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Comparative proximate composition and cyanide contents of each parts of local cassava (*Manihot esculenta* Crantz)

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Abstract
Each cassava parts, namely tuber, discarded tuber, leaves, stems, inner and outer peels of yellow cassava (Manihot esculenta Crantz) from Selangor, Malaysia were used in this study. The cassava plant portions such as the tubers, stems, peels, discarded tuber, and leaves were 50.06%,31.01%, 10.63%, 6.92 and 1.49% (w/w) respectively. Proximate analysis show that all the cassava parts had high dry matter content with stems had the highest dry matter (98.77±0.00) than other parts and the leaves had the least (93.89±0.06). There were significant differences ($p<0.05$) in crude protein, crude fat, crude fiber, ash, and carbohydrate. The leaves had the highest crude protein (28.02±0.10), crude fat (5.63± 0.12) and gross energy (4824.3 g/cal). Stems had the highest crude fiber (39.51±0.05), outer peels have the highest ash (14.59± 0.07) and tuber had the highest carbohydrates(92.66± 1.88) compared to other parts. All parts were observed to had no significant difference and have very low cyanide content ($p>0.05$).These results indicate that the leaves and the stems contained nutrients which can be included in the diet of animal after proper processing techniques that can lowering the cyanide content to the safe level.

Keywords: cassava parts, proximate analysis, cyanide, waste utilization

Introduction

Malaysia harvested 3400 ha of cassava in 2015, and the amount of wastes produced by the agricultural processing operations was 50%. Yearly, approximately 80000t of cassava wastes are discarded or burnt during post-harvesting at the factory site (Department of Agriculture Peninsular Malaysia, 2017). Most of the wastes is from the cassava chip factories which are given to the villagers as ruminant feed. However, without proper processing techniques, the livestock could die due to the high level of anti-nutrient contained in the various parts of cassava plant.

In the developing countries, cassava tuber serves as a major staple food and is a secured source of energy (Otache et al., 2017). Food is made up of different nutrients needed for growth and health, which include protein, carbohydrates, fat, water and minerals. Each nutrient has specific uses in the body. According to Thomas (2006), proper nutrient means that all nutrients are supplied and utilized in adequate amount to maintain optimal health and well-being.

Carbohydrates are consumed as a major source of energy. Carbohydrates are hydrolyzed in the body to produce glucose which can be used immediately, or stored as glycogen in the muscles and liver for future use (Okeke et al., 2008). When carbohydrates are consumed in excess of the body requirement, the excess is converted to fat and stored in the adipose tissues under the skin.

Protein is important in the body for the production of hormones, enzymes and blood plasma. They act as an immune booster and help in cell division and growth (Okeke et al., 2008). Fat yields more energy than carbohydrates. Dietary fat is important because of their high energy value and essential fatty acids contained in the fat of natural foods. Moisture or water content dissolves substances, carries nutrients and other materials throughout the body, making it possible for every organ to perform its function effectively (Ilodibia et al., 2014).

Fibers are parts of plants which cannot be digested nor absorbed by the human system (Agarwal and Rastogi, 1974). Dietary fibers role in the body to slow down the rate of sugar absorption into the bloodstream. They also reduce the levels of plasma cholesterol and prevent colon cancer and cardiovascular diseases (Davidson et al., 1975).

Ash content of plant-based food is the function of the mineral elements present. Dietary ash is proven to help in establishing and maintaining the acid-alkaline balance of the blood system and also in controlling hyperglycemia condition (Gokani et al., 1992). Nutritive value of cassava plant depends on the chemical composition and gross energy. One of the characteristics of cassava plants is the presence of natural nitrile (^{-}CN) compounds called cyanogens, which are in the form of linamarin (93%) and lotaustralin (7%). These precursors upon breakdown release the cyanide (HCN) which can be harmful to the consumer such as goiter, Tropical Ataxic Neuropathy, and kwashiorkor (Akintola et al., 1998). Various parts of cassava plants such as the tubers, stems, petioles, leaves, and peels are differentiated from one another by their chemical composition. Processing of cassava plants such as peeling, drying, soaking, and cooking is sufficient to eliminate all the toxicity.

