

EFFECTS OF HYDROTHERMAL TREATMENT ON ANTI-NUTRITIONAL FACTOR COMPOSITION AND MINERAL ELEMENT BIOAVAILABILITY OF CASSAVA PEELS

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Abstract

Antinutritional factors (ANFs) have been found out to hinder the utilization of minerals in cassava peels. This study was conducted to determine the effects of hydrothermal treatment on some ANF contents and some mineral element bioavailability of dried cassava peels. Three dried samples of cassava peels were treated as raw (A), blanched at 60°C (B) and 80°C (C), dried and ground into powder. Standard methods of analyses were used to determine the parameters. The results for anti-nutritional factor contents showed that B had the lowest values for all ANF determined, except for oxalate which had the highest value at B and lowest value at C. The values for ANFs ranged from A to C to B are as follows (in %): Tannin, 52.96±0.01 to 47.69±0.03 to 42.48±0.00; phytate, 63.54±0.12 to 55.66±0.01 to 50.26±0.12; oxalate, from B to A to C, 11.55±0.01 to 8.87±0.01 to 7.60±0.01; trypsin inhibitor, from C to A to B cyanide, 20.14±0.05 to 25.05±0.01 to 21.71±0.02 C to A to B, 5.42±0.01 to 5.10±0.02 to 3.39±0.00 and cyanide, from C to A to B, 5.42±0.01 to 5.10±0.02 to 3.39±0.00. Mineral elements had the following range of values (mg/Kg) from A to C as follows: Fe, 0.077 to 0.097; K, 0.124 to 0.143; Ca, 0.086 to 1.021; Mg, 0.103 to 0.116; Cu, 2.20 to 3.60; Zn, 5.70 to 7.80 and Fe, 11.61 to 14.60. The results of the mineral bioavailability gave a good index in terms of improving nutritional qualities of dried cassava peels. Blanching at 60°C is recommended.

Keywords: Cassava peel; hydrothermal; proximate; minerals.

Introduction

During the dry periods of the year, ruminant diets are limited by shortage in quantity and quality of available forage (Shelton, 2004), resulting in low milk and meat production. In recent times, non-conventional feed resources are gaining acceptance as feedstuff in livestock diets (Amata, 2010). These feed resources are incorporated in livestock diets as long as they do not have detrimental effects on the health status and production potentials of the animals. Cassava, especially its peel, is one of such feed resources. Cassava (*Manihot esculenta*) is widely grown in the tropical regions. It is estimated that most (60%) of the cassava crop is used for human consumption while the remainder (40%) is used for animal feed, starch and industrial applications (Obboh, 2004). Since the early 1930s, cassava has been known and used as a livestock substitute instead of grains for monogastric animals. Enormous cassava peels are generated as by-products from Cassava processing and holds enormous potential as feed resource for livestock if properly processed (ILRI, 2015). Cassava peel had been in use for a long time as an energy source in place of cereal grains for livestock feeds. Nutrient analysis enables

livestock producers to make optimum use of nutrient, help researchers relate feed to animals' performance and reduce production costs. However, cassava peel contains anti-nutritional factors that can affect the availability of the nutrients. Anti-nutritional factors are known to interfere with metabolic processes such that growth and bioavailability of nutrients are negatively influenced (Abara, 2003; Binta and Khetarpau, 1997). According to Ademoroti (1996), phytate and oxalates have the ability to form chelates with di- and trivalent metallic ions such as Cd, Mg, Zn and Fe to form poorly soluble compounds that are not readily absorbed from the gastrointestinal tract thus decreasing their bioavailability. He further stated that phytate inhibits the functions of some digestive enzymes. It has also been reported that oxalates cause irritation and swelling in the mouth and throat (Ladeji *et al.*, 2004). High level of hydrogen cyanide has been implicated for cerebral damage and lethargy in man and animals (Ekop, 2007). It has been reported that cassava peel contains some levels of anti-nutrients (phytates, oxalates, tannins, alkaloids, saponins and many more) which diminish useful nutrient

bioavailability specifically when they are found in high levels (Ogunka-Nnoka and Mepba, 2008).

