eat snacks. They use sweet-type cassava cultivars. The skin and periderm parts are separated manually by gradually slicing the fleshy edible portion's surface with a knife. As the residue from the root pre-cleaning, the cassava peel comprises peel (composed of cracked bark), inner peel (between cortex layer and central cylinder), discarded tubers, and tuber tips. Farmers collect fresh peels presumably rich in residual starch from the fleshy edible part to feed goats and cattle. The peels are soaked in water to reduce cyanogenic glucosides and soil adhering to the periderm. Using this agricultural by-product for livestock in fresh form is considered safe. The peels are mixed with rice bran and tofu pulp before feeding to beef cattle or goats as additional feed in fresh conditions. The fresh peels are presumably rich in residual starch from the fleshy edible part and potentially used as energy sources for poultry and monogastric livestock.

On the other hand, cassava tuber peels on the farm are mostly discharged and dumped and permitted to rot, causing environmental problems, such as unsightly scenery and odor. The fresh tubers are hand peeled directly on the farm with a table knife to rid the two outer coverings, composed of skins (cortex) and epidermis (bark). Farm owners harvest only the fleshy edible portion, while the peels account for about 10-20% of tuber by weight (Ratnadewi et al., 2016; Asharuddin *et al.*, 2017) and are still underutilized. According to Ajagbe *et al.* (2020), the use of cassava peel in ruminant diets was intended to optimize the utilization of low-quality feeds like crop residues, enhance maximizes roughage degradation, and optimize rumen microbial protein synthesis. Otache *et al.* (2017) reported cassava peels are rich in sugars and polysaccharides such as starch and hemicelluloses. The peel contains about 5 % crude protein and a reasonable amount of minerals (Tewe and Kasali, 1986). Cassava peels could be used as a cheap source of readily available carbohydrates for ruminants. Pertiwi *et al.* (2019) reported that using cassava peel as feed for dairy cattle increased milk's total solid and protein level.

There are few reports on the potency of cassava wastes as feed in the Payakumbuh region. Notably, there is no published information on crude nutrient and fiber fraction and mineral composition of cassava peels produced from different cassava cultivars and peeling practices. The nutrient content, mineral composition, and nutritional values of cassava peel depend on the cassava cultivar and peeling methods.

Therefore, the present research aimed to study the new meal yield rates, crude nutrient, fiber fraction, and mineral composition of cassava peels as by-products of cassava farm and snack food industries. Analysis and evaluation of the nutrient composition and mineral contents of different varieties of cassava produced, thereby providing documented information that will be useful in cassava waste management and enable its optimal use as feeds for various types of ruminant animals.

MATERIALS AND METHODS

Twenty local cassava cultivation farms and ten home-scale snack food industries were visited and observed the process of pre-washing the cassava processing and collecting data of cassava tuber peel production. The cassava farms were distributed in six villages and two subdistricts (Halaban and Tanjung Gadang) as cassava farming centers in the Limapuluh Kota district of West Sumatra. The snack food industries are located along the main road of Payakumbuh city and Limapuluhkota district. Different types of cassava are planted and used in every farm and company to define the number and type of cassava variety in snack food production. The owners of farms and companies were interviewed to gain information on cultivation practices, harvesting techniques, total cassava production, type of products of the processing companies. We observed and noted the morphological character of fresh tubers and peels based on parameters that Fukuda et al. (2010) described. A sample of fresh peels derived from 5 kg of intact cassava tuber of each casava type was collected and weighed to calculate the percentage of the fresh peel. The fresh peel samples were packed in individual polythene bags and brought to the laboratory for drying and preparation of chemical analysis.

Fresh peel samples were chopped and dried under the sun for two days and then in a forced draught oven at 60ºC for 48 hours. The air-dried samples were weighed and ground through a 0.5-mm screen mill to produce peel meals. The meal products were measured to calculate the meal yield rate before analyzing the dry matter, crude nutrient, fiber fraction, and minerals. DM and crude nutrients of protein, fat, ash, and fiber were determined using proximate procedures (AOAC, 2005). Fiber fraction of neutral detergent fiber (NDF), acid detergent fiber (ADF), and cellulose were determined according to the method described by Goering and Van Soest (1970). The concentration of minerals was determined using the atomic absorption spectrophotometer (AAS, 1996). All analysis results were reported on DM basis. Analysis of variance (ANOVA) was used to compare the mean and the level of significant difference determined at $p<0.05$ using an SPSS program (Version 21) (IBM).

