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Physicochemical and Hydrogen Cyanide Content of Three Processed Cassava Products Used for Feeding Poultry in Nigeria

[1]I.C. Okoli, [1]C.O. Okparaocha, [2]C.E. Chinweze and [1]A.B.I. Udedibie

[1]Department of Animal Science and Technology, Federal University of Technology, PMB 1526, Owerri, Imo State, Nigeria

[2]Department of Agricultural Engineering, Federal University of Technology, PMB 1526, Owerri, Imo State, Nigeria

Corresponding Author: I.C. Okoli, Department of Animal Science and Technology, Federal University of Technology, PMB 1526, Owerri, Imo State, Nigeria

ABSTRACT

Several processing methods have been used to reduce the cyanogenic glycoside content of cassava used in animal feeding, resulting in wide variations in the physicochemical and hydrogen cyanide (HCN) contents of available processed cassava products. This study evaluated the physicochemical and HCN contents of three differently processed cassava products used for feeding poultry in Nigeria. The three products were designated Abi (AB), Nali (NB) and Local (LB) brands. They were analyzed for their physical properties Bulk Density (BD), Water Holding Capacity (WHC) and specific gravity (SP); chemical properties Moisture Content (MC), Crude Protein (CP), Crude Fiber (CF), Ether Extract (EE) Ash Content (AC), Nitrogen Free Extract (NFE) and Metabolizable Energy (ME) and hydrogen cyanide contents. The LB and AB had significantly higher ($p<0.05$) WHC than NB while LB had the lowest BD and SG which were again significantly different from those of AB and NB ($p<0.05$), indicating significantly higher insoluble Non Starch Polysaccharides (NSP) or indigestible fiber in LB. The AB and LB were similar in their CF, AC and NFE values ($p>0.05$) which were significantly different from the NB values ($p<0.05$). The significantly higher CF (5.5%) in NB is chiefly soluble NSP as shown by the low WHC of the brand. The NB recorded very high HCN value (100-200 ppm), while the LB and AB had 5-15 ppm, indicating value in poultry feeding. Comparatively, NB, which is an oven toasted product, recorded superior physicochemical values, while the AB and LB gave more desirable HCN values. The Nali and Abi processing methods could be combined to produce a superior cassava product for the feeding of poultry in Nigeria.

Key words: Cassava, cyanogenic glycosides, hydrogen cyanide, feed, poultry

INTRODUCTION

Cassava, also called manioc, tapioca or yucca is one of the most important food crops in the humid tropics, being particularly suited to the conditions of low nutrient availability of the region and able to survive drought (Burrell, 2003). Under tropical conditions, cassava is the most productive crop in terms of energy yield per unit land area (Ranvindrian and Blair, 1992). Among the starchy staples, it gives carbohydrate yield of about 40% higher than rice and 25% more than maize, making it the cheapest source of calories in both human and animal diets (Nwaokoro *et al.*, 2002; Nyerhovwo, 2004).

Nigeria alone currently produces over 14 million tons of cassava annually, representing about 25% of sub-Saharan Africa's output (Ayodeji, 2005). It is the third most important food source in the tropics after rice and maize and is the source of energy food to more than 160 million Africans (Polsen and Spencer, 1991).

In spite of all these important agricultural and nutritional roles played by cassava, its food value is greatly compromised by the presence of endogenous cyanogenic glycosides; especially, linamarin and lautrstralin which under several prevailing tropical conditions are readily hydrolyzed to liberate hydrogen cyanide (Esonu, 2006; Udedibie *et al.*, 2008). Several processing methods such as ensiling and drying have been tried and found to be effective in reducing the cyanogenic glycoside content of cassava products (Phuc *et al.*, 2000; Enyenihi *et al.*, 2009; Udedibie *et al.*, 2008, 2009).

Some of these methods such as traditional sun drying, crushing and sieving of peeled cassava roots manage to retain between 25 and 33% of the endogenous linamarin in the final products (Bradbury *et al.*, 1999; Cardoso *et al.*, 2005). This has limited the effective utilization of such products in animal production, since much lower cyanide levels are needed for optimal inclusion of cassava products in animal diets, especially those meant for monogastric animals (Udedibie *et al.*, 2004).