There are reports of different methods been used for the treatment of anti-nutritional factors in cassava peel. However, there is no record of the use of hydrothermal treatment to process cassava peels with the aim to find out whether the method can be used to reduce the anti-nutritional factors in cassava peel or not. There is no report of evaluation of element bioavailability of cassava peel using blanching processing method. This study, therefore, sets out to bridge these gaps by using hydrothermal treatment (blanching) as a mean of processing cassava peel to find out what effects it will have on the anti-nutritional factors and some mineral elements bioavailability of cassava peels.

Materials and methods

Area of the study: The study was carried out at the Research Laboratory of Oyo State College of Agriculture and Technology, Igboora, Oyo State, Nigeria. Igboora is located in derived Savannah Zone of 7°15' North and 3°30' East of the Equator with an average annual rainfall of 1278mm and an annual temperature of 27°C (Akamigbo, 2010).

Sample and sample treatments: Cassava peels were obtained from cassava (*Manihot esculenta*) purchased from a cassava farmer in the vicinity of Oyo State College of Agriculture and Technology, Igboora, washed and peeled. The cassava peels were again properly washed with water and air-dried for four weeks. The air-dried cassava peels were divided into three portions (1kg each) to form three treatments used in the study. A portion of the samples was left unheated (raw) and served as control while the other two portions were blanched in water (hydrothermally treated) at 60°C and 80°C respectively. The hydrothermally treated sample were removed from water and air-dried. Thereafter, the three samples were

ground into powder, sieved and stored in air tight containers for chemical analysis.

Anti-nutritional factor analysis: Oxalate contents determination was done by using the titration method described by Day and Underwood (1986). Phytate contents were determined by using the method of Wheeler and Ferrel (1971). Tannin contents were determined using the method described Paul *et al.* (1988). Trypsin inhibitor contents of the samples were determined by the method described Liener (1979). Cyanide contents were determined by alkaline titration method of AOAC (2005).

Mineral analysis: The official method of AOAC (2005) was adopted for the mineral analysis of the samples: The samples were previously ashed in a furnace for 5 h at 600°C, and then refluxed with 20% hydrochloric acid. The mixture was filtered into a 100 mL standard flask; the filtrate was then made up to the mark with deionized water. Sodium (Na) and potassium (K) levels of the samples were determined using a flame emission photometer with NaCl and KCl as standards. All other metals were determined by atomic absorption spectrometry (AAS).

Determination of element bioavailability: The bioavailability of elements (calcium, magnesium, iron and zinc) was calculated as reported by (Woldegiorgis *et al.*, 2015). The molar ratio between anti-nutrients (phytates and oxalates) and element (Ca or Fe or Zn) was obtained after dividing the mole of anti-nutrient with the mole of element. The mole of phytates (phytic acid) was calculated as the measured value of phytic acid divided by the molecular weight of phytic acid while the mole of various element (Ca or Fe or Zn) was calculated as the measured value of the element divided by the individual element molecular weight.

Results and discussion

Table1: Anti-nutritional factors compositions of raw and hydrothermally treated cassava peels.

Antinutritional factors (mg/100g)	Raw	Hydrothermally treated	
		60°C	80°C
Tannin	52.96±0.01	42.48±0.00	47.69±0.03
Phytate	63.54±0.12	50.26±0.12	55.66±0.01
Oxalate	8.87±0.01	11.55±0.01	7.60±0.01
Trypsin inhibitor	25.05±0.01	21.71±0.02	28.14±0.05
Cyanide	5.10±0.02	3.39±0.00	5.42±0.01

Table2: Mineral elements composition of raw and hydrothermally treated cassava peel.