RESULTS AND DISCUSSION

Peel Characteristics and Yield Rate

Three types of local cassava cultivars were planted or used for making snack food in the Payakumbuh region, i.e., black, bread, and sticky. Black cassava was the cultivar grown by farmers, while snack food companies used the bread and moist types. According to Firdaus *et al.* (2016), there were 15 cassava cultivars commonly found in West Sumatra. The tubers showed various tuber shapes conical, cylindrical (cylindrical cone), cylindrical, and irregular. The black cassava root differed from the bread and was sticky based on shape, size, and color. Table 1 shows the physical characteristics of the three local cassava tuber cultivars in the Payakumbuh region based on morphological parameters described by Fukuda *et al*. (2010). Black cassava tuber hat cylindrical shape with bigger size and bitter taste than bread and sticky cassava. Livestock farmers might be considered that the black cassava peel contained a high cyanide level. These findings indicated that the main factor for underutilized black cassava peels in Payakumbuh is presumably concern about the cyanide content. Idris *et al.* (2020) reported that the limitation of recommended cyanide level in feed is 10 mg HCN equivalent/kg dry weight which means cassava peel cannot be consumed in fresh and raw conditions.

Table 1. Morphological characteristics of cassava root and yield rate of peel

Parameter	Type of cassava		
	Black Cassava	Bread Cassava	Sticky Cassava
Root shape			
▪ Shape	Cylindrical	Conical-cylindrical	Conical
▪ Size	Big	Small	Small
Root pulp (parenchyma):			
▪ Colour	White	Cream	Cream
▪ Taste	Intermediate	Sweet	Sweet
Cortex:			
▪ Colour	White	Cream	Cream
▪ Thickness	Thick	Thin	Thin
▪ Ease of peeling	Easy	Difficult	Difficult
Periderm:			
▪ Colour	Dark brown	Light brown	Yellow
▪ Texture	Rough	Intermediate	Smooth
Yield rate of peel:			
▪ Percentage of fresh peel (% root weight)	16.74± 0.52	16.41±0.30	16.50±0.21
▪ Meal yield rate (% fresh peel)	25.42± 0.84 ^{b}	26.85±0.69 ^{a}	21.93±0.90 ^{c}

Mean ± standard deviation

Moreover, the tuber's outer layer is composed mainly of dead cork cells called periderm, and the layer located beneath the periderm is called the cortex. The cortex of black cassava was thicker and easier to peel than that of bread and sticky cassava. Still, there was no significant difference in the fresh peel percentage, which accounted for about 16% of intact root weight (w/w). These values were higher than the reported values of 10% (Idris *et al*., 2020). However, the bread type found the highest meal yield rate due to the highest dry matter content (Table 3), followed by the black and sticky cassava tubers. According to Ezekiel *et al.* (2010), the thickness of cassava peels varies between 1 to 4 mm and may account for 10 to 13% of the tuber dry matter. The yield rate of the meal ranged between 21.9-26.9% of the fresh peel. Bread cassava produced the highest meal yield rate ($p<0.05$), followed by black and sticky cassavas.

Dry Matter, Crude Nutrient, and Fiber Composition

The dry matter, crude nutrient, and fiber composition of cassava peel are presented in Table 2. The DM ranged from 23.8 to 27.0% (FW). Bread cassava peel has the highest dry matter, followed by sticky and black types. However, the dry matter content in peel was comparable to 27.5% (Souto *et al*., 2017), lower than 33.5% (Afolabi *et al*., 2012), and 28.8 to 33.0 % (Otache *et al*., 2017). Otache *et al*. (2017) reported that the dry matter content of cassava peel derived from three sweet cassava cultivars ranged from 28.8 to 33.0 % fresh weight. Crude protein ranged from 9.2 to 11.2%. There was no statistically significant difference in crude protein content. The crude protein content was much higher than the crude protein of 2.4 to 4.3% cassava peel from three cultivars, as Otache et al. (2017) reported. The crude protein content obtained in this study was also higher than the 3.7% reported by Afolabi *et al*., 2012)