The nutrient compositions of several processed cassava products and sievates have been reported by Nwaokoro *et al.* (2002) Udedibie *et al.* (2004) and Udedibie *et al.* (2008) among other workers. However, there is a dearth of information on the effects of the various processing methods on the physical characteristics of the final products. There is therefore the need to understand the actual interplay of the physical, chemical and HCN content of available cassava products employed in livestock feeding. For example, the water holding capacity of a starchy product like cassava could yield information on the degree of exposure of internal structures of the starch granules to water (Raules *et al.*, 1993). Similarly, increases in bulk density and specific gravity on the other hand may indicate more fiber content in a processed cassava product (Mathew *et al.*, 1995; Aloysn and Zhou, 2006; Omede, 2010).

The objective of the present study is to determine the physicochemical and HCN content of three processed cassava products used in poultry feeding in Nigeria.

MATERIALS AND METHODS

Study site and materials: The study was carried out at the Animal Science and Technology Laboratory, Federal University of Technology, Owerri, Nigeria. The materials tested were three differently processed cassava products used for poultry feeding. They were obtained from their different producers and were designated the Abi, Nali and Local brands (AB, NB and LB brands, respectively).

The Abi brand production involves sophisticated technological processes that subject the cassava tuber to various stages of peeling, fermentation, sieving, cooking, sun drying and milling (Udedibie *et al.*, 2008). This process has been shown to reduce the cyanide content of cassava roots from 800 ppm HCN to below 10 ppm (Udedibie *et al.*, 2008).

The Nali brand is derived basically from cassava tubers which were washed, chopped into small pieces, soaked in water for 48 h, toasted and milled to form free flowing grains .The cyanide content of this product has not been determined before.

The Local brand is produced by different local processors from cassava roots that were peeled, washed, fermented for some days (4-5 days), sun dried and ground into cassava flour. Again, the cyanide content of this locally prepared product may vary from 25-33% reduction in the original endogenous cyanogenic glycosides content, even though they are extensively used as human and animal energy ingredient.

Water Holding Capacity (WHC) determination: The filtration method described by Makinde and Sonaiya (2007) was adopted with slight modification. Accordingly, the weight of water held by the sample material to the weight of the dry feed was given as the water holding capacity of the sample in g water/g dry cassava product (Omede, 2010). It was assumed in all cases that the initial moisture content of the dry processed cassava product did not exceed 14% (Omede, 2004).

Bulk Density (BD) determination: The method described by Makinde and Sonaiya (2007) was again adopted. For example, the bulk density of a dry processed cassava product sample weighing 50 g in a 165 cm^3 funnel was calculated as 50 g/165 cm^3 = 0.3030 g cm^{-3} (Makinde and Sonaiya, 2007; Omede, 2010).

Specific Gravity (SG) determination: Specific gravity of a substance is a comparison of the density of that substance relative to a standard value (density of water). Thus, BD value was used to determine SG of the test sample materials. SG was determined as a ratio of the bulk density of known mass of the experimental sample to the density of water (Omede, 2010). For example, if the BD of a given test sample material is 0.5 g cm^{-3}, the SG of that sample material will be:

$$\text{BD of test sample material/the Density of water } (1.0 \text{ g cm}^{-3}) = 0.5/1.0 \text{ g cm}^{-3} = 0.5$$

Determination of proximate compositions: Samples of the differently processed cassava products were subjected to proximate analyses according to the methods of AOAC (1995). The parameters determined included Moisture Content (MC), Crude Protein (CP), Crude Fiber (CF), Ether Extract (EE) Ash Content (AC) and Nitrogen Free Extract (NFE).

