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Chemical properties of raw and processed breadfruit (*treculia africana*) seed flour

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Abstract. *Treculia africana* seeds (TAS) were fermented, autoclaved and toasted. Each sample was milled and divided into two parts; one part was defatted while the other was not Unprocessed TAS served as control. The chemical properties were investigated. Results show significant increases (P < 0.05) in the protein and ash contents of fullfat and defatted fermented TAS flours compared with the other flours. Fermented TAS flours had 18.6 and 20.8% of its total dry matter as protein while the autoclaved, toasted and untreated TAS flours had 18.0 and 17.0%, 16.3 and 16.8%, and 15.1 and 18.1% protein respectively. The energy value of unprocessed full fat TAS flour (17.12 Kj/g) is significantly higher (P < 0.05) than the processed fullfat TAS flours (15.53 Kj/g, 16.28 Kj/g and 16.32 Kj/g for fermented, autoclaved and toasted TAS flours respectively). The percent utilisable energy due to protein was highest in the fermented TAS flour (20.2 and 23.9% for fullfat and defatted samples). Autoclaved TAS flour was 18.6 and 18.81%; toasted TAS flour, 16.87 and 18.64%; unprocessed TAS flour: 14.81 and 20.28% respectively for the full fat and defatted samples. The K/Na ratio >> 1 while the Ca/P ratio is << 1 in all the flours. Zinc was the predominant mineral in the flours and highest in fermented TAS flour. Results show significant reduction in oxalates, phytates, tannin and hydrocyanic acid contents of processed TAS flours. Hydrocyanic acid was not detected in the processed TAS flours.

Key Words: *Treculia africana* seeds, processing, chemical properties

Introduction

The African breadfruit tree (*Treculia africana* Decn var africana) is native to many tropical countries like West Indies, Ghana, Sierra Leone, Nigeria and Jamaica[1]. Its seed, commonly called “afon” and “ukwa” by the Yoruba and Igbos of Nigeria, is popular as a traditional food item. It is commonly roasted, cooked, mashed and consumed either directly as snack food or as flour for use in soup thickening and cakes.

Investigations by various authors have shown that *Treculia africana* seeds (TAS) are rich in amino acids, minerals and fatty acids[2,3,4]. Preliminary investigations have revealed the presence of some antinutritional factors like hydrocyanic acid, oxalates, phytates and tannins. Antinutritional factors (antinutrients) are plant components which interfere with metabolic processes so that growth and bio-availability of nutrients are negatively influenced[5]. Consumption of foods containing these factors reduces nutrient utilisation, feed efficiency and productivity (in animals). At high levels of intake, toxicity ensues and in extreme cases, death. The activity of these compounds can be reduced/removed by dehulling, soaking, cooking, toasting and fermenting [6,7,8].

The high nutritional quality and the presence of antinutrients in TAS necessitate the need to evaluate the effects of different conventional processing operations, namely: fermentation, autoclaving and toasting, on the chemical properties of its flour. This would serve as basis for assessing the food, feed and commercial potentials of the flour.

Material and Methods

Mature healthy *Treculia africana* seeds (TAS) used in this study were obtained from a local farm in Akure, Ondo State, Nigeria and taken to the Crop, Soil and Pest Management laboratory, Federal University of Technology, Akure, for identification.

Preparation of Flours: Raw seeds were parboiled (100º C, 15 minutes) to facilitate dehulling. The dehulled seeds were oven dried (55 ± 2ºC, 24 hours), milled in a laboratory mill and sieved with a 200-mm mesh sieve to obtain unprocessed TAS flour (UTF). About 200g of TAS was cooked with 2 litres of water in a pressure pot at 15 PSI. After steaming for 20 minutes, it was allowed to cook for additional 10 minutes. The water was drained off and the seeds were wrapped in banana leaves, placed inside a jute bag and wetted everyday for seven days. The fermented TAS was oven-dried (55±2° C) until sufficiently dried, milled and sieved (200mm mesh size) to obtain fermented TAS flour (FTF). Raw seeds were parboiled (100º C, 15 minutes), dehulled, wrapped in aluminium foil and autoclaved at 121º C for 15 minutes. The autoclaved seeds were oven dried (55±2ºC, 24 hours), milled in a laboratory mill and sieved with a 200-mm mesh sieve to obtain autoclaved TAS flour (ATF). Raw seeds were toasted in heated sand (180°C) for 20 minutes. The toasted seeds were dehulled, milled in a laboratory mill and sieved with a 200-mm mesh sieve to obtain toasted TAS flour (TTF). Each of the flour samples obtained was divided into two parts: one part was defatted (using soxhlet extractor and petroleum ether as the extracting solvent) prior to chemical analysis while the other was not. The resulting eight flour samples were packaged in airtight polythene sachets, labelled and stored in a cool (4°C) dry place till they were used in chemical analysis.