Crude fiber represents that portion of carbohydrate that is not digestible by the body, and it mainly consists of mainly of cellulose (60-80%), lignin (4-6%), and other soluble fiber (Eleazu and Eleazu, 2012). Based on the findings, all samples showed significant differences in the crude fiber content and fiber fractions. Crude fiber ranged between 9.4 to 16.1%. Peel from black cassava tuber hat the lowest crude fiber, NDF, ADF, and cellulose, followed by the bread and black cassava. The black cassava peel was also rich in nitrogen-free extract (NFE) as a readily available carbohydrate. This suggests that cassava peel from the black variety could also be used to feed ruminants and monogastric. The fiber fraction content of NDF, ADF, hemicellulose, and cellulose followed the pattern of crude fiber. In general, crude fiber and ADF content of the cassava peel was optimal for ruminants, according to Luthfi *et al.* (2018), who reported that about 15% of crude fiber content is required in the ruminant feed (Luthfi *et al.*, 2018).

The crude ash content ranged from 16.7 to 31.8%. Bread cassava peel has the highest crude ash content, followed by sticky and black cassava tuber peels. Values obtained were much higher than those obtained from other studies by 2.5-4.5% (Daud *et al*., 2013; Otache *et al*., 2017). The high crude ash content is caused by residual soils and sand attached to the periderm. It is referred to the data from Idris *et al.* (2020), who reported that periderm contained about 15% crude ash. Cassava peel had a very low crude fat of only 1.5%. The crude fat levels from the present results are comparable with current values reported by Idris *et al*. (2020). On the other hand, crude ash content in the black cassava peel was significantly lower than in the two varieties.

Table 2. Dry matter, crude nutrient, and fiber fraction content of cassava tuber peel derived from three different cassava varieties.

Parameters	Black Cassava	Bread Cassava	Sticky Cassava
DM content (% fresh weight)	23.80 (0.69) [b]	27.02 (0.91) [a]	25.32 (0.55) [ab]
Crude nutrient content (% DM)			
▪ Crude protein	10.50±2.23	9.27±1.10	11.20±0.93
▪ Crude fiber	9.43± (0.58) [c]	14.48± (0.43) [b]	16.13± (1.03) [a]
▪ Crude ash	16.70± (1.60) [b]	31.76± (2.84) [a]	19.74± (3.70) [b]
▪ Crude fat	1.45± (0.29)	1.48± (0.95)	1.46± (0.38)
▪ Nitrogen Free Extract (NFE)	61.93± (1.48)	43.01± (1.83)	51.47± (3.82)
Fiber fraction (% DM)			
▪ Neutral detergent fiber (NDF)	39.45± (1.91) [c]	50.84± (1.38) [b]	60.36± (1.67) [a]
▪ Hemicellulose	13.70± (2.47) [b]	8.14± (1.40) [b]	23.50± (2.58) [a]
▪ Acid detergent fiber (ADF)	25.75± (1.26) [c]	42.70± (1.13) [a]	36.86± (1.06) [b]
▪ Cellulose	2.98± (0.53) [c]	10.92± (1.05) [b]	14.16± (1.76) [a]

Mineral Composition

The mineral substance of the peels of the three cassava cultivars studied is shown in Table 3. Except for potassium, the local cassava peels were poor in macro minerals of Ca, P, Mg, and Na, with an average concentration of <1.0 g/kg DM). Still, they had a relatively high potassium concentration of 5.0 to 7.6 g/kg DM. The Ca, P, K, and Mg levels obtained in this study were higher than the mean concentration of Ca, P, K, and Mg of 0.31; 0.32; 0.57, and 0.01 mg/kg of cassava peel collected from four different locations in Nigeria, respectively (Idugboe *et al*., 2017). The magnesium and potassium levels obtained in this study were comparable to 0.22 and 9.0 g/kg cassava peel reported by Afolabi et al. (2012). The sodium concentrations were higher than 0.8-1.4 mg/kg of cassava peels derived from three sweet cassava cultivars reported by Otache *et al*. (2017). The potassium content of all the samples was high, with a mean concentration of 5.0-7.6 g/kg DM. It means that the local cassava peels are good sources of potassium since the standard potassium requirement for ruminants is within 50 - 80 mg/100g (NRC, 1984).