Furthermore, the Metabolizable Energy (ME) values of the processed cassava products were calculated from their respective proximate values using the production equation outlined by Morgan *et al.* (1975) as follows:

$$\text{ME}\,(\text{MJkg}^{-1}) = \frac{[0.416(\text{CP}) + 0.605\ (\text{EE}) + 0.367\ (\text{NFE})}{40184} \times 100$$

HCN content determination: Estimates of the hydrocyanic acid contents of the processed cassava products were determined according to the picrate paper method outlined by Bradbury *et al.* (1999). Briefly, a round paper disk containing buffer at pH 6 and enzyme (identified as black spot) was placed in a flat-bottomed plastic bottle and 100 mg of the ground cassava sample poured on top of it. 0.5 mL of distilled water was added in drops using a plastic pipette and a yellow picrate paper attached to a plastic string inserted in such a way as to touch the liquid in the bottle. The bottle was immediately corked tight and allowed to stand for 16-24 h at room temperature and then opened. Thereafter, the color of the picrate paper was matched against with the shades of colors of a chart. The total HCN content in parts per million (ppm) in the cassava sample was read off from the color chart.

Data analyses: Data generated from the experiments were subjected to analysis of variance (ANOVA) and where significant differences were established among means, they were separated using the least significant difference method (SAS, 1999).

RESULTS AND DISCUSSION

Physical characteristics: The physical characteristics of the three differently processed cassava products were presented in Table 1. The local and Abi brands held significantly higher ($p<0.05$) volumes of water than the Nali brand indicating significantly higher insoluble Non Starch Polysaccharides (NSP) or indigestible fiber in these products. The local brand with significantly high WHC, also recorded the lowest BD and SG which were again significantly different from the values recorded for the Abi and Nali brands ($p<0.05$).

As expected, the brand with the lowest BD (local brand) had the highest WHC, while the brand with the highest BD (Nali brand) had the lowest WHC authenticating the report of negative correlation between BD and WHC (Knott *et al.*, 2004; Sundu *et al.*, 2005).

The Nali brand is thus low in its insoluble NSP content, hence the low WHC. Thus, the Nali brand possesses a better tendency to sink below the GIT fluid than the other cassava processed brands as shown by its higher specific gravity. This allows for better and longer interaction with food enzymes and gastric juices needed for maximum digestion and absorption within the birds' GIT (Omede, 2010). The local brand may restrict feed intake due to the negative effect of its higher WHC (Kyriazakis and Emmans, 1995). It is known that high WHC feeds absorb excess water within the GIT of birds and then swell up to form a gel beyond the holding capacity of the bird's gut. This mechanism triggers satiety and reduces feed intake, with an after effect of inferior growth and performance (Kyriazakis and Emmans, 1995).

Proximate composition: The proximate compositions of the three differently processed cassava products were shown in Table 2. These values were within the ranges stated in literature for cassava products (Asaolu, 1988). The crude protein values obtained are in agreement with earlier reports that cassava root is poor in protein and that its use in poultry diets will require appropriate amino acids supplementation (Burrell, 2003; Esonu, 2006).

Abi and Nali brands were similar in their moisture and crude protein values ($p>0.05$), which were significantly higher than the local brand values ($p<0.05$). The Abi and local brands were on the other hand similar in their crude fiber, ash content and nitrogen free extract values ($p>0.05$), which were significantly different from the Nali brand values ($p<0.05$).

Table 1: The physical characteristics of three differently processed cassava products

Parameters	Abi brand	Nali brand	Local brand	SEM
Water holding capacity (WHC)	0.66^{a}	0.17^{b}	1.10^{a}	0.47
Bulk density (BD)	0.71^{a}	0.97^{a}	0.47^{b}	0.17
Specific gravity (SG)	0.71^{a}	0.97^{a}	$0\text{-}47^{b}$	0.16

ab means within a row with different superscripts are significantly different ($p<0.05$)

Table 2: The proximate compositions (%) of the three processed cassava products

Parameters	Abi brand	Nali brand	Local brand	SEM
Moisture content	7.69^{a}	8.51^{a}	5.75^{b}	1.01
Crude protein	2.60^{a}	2.90^{a}	2.56^{b}	0.20
Crude fiber	3.05^{b}	5.50^{a}	3.90^{a}	0.88
Ether extract	1.79^{b}	3.20^{a}	1.70^{b}	0.60
Ash content	0.79^{b}	1.34^{a}	1.86^{a}	0.38
Nitrogen free extract	84.08^{a}	78.50^{b}	84.23^{a}	2.32
Metabolizable energy (MJ kg^{-1})	2842.23^{b}	3094.14^{a}	3142.71^{a}	114.40

ab means within a row with different superscripts are significantly different ($p<0.05$)

Nali and local brands were also similar in their crude fiber, ash content and metabolizable energy values ($p>0.05$) and again had significantly higher values than Abi brand ($p<0.05$).