Chemical analysis: The proximate analyses of the full fat and defatted flours were carried out using standard methods [9]. Nitrogen was determined by the micro-kjeldahl method and the nitrogen-free extract estimated by difference. All chemicals used were of analytical grade. Energy content of the flour samples was determined using the Gallenkamp adiabatic bomb calorimeter (Gallenkamp CBB – 330 – 010L). Sodium, calcium and potassium contents were determined by flame photometry [9]. The concentrations of Fe and Zn were determined after wet-digestion with a mixture of perchloric and nitric acid using atomic absorption spectrophotometry (AAS, Model SP9, Pye Unicam, UK) while phosphorus was estimated colorimetrically by the ammonium molybdate method. Phytin-phosphorus was determined by the method of Wheeler and Ferrel [10] as modified by Reddy et al [11]. Phytic acid was calculated by multiplying Phytin-P by the factor of 3.55 [12]. The tannin content was determined by the quantitative method of Makker & Goodchild[13]. Oxalate was estimated as described by Day and Underwood[14] while the hydrocyanic acid content was determined using the alkaline titration method of AOAC [15]

Statistical analysis: The statistical significance of the observed differences among the means of triplicate readings of experimental results obtained were evaluated by analysis of variance (ANOVA) and Duncans multiple range test (DMRT) out using GenStat 6.1 computer program [16].

Results and discussion

The proximate composition and energy values of the TAS flours obtained through different processing techniques are presented in Table 1. There were significant decrease ($P < 0.05$) in the crude fat, fibre and NFE of the processed TAS flours compared with the control (UTF). These decreases may be due to losses which often accompany heat-processed foods. The decrease in carbohydrate content of the fermented TAS flour might be due to the activity of fermentative microbes and the respiratory loss of sugars as CO2.

There are significant increases ($P < 0.05$) in the protein and ash contents of full fat and defatted fermented TAS flours compared with the other flours. The fermented TAS flours had approximately 18.6 and 20.8% of its total dry matter as protein while the autoclaved, toasted and unprocessed TAS seed flours had 18.0 and 17.0%, 16.3 and 16.8%, and 15.1 and 18.1% protein respectively. Fermentation has been reported to improve the nutritional value of weaning foods and converts insoluble proteins to soluble components and increases the levels of lysine as well as of vitamins B and C [17]. This may account for the observed increase in the protein and ash content of fermented TAS flours. With the protein content of the processed flours ranging between 16.30 and 20.80%, they would be capable of meeting the RDI of infants fed solely on it[18]. To meet the 55g daily protein requirement of an adult weighing 70kg, about 264 – 337g of the processed TAS flours would have to be consumed [19, 20]. Thus the processed (and especially fermented) TAS flours could serve as alternative protein source in the diets of young and old.

The fat content of the raw and processed full fat TAS flours are lower than the values reported for oilseeds [21], hence, TAS do not qualify as a true oil seed. The fat extraction rates were: FTF 78%, ATF 69%, UTF 67% and TTF 67%. The high rate of fat extraction in the fermented samples could be due to microbial / enzymatic activity which often accompanies fermentation.

The energy producing value of the flours is shown in Table 1. The energy value of full fat UTF (17.12 Kj/g) is significantly higher ($P < 0.05$) than the processed full fat TAS flours (15.53 Kj/g to 16.32 Kj/g). This may be attributed to the lower fat content recorded in the processed flours. The atwater factor of fat is 37.8Kj/g, which is more than twice the value for protein and carbohydrates (16.8Kj/g). The daily energy requirement for adults range between 10,000 – 12,600 Kj, depending on their physiological state. Thus, an adult would require about 660g of UTF, 728g FTF, 692g ATF and 694g of TTF to meet his minimum daily energy requirement [19, 20]. However, in practical terms, higher quantities may be required because of the incomplete nature of the digestion of energy giving nutrients in the body, which in turn, leads to lower metabolisable energy from the diet. Furthermore, unavailable carbohydrates (e.g fibres present naturally in plants) are combusted in the bomb calorimeter, while they are not in the human body. This further widens the energy differentia between gross energy and metabolisable energy in foods, necessitating the consumption of higher quantities of the food item than was predicted theoretically. This notwithstanding, the quantity required to meet the daily energy requirements is rather high (692 – 728g), thus the processed full fat TAS seed flours can only effectively be used to supplement daily energy requirements since less than 350g of the processed TAS flours is required to meet the daily protein needs of an adult. Since defatting reduces the total energy density, the full fat processed flours would be preferred for food supplementation purposes.