Table 3. Mineral composition of cassava tuber peel derived from three different cassava varieties

Parameters	Black Cassava	Bread Cassava	Sticky Cassava
Macrominerals (g/kg DM)			
▪ Calcium	0.00± (0.00)	0.01± (0.00)	0.05± (0.03)
▪ Phosphorus	0.20± (0.11)	0.66± (0.07)	0.41± (0.12)
▪ Magnesium	0.23± (0.10)	0.26± (0.03)	0.74± (0.22)
▪ Potasium	4.97± (0.33)	7.64± (0.14)	5.91± (1.00)
▪ Sodium	0.11± (0.02)	0.10 ± (0.03)	1.12± (0.02)
Micro minerals (mg/kg DM)			
▪ Manganese	137.04± (23.13)	1362.13± (296.91)	1263.60± (792.33)
▪ Cobalt	1.95± (0.78)	3.33± (0.87)	4.82± (1.46)
▪ Zink	33.72± (0.90)	39.60± (1.35)	42.62± (1.45)
▪ Iron	12283.47± (899.75)	11957.84± (1532.22)	8977.28± (2183.68)
▪ Cupper	5.16± (0.63)	8.92± (5.34)	5.42± (1.36)

Cassava peels were rich in iron with an average concentration of 9.0-12.3 g/kg DM. Most of the iron originated from the residual soil attached to the periderm. Khalil *et al*. (2016) found that soil in the Payakumbuh region contained very high Fe levels of 20217.9 mg/kg DM, or approximately 350 times the Fe content of the forages (57.2 mg/kg DM). The iron concentration obtained in this study was much higher than the 0.1 g/kg DM reported by Afolabi *et al*. (2012). Iron is an essential component of hemoglobin and is involved in oxygen transport to cells (FAO, 2011). Iron is also integral to cytochromes and Fe-dependent proteins involved in electron transport and constituent of several Fe-activated enzymes (Theil, 2004). Another essential trace element was Mn, Zn, and Cu, with an average concentration of 0.1-1.4; 33.7-42.6; and 5.2-8.9 mg/kg DM, respectively. There were no statistical differences in mineral composition among the varieties, mainly due to high data variation. Zn concentration obtained in this study was lower than 50-75 mg/kg reported by Otache *et al*. (2017) but higher than 17.5 mg/kg DM reported by Afolabi *et al*. (2012).

The present research found that the local tuber peels contain inadequate calcium, phosphorus, and magnesium content which are under the critical levels of <3.0, <2.5, and <1.0 g/kg DM for ruminants (McDowell, 1997). The cassava tuber peel in the diet needed adequate supplementation of Ca, P, Mg, and some trace elements of Mn, Zn, and Cu. Calcium, phosphorus, and magnesium are essential minerals for livestock animals due to their crucial roles in various body functions and metabolism. The optimum Ca:P ratio is about 1.5-2:1 to form a normal bone structure (Weaver and Heaney, 1999). Calcium plays an essential role in bone and teeth development, muscle contraction, conduction of nerve impulses, activation of enzymes, alteration of cell permeability, blood clot formation, and milk synthesis (McDowell, 1997). P is required for energy metabolism (ATP), amino acid metabolism, and protein synthesis (Coon *et al*., 2002). Magnesium is essential as an activator of many enzymes in the cells and plays a role in neuromuscular transmission (FAO, 2011). Manganese, zinc, and copper play an essential role in the normal function of reproduction of ruminant livestock. Adequate Mn, Zn, and Cu intake are necessary for forming ovarian hormones (Hidiroglou, 1979), proper sexual maturity, and regular oestrus expression (Yasothai, 2014).

CONCLUSION

The survey reveals that the peels of the three cassava cultivars examined have appreciable levels of fresh and meal yield percentages. The proximate, fiber, and mineral analysis of cassava peels revealed that the local cassava peels were rich in crude protein and carbohydrates. It also contains considerable high Fe and moderate amounts of K, Mn, and Zn minerals. They, however, do not contain adequate amounts of vital minerals of calcium, phosphorus, and magnesium required for the growth, maintenance, and reproduction of the ruminants. This study has also shown that black cassava peels are good carbohydrate sources and are thus an excellent source of energy for ruminants.

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