Different parts of cassava plants have different nutrient and cyanide contents from one another. Evaluation of the nutrient compositions and cyanide contents of different parts of cassava plant thereby providing the nutritional data of some underutilized cassava wastes. The objective of this study was to determine the proximate analysis, gross energy, cyanide contents from every part of the cassava plant in Malaysia. The results are important in order to identify the edible parts of the cassava plant as the potential usage as ruminant feed. Furthermore, this will reduce the disposal of solid wastes of cassava plant in the field to minimize environmental pollution.

Materials and methods

Samples preparation

According to Steyn (1959), the samples were cleaned using tap water to remove soil. Then, the samples made up of tuber, discarded tuber, stem, peel, and leaf were cut using a sharp knive as in Figure 1. Each part was determined and reported as a percentage of the proportion of a cassava plant. After washing, the samples were hand-peeled and cut down to 2 to 3 cm. The samples were put into separately labelled clean trays, followed with oven-drying at 60 ℃ for 24 hr to preserve the nutritional content of the samples. All the samples were ground into powder and screen shived at 2mm and were stored in a desiccator until required. All the samples were used to analyze the proximate, gross energy and their cyanide content.

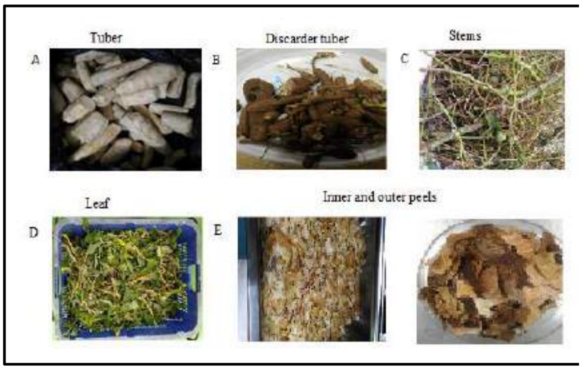

Figure 1: Morphology of cassava parts

Proximate Analysis

Dry matter content represents all the constituents in plant except water. In practice, dry matter is calculated from the formula 100−moisture content. Moisture content was determined according to AOAC (1990). Total ash was determined using a furnace at 525 °C for 6 hr. Crude fiber determined by using fibertec analysis (FibertecTM 2010, Foss Analytical; Denmark). Crude Protein is determined by Micro Kjeldahl method (N × 6.25). Crude Fat was obtained by using the Soxtec 2050 system, Hogan, Sweden apparatus. Carbohydrate content was determined by using the difference method. This method involves adding the total values of crude protein, fat, crude fiber, moisture, and ash constituents of the sample and subtracted it from 100.

Determination of gross energy

Gross energy of dried samples were determined using a Parr 1341 Oxygen Bomb Calorimeter. The samples were burnt in a closed container and heat produced from it was measured.

Cyanide analysis using picrate in solution method

The cyanide levels of each part of the samples was determined using picrate in solution method (Gervason et. al., 2017). 3.0 g of each part of the samples was dissolved in 5.0 mL distilled water. The samples were filtered and 0.04 mL of each extract was mixed with 2.0 mL alkaline picrate solution (obtained by dissolving 2.56 g moist picric acid and 5.0 g sodium carbonate in 100 ml of distilled water) and 1.96 mL distilled water. Then, the mixture was incubated in a water bath at 37°C for 15 min. Then, the mixture was added 15 µL of concentrated sulphuric acid. The mixture was read spectrophotometrically at 535 nm against a distilled water. The cyanide absorbance of the samples was extrapolated from a standard curve that was prepared by diluting potassium cyanide in water, with varies concentrations (0.0 to 0.05 µg/mL) as shown in Figure 2 using the equation of the standard graph Y = 0.0342x+ 0.0039 (R^2 = 0.9793) Where Y = Unknown concentration of the sample, 0.1528 = slope of the graph, x = absorbance.