The recommended safe level of utilizable energy due to protein is 8%. The percent utilisable energy due to protein ranged from 16.87 to 20.2% in the full fat processed TAS flour and 16.64 to 23.7% in the defatted processed TAS flours. These values are higher than the recommended value.

Hence, the protein content relative to energy provided would be adequate to prevent protein energy malnutrition in people fed on it as their main protein source. However, of the flours evaluated, fermented TAS seed flours had the highest value, hence, it would be the flour of choice in any supplementation program involving the use of TAS.

The mineral composition of the raw and processed TAS flours are shown in Table 2. Autoclaving significantly reduced the Na, Ca, P, K, Fe and Zn contents of the TAS flours. This may be due to leaching, solubilisation and cooking losses during processing. The levels of sodium and potassium are relatively low, although the amount of potassium present is higher. The low sodium level may suggest that the sodium levels in the soil on which the trees grew is low. This appears so in view of the report of Olaofe and Sanni [22] that sodium levels in Nigerian plant foods are generally lower than the potassium. The K/Na ratio of the processed TAS flour ranged between 63.62 and 123.69. These values are very much greater than the recommended value (1) [23], hence the consumption of the processed flours could be accompanied by salting with NaCl to enhance balance of body fluids. Its consumption without salting with NaCl may lead to mineral imbalance in those fed solely on it [24]. The calcium content in the processed TAS flours ranged 14.56 and 20.45 mg/kg DM. To meet the dietary requirement of 800 mg/day would require the consumption of about 55kg of the flour which could lead to dietary stress. Thus, the flours cannot be said to be good sources of calcium. The phosphorus content of the fermented TAS flour increased significantly. This may be due to the synthesis and release of phosphorus by phytase enzyme during boiling and fermentation. The Ca/P ratio ranged between 0.04 and 0.05. These values are much lower than the recommended value [23]. Hence, meals based solely on processed TAS flour would have to be supplemented with calcium to avoid mineral and osmotic imbalance. The level of zinc in the flours is relatively high when compared to the other minerals. With values ranging between 0.70 – 0.87g/kg DM, the flours can be said to be a good source of dietary zinc and thus would be capable of meeting the 0.04g/kg DM zinc in the diet recommended for humans [25].

The antinutritional factors in the raw and processed TAS flours are shown in Table 3. The results show a significant reduction in the oxalates, phytates, tannin and hydrocyanic acid contents of processed TAS flours. This further confirms previous reports on the effect of heat and fermentation on antinutritional factors [7,8,26]. However, the values obtained in this work are lower than values reported for some legumes and oilseeds [24]. The antinutritional activity of oxalates and phytin lies in their ability to form complexes with metals like Ca, Zn, Mg and Fe. However, the risk of calcium deficiency due to the consumption of oxalate-rich plants has been reported to be very minor. This is because humans are able to efficiently use very low amounts of calcium in food [27,28]. The low values obtained for phytic acid in the autoclaved and toasted TAS flours may be due to its thermolabile nature [29,30]. Phytic acid acts as a strong chelator, forming protein and mineral-phytic acid complexes thereby reducing protein and mineral bioavailability [30]. It chelates metal ions such as calcium, magnesium, zinc, copper and iron to form insoluble complexes that are not readily absorbed from the gastrointestinal tract [27]. Phytin renders many essential minerals unavailable (especially Ca and Mg), leading to a prevalence of osteomalacia and rickets in test animals [31]. The tannin content in the processed seeds were significantly lower than the control (UTF). Tannins interfere with digestion by displaying anti-trypsin and anti-amylase activity [32, 33], form complexes with vitamin B_{12} and interfere with the bioavailability of proteins through complexing reactions with proteins [27]. However, its presence may predispose the reconstituted flour to the development of astringent taste. This is particularly so in the unprocessed TAS flour which had the highest value (16.5 mg/kg DM). Hydrocyanic acid was not detected in the processed TAS flours. This may be due to volatilisation and leaching [26] during the process of heating the seeds prior to subsequent processing. For nutritional purposes, processed TAS flours would be preferred since antinutritional activity is highest in the unprocessed TAS flour.

Conclusions

This work has shown that significant improvement in the nutrient density and its bioavailability in *Treculia africana* seed flour can be attained through fermentation of the seeds prior to conversion into flour. Seed processing prior to conversion into flour offers greater nutritional advantages over its untreated counterpart.

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