Mineral elements (mg/kg)	Raw	Hydrothermally treated	
		60°C	80°C
Sodium	0.077±1.06	0.089±0.02	0.097±0.04
Potassium	0.124±0.01	0.132±0.00	0.143±0.42
Calcium	0.086±0.02	0.092±0.00	1.021±0.01
Magnesium	0.103±0.04	0.107±0.01	0.116±0.02
Copper	2.20±0.02	2.80±0.01	3.60±0.01
Zinc	5.70±0.04	6.80±0.02	7.80±0.05
Iron	11.61±0.03	12.60±0.04	14.60±0.01

Table 3: Mineral element bioavailability of raw and hydrothermally treated cassava peel

Anti-nutrients to nutrient ratio	Calculated mole ratio			Standard critical value
	(Raw)	(60°C)	(80°C)	
Oxalate/Ca	45.86	55.78	3.31	2.5
Oxalate/[Ca+Mg]	15.31	18.98	2.78	1.0
[Ca]/[phytate]/Zn	0.002	0.002	0.018	0.5
[phytate]/Zn	1.09	0.73	0.70	15
[phytate]/Ca	44.79	33.13	3.3	0.24
[phytate]/Fe	0.46	0.34	0.32	1.0

Table 1 showed the result of analysis of anti-nutritional factors (ANFs) for raw and hydrothermally treated cassava peels. Quantitatively, the cassava peels hydrothermally treated at 60°C gave lowest values for all the ANFs except for oxalate which is relatively high when compared to the raw and 80°C treatment. Anti-nutritional factors in feed are lethal to animals if consumed beyond their tolerable levels and may have negative effects on mineral bioavailability. Anti-nutrients reduce the maximum utilization of nutrients especially proteins, vitamins and minerals, thus preventing optimal exploitation of the nutrients present in a food and decreasing the nutritive value (Fekadu, 2013). All the anti-nutritional factors determined in this study were observed to be significantly higher in the raw seeds and lowest in the 60°C treated samples except for oxalate which has highest value at 60°C and cyanide which also possess highest value at 80°C (Table 1). This indicated that blanching at 60°C may significantly reduce anti-nutrients in feed materials. This conformed to the reports of Nyachoti *et al.* (1997), Lola (2009) and Ndidi *et al.* (2014). However, the level of oxalate was observed to be relatively lower at 60°C when compared to 33mg/100g standard value of oxalate as reported by Nwaoguikpe *et al.* (2011).

Table 2 shows the mineral contents of the raw and hydrothermally treated cassava peel. The highest levels of minerals obtained in this study were in the sample hydrothermally treated at 80°C, closely followed by sample treated at 60°C while the lowest values for mineral elements were observed in the raw sample. Furthermore, the iron and zinc contents of the hydrothermally treated sample were significantly higher than those of the raw sample. Minerals are essentially required for tissue functioning in animals and their presence in plants can have a positive contribution as a source of essential nutrients or even as active principles, or a negative effect because of the accumulation of high concentrations of potentially toxic elements (Olu-Owolabi *et al.*, 2007). Mineral contents of

the hydrothermally treated sample (60°C and 80°C) ranged between 0.089 to 0.097, 0.132 to 0.143, 0.092 to 1.021, 0.107 to 0.116, 2.80 to 3.60, 6.80 to 7.80 and 12.60 to 14.60 for sodium, potassium, calcium, magnesium, copper, zinc and iron respectively. Increase in Iron and zinc concentrations were observed in treated peels when compared with the raw. This suggested that iron was not easily leached by blanching.

The result of the mineral element bioavailability of raw and hydrothermally treated cassava peel were shown in Table 3 above. The calculated [oxalate]/[Ca], [oxalate]/[Ca+Mg], [Ca]/[Phytate]/[Zn], [Phytate]/[Zn], [Phytate]/[Ca], and [Phytate]/[Fe] molar ratios of raw and hydrothermally treated cassava peel in comparison with critical values are shown in the table 3. The quantitative analysis of the mineral elements bioavailability shows that [Ca]/[phytate]/Zn, [phytate]/Zn and [phytate]/[Fe] are very low when compared with standard critical value while Oxalate/Ca, Oxalate/(Ca+Mg) and [phytate]/Ca are very high when compared with standard critical value. Bioavailability is the proportion of the total amount of mineral element that is potentially absorbable in a metabolically active form, and Mineral bioavailability can be defined as the ability of the body to digest and absorb the mineral in the food consumed (Fekadu *et al.*, 2013). The calculated values of the molar ratios were compared with the reported critical toxicity values for these ratios. Table 3 shows the calculated molar ratios of the raw and hydrothermally treated sample. The molar ratios for calcium, zinc, iron and phytate, oxalate were calculated to evaluate the effects of high levels of phytate and oxalate in the bioavailability of dietary minerals. The calculated Phy:Ca, Phy: Zn, Phy: Fe, Ox: Ca and Ca Phy/Zn molar ratios of raw and hydrothermally treated cassava peel in comparison with critical values are shown in Table 3. Woldergiorgis *et al.* (2015) reported that the phy:Ca molar ratio has been proposed as an indicator of