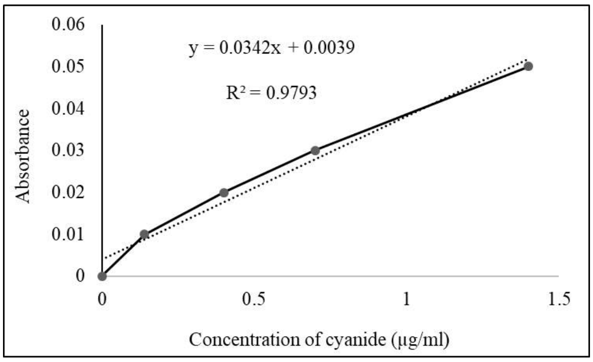

Figure 2: Cyanide standard curve

Amount of cyanide in the tested samples was calculated using the formula:

mg/Kg cyanide =

$$\frac{\mu g/mL \text{ of cyanide} \times \text{final volume (L)}}{\text{sample weight (Kg)}}$$

Where: ug/mL obtained from the KCN calibration curve; the final volume is the filtered extract; sample weight is the weight of the sample extracted.

Statistical analysis

The results were subjected to Analysis of Variance (ANOVA) using Minitab, version 17.0. Results are presented as Means±standard deviations. ANOVA was used for comparison of the means. Differences between means were considered to be significant at $p < 0.05$ using the Tukey test.

Results and discussion

The proportion of the cassava plant

Local cassava plant was divided into different parts as presented in Table 1. From the cassava wastes, the stems were the largest portion (31% w/w). Other proportions namely peels, discarded tuber and leaves were 5.14, 3.35 and 0.72 % (w/w), respectively. While cassava tuber was 50% (w/w). As a result, the cassava plant wastes (discarded tuber, stem, leaf and peel) accounted for 50% (w/w) of total cassava stems, 4701.55 Mt of peels, 30606.50 Mt of discarded tubers and 659.01 Mt of leaves are generated annually (Department of Agriculture Peninsular Malaysia, 2017).

Proximate analysis, gross energy, and cyanide content

Table 2 shows the results of the proximate analysis, gross energy and cyanide content of the cassava parts studied. The data show that the dry matter content is the highest component in all cassava parts, followed by total carbohydrate. Other components such as crude weight. In Malaysia, approximately 12711.01 Mt of stems, fiber, crude protein, ash, and crude fat were found to vary according to the different parts of plant.

Table 1: Proportion of local cassava parts

Cassava parts	Weight (Kg)	Percentage % (w/w)
Tuber	24.20	50.06
Stem	14.93	31.00
Peel	5.14	10.63
Discarded tuber	3.35	6.92
Leaf	0.72	1.49
Total	48.34	100

Table 2: Proximate analysis of different parts of local cassava plants

Cassava Parts	Dry matter (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)	CHO (%)	Gross energy (cal/g)	HCN equivalent (mg/Kg)
Tuber	97.17 ±0.02[c]	1.75 ±0.01[d]	0.64 ±0.05[d]	2.11 ±0.03[f]	1.24 ±0.05[e]	92.66 ± 1.88[a]	4223.9 ±4.9[c]	0.00± 0.00[a]
Discarded tuber	95.97 ±0.02[d]	3.54 ±0.04[c]	0.75 ±0.05[c,d]	5.31 ±0.11[e]	2.94 ±0.00[d]	83.39 ±0.43[b]	3645.0 ±0.1[e]	5.99×10^{-3}± 0.00[a]
Stem	98.77 ±0.00[a]	5.24 ±0.19[b]	1.37 ±0.05[b,c]	39.51 ±0.05[a]	6.43 ±0.18[b,c]	42.99 ± 1.52[e]	4168.4 ±38.4[c]	5.71×10^{-3}±0.00[a]
Leaf	93.89 ±0.06[f]	28.02 ±0.10[a]	5.63± 0.12[a]	21.41 ±0.00[c]	7.28 ±0.39[b]	31.55 ±1.09[f]	4824.3 ±10.6[a]	5.68×10^{-3}± 0.00[a]
Inner peel	98.60 ±0.01[b]	0.023 ±0.03[e]	1.59 ±0.06[b]	12.41 ± 0.12[d]	5.58 ± 0.28[c]	78 .94 ± 0.05[c]	4069.2 ±26.8[d]	4.618×10^{-3}±0.00[a]
Outer peel	94.97 ±0.02[e]	4.08 ±0.16[c]	1.14 ±0.37[b]	24.49 ±0.11[b]	14.59 ± 0.07[a]	50.71 ±0.20[d]	4666.5 ±0.3[b]	5.64×10^{-3}±0.00[a]