It is interesting to note that the Nali brand with the lowest WHC and highest BD recorded the highest CP content among the three samples. It is known that for many feed raw materials, what determines physical characteristics (BD, WHC and SG) is their nature or physical structure, i.e., fibrous nature and the kind of NSPs they are made of-soluble or non-soluble among other factors as listed by De Lange (2000). The present results therefore suggest that the fiber content of Nali brand although higher is basically composed of soluble NSPs, which could be utilized by monogastric animals such as poultry. This phenomenon indicates that the Nali brand has a higher potential benefit in poultry diets. Only the Nali brand received oven toasting as part of its preparation even though the exact temperature of toasting was not revealed. It is possible that this oven toasting may have positively influence the nature of its fiber and ether extract compositions, which were significantly higher than others.

The very dry nature of the local brand (5.75% moisture content) may have added to its higher WHC value, even though the other two brands also recorded very low moisture contents. While this very low MC may relate positively to their keeping quality, the Local brand may be too dusty for birds to handle, since it is presented in flour form (Odukwe, 1994).

The relatively lower crude fiber, ash content, ether extract and metabolizable energy values of Abi brand is expected since the processing method required more steps which may have led to higher losses of nutrients. The significantly lower NFE recorded for the Nali brand is accounted for by its higher crude fiber content, even though this fiber has been shown to be relatively composed of soluble NSPs.

Adebowale *et al.* (2008) reported that there were significant changes in the chemical composition and pasting properties of tapioca grits from different cassava varieties and roasting methods. Specifically, the study showed that the Principal Component Analysis (PCA) of variation in the chemical properties of the tapioca grits indicated that moisture, sugar and starch accounted for 83% of the variation in the chemical properties of tapioca grits. The study further revealed that peak and hot paste viscosities were the key pasting parameters in characterizing tapioca grits from the cassava varieties and roasting methods studied and that variation in peak viscosity of the tapioca grits might be due more too varietal influence than the roasting method. There is the need to fully elucidate how oven toasting may influence the various physicochemical and nutritional characteristics of processed cassava products used in monogastric animal feeding.

Hydrogen cyanide content: The hydrogen cyanide values of the three differently processed cassava products were shown in Table 3. Clearly, the Nali brand had much higher HCN value of 100-200 ppm. The values recorded for the Abi and Local brands on the other hand were low and within the range allowed in monogastric animal diets (Udedibie *et al.*, 2008).

On a scale of HCN content, the Nali brand ranks high and may even cause poisoning when fed to birds over extended periods, since HCN levels above 50 ppm have been shown to be detrimental to poultry health (Udedibie *et al.*, 2004). Oven toasting might therefore not be an effective method of reducing the hydrogen cyanide content of processed cassava products.

It would seem from these results that the local cassava flour processing method is a good method but not as good as the Abi method in reducing the HCN content of the processed cassava tuber. However, the variability in the nutrient and HCN content of the locally processed products across different producers and zones of production, which has been shown to retain 25-33% of its original linamarin content (Cardoso *et al.*, 2005) makes the standardized Abi method more desirable.

Table 3: The hydrogen cyanide content of the differently processed cassava products

Brand samples	Hydrogen cyanide content (ppm)
Abi	<10
Nali	100-200
Local	25

CONCLUSION

Comparatively, the Nali brand, which is an oven toasted cassava product, is of superior physicochemical quality; however it has the major draw back of containing excessive amounts of HCN. Abi and Local brands gave more desirable values of HCN, which were adequate for diets intended for poultry.

RECOMMENDATION

It is therefore recommended that the different positive attributes of these processed cassava product brands, especially the Nali and Abi brands be combined to produce a superior processed cassava product for the feeding of poultry in Nigeria.

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