Ca bioavailability and critical molar ratio of less than 0.24 indicating good calcium bioavailability. The value of phy:Ca, 44.79 (raw), 33.13 (60°C) and 3.3 (80°C) obtained in this study was higher than the reported critical molar ratio 0.24 indicating that absorption of calcium may be slightly affected by phytate content in the raw and treated samples. Meanwhile, (Hurrell *et al.*, 2003) confirmed that phytate starts to lose its inhibitory effect on iron absorption when phytate/iron molar ratios are less than 1.0, although even ratios as low as 0.2 exert some negative effect. The result 0.46 (raw), 0.34 (60°C) and 0.32 (80°C) obtained for raw and hydrothermally treated cassava peel indicates that the phytate/iron molar ratios of the sample is lower than the critical value 1.0 which implies good absorption of iron in the sample. In addition, zinc is another important dietary mineral of foodstuffs which depends on both the total zinc content and the level of other constituents in the diet that affect zinc bioavailability. (Bhandari and Kawabata, 2004) stated that phytate may reduce the bioavailability of dietary zinc by forming insoluble mineral chelates at a physiological pH level which depends on relative amounts of both zinc and phytates. Hence, the phytate: Zn molar ratio is considered a better indicator of zinc bioavailability than total dietary phytate levels alone (Woldergiorgis *et al.*, 2015). The values 1.09 (raw), 0.73 (60°C) and 0.70 (80°C) obtained in this study was far lower than the critical molar ratios of Phy:Zn, 15.0. This therefore indicates good zinc availability in the sample according to the submissions of (Morris and Ellis, 1989). Furthermore, the function of oxalate contents in plant product in limiting total dietary Ca availability is of significance only when the ratio of Ox:Ca is greater than 1.0 (Frontela *et al.*, 2009). In this study, the value of Ox:Ca was 45.86 (raw), 55.78 (60°C) and 3.31 (80°C) which is far higher than the reported critical value (2.5). This implies that high level of oxalate would have adverse effects on bioavailability of dietary calcium in this sample. In addition, Oxalate/(Ca+Mg) ratio are far above the critical level of standard value of 1.0 with the values 15.31 (raw), 18.98 (60°C) and 2.78 (80°C). However, the potential effect of calcium on zinc absorption in the presence of high phytate intakes has led to the suggestion that the [Ca]/[Phy]/[Zn] molar ratio may be a better index of zinc bioavailability than the [Phy]/[Zn] molar ratio alone (Obah and Amusa, 2009); therefore, high calcium levels in foods can promote the phytate-induced decrease in zinc bioavailability when the [Ca]/[phytate]/[Zn] value exceeds 1.0 (Adetuyi *et al.*, 2011). The value of [Ca]/[Phy]/[Zn] ratio in this study was 0.002 (raw), 0.002 (60°C) and 0.018 (80°C) which is less than the critical level which then implies good zinc bioavailability in the sample studied.

Conclusion

Hydrothermal treatment had significant effect in the reduction of anti-nutritional factors in cassava peels and has a significant effect on improvement in mineral elements bioavailability.

This study suggests that cassava peel when hydrothermally treated (blanched) may be incorporated in livestock feed as energy and mineral sources. This study also advocates the

need for future research in the same manner to ascertain whether at temperature above 80°C the anti-nutritional factors will be reduced when compared to that of 60°C

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