Values are mean of duplicate determination expressed on dry weight basis±standard error.
Different alphabets indicate significant different at $p<0.05$ between samples

The dry matter content of cassava plant varied from 98.77% (stem) to 93.89% (leaf), which were significantly different from each other ($p<0.05$). Cassava leaf has been reported to have the highest moisture content than other parts. Siti Sarah and Aishah (2016) found that the local cassava leaf has quite similar dry matter content (92.6%). Sarkiyayi and Agar (2010) also reported tuber has 99.18% dry matter. Percentage of dry matter in peels are higher compared to the result of Otache et al. (2017). This
result shows that as the cassava parts have high dry matter content, it may have long storage lives if packaged properly and well stored (Eleazu and Eleazu, 2012).

Crude fiber represents that portion of carbohydrate that is not digestible by the body. It mainly consists of largely cellulose and lignin (97%) and other minerals (Eleazu and Eleazu, 2012). The fiber content of all parts of plant showed the significant differences in the fiber contents $p < 0.05$. Crude fiber contents were highest in the stem and tuber the lowest. The value for tuber is within a range of 1.5 to 3.5% (Charles et al., 2005).

Crude fat is important to the structure and biological functions and also giving high energy to the body (Eleazu and Eleazu, 2012). Crude fat contents in leaf (5.63%) was significantly higher than parts, while inner and outer peels, and stem did not show significantly different ($p<0.05$). The value obtained is comparable to the study by Siti Sarah and Aishah (2016).

The values of the carbohydrates content of the cassava parts ranged from 31.55% (leaf) to 92.66% (tuber). The result shows a significant difference ($p<0.05$) between each part. Tubers would be a good source of energy to the ruminant as animal feed.

The gross energy values presented based on the dry matter indicate their potentials as food or as feed for ruminant. From Table 2, it shows that the leaf has the highest in gross energy content (4824.3 cal/g). This result may be explained by the fact that the leaves has the highest crude fat and protein, but low in carbohydrate than other parts. This suggests that after harvesting of the tubers, cassava leaf wastes could used as animal feed because of its high protein, fat, and energy gross contents.

Due to concern about the cyanide content after cassava plants being dried, the limitation of recommended cyanide level in food is 10 mg HCN equivalent/Kg dry weight which means cassava cannot be eaten raw. All dried cassava parts showed the value that are below the cyanide content limit, which are 50mg/ kg of fresh forms (Delange et al., 1982).This indicating the efficiency of the processing method and safe for use.

From this study, it shows that almost all dried cassava parts contained high nutrient, high energy gross and low in cyanide. All the dried cassava wastes showed the potential as ruminant feed. According to Apata and Babalola (2012), cassava leaf has relatively same properties compared to maize (high protein), would be an alternative feed for non-ruminant and also for ruminant.

Conclusion:

In conclusion, the stem was the largest wastes portion of cassava plant followed by the peel, discarded tuber, and the leaf. According to the nutrient and cyanide composition of cassava wastes, the leaf has the highest protein with 28.02%, whereas other parts were around 1.75% to 5.24%. The stem seems to have the most potential for animal feed because it accounts for the highest waste proportion. It also has the second highest gross energy after the leaf. The proximate analysis indicates that all parts of cassava wastes were rich in nutrient, especially the carbohydrate. With these findings, cassava wastes can be formulated into animal feed. Clinical studies are recommended to determine at what level the nutrient becomes toxic to ruminant and ascertain the side effects if any.

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