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Full Length Research Paper

Development and evaluation of African breadfruit (*Treculia africana*) based ready-to-cook food product for the elderly

Gibson Lucky Arueya*[1] and Juliet Kelechi Iloghalu[2]

[1,2] Department of Food Technology, University of Ibadan, Ibadan, Nigeria.
*Corresponding Author E-mail: arueygibson@yahoo.com. Tel: 234-805-9546-297

ABSTRACT

Many elderly often contend with inappropriate and poorly digested food resulting in nutritional and health challenges. Development and use of a ready-to-cook nutrient dense diet to mitigate this, remains largely unexplored, hence this study.African breadfruit (*Treculia africana*) seeds were malted and processed with selected vegetable-inputs amongst others..Compositional analysis, phytochemical and sundry assays were conducted.The malted product contained protein (19.61%), fat (11.56%) and ash (5.82%). Calcium and iron contents were 416.2mg/100g and 3.95 mg/100g respectively. Total phenols were 5.63mg/g while flavonoids was 1.59mg/g. Water absorption capacity and viscosity were 2.54ml/g and 2.3RVU respectively. Although higher, these values were not significantly different from those of the unmalted (P< 0.05). The malted variant was the more preferred. Rats fed it gained more weight (20-29%) than control (13%). Sub-acute toxicity tests showed that the food was not deleterious. An appropriate Geriatric diet has been developed and found to be acceptable.

Keywords: Geriatric diet, Ready-to-cook, Gerontological care, Flavonoids, Elderly.

INTRODUCTION

Worldwide the number of persons aged 60 or above continue to witness phenomenal increase. It is expected to more than triple by 2100, increasing from 841 million in 2013 to 2 billion in 2050 and close to 3 billion by 2100. Already some 60% of the world's older persons now live in less developed regions (UN, 2013).

The elderly are faced with health and nutritional challenges mainly caused by poor nutrition. Micronutrient deficiencies are also often common in elderly people due to factors such as reduced food intake and a lack of variety in the foods they eat. A closely related factor is the high cost of micronutrient rich foods which further restricts their consumption (WHO, 2002). As humans age, lean body mass decreases (sacropenia) leading to a gain in body fat. This may be more noticeable by loss of physical strength, functional decline and poor endurance, culminating in reduced total body water content (Tabloski, 2006). The elderly do not form vitamin D in their skin as efficiently (in the presence of sunlight) as younger individuals do and therefore may be at a greater risk of vitamin D deficiency. Thirty percent of people aged over 65years develop the inability to produce stomach acid (Reavley, 1998). The inability to consume the required daily nutrient intake places the elderly at greater risk of malnutrition related diseases (Zheng and Rosenberg, 1989; Reavley, 1998). Changes also occur in the kidneys, lungs and liver and in their potential to generate new protein tissue. In addition to this, aging tend to slow the immune system's response in making antibodies (Chandra, 1992).

Application of food based pyramids incorporating food groupings (carbohydrate, fruits/vegetable, proteins, fats/oils, vitamins) and their daily servings have been advocated as a strategy to mitigate this challenge. Rusell et al (1999) included placement of water at the bottom of the pyramid because many older adults do not drink enough water to stay hydrated. He further proposed the placement of a flag at the top of the pyramid indicating the need for calcium, vitamin D and vitamin B_{12} supplements since many older adults do not get enough of these nutrients in a standard diet. Lichtenstein et al (2008) created a new modification to the foregoing by including the addition of examples of physical activity at the bottom of pyramid. They posited that greater physical

activity allows for intake of larger quantities of food which in turn increases the likelihood that all of the necessary nutrients will be consumed.

In developing countries where disposable income is low and Agriculture supplies are erratic coupled with high prices, affordability and accessibility to the right kind of foods by the elderly can be a real challenge. Moreover getting these foods ready for consumption can also be time consuming with attendant high energy costs. In some adult populations, aging leads to a decreased ability to conduct daily activities as food-shopping or meal preparation as well as critical abilities such as self feeding or walking. Individuals with these types of functional limitations may be less able to acquire nutritious foods from grocery stores and prepare nutritious meals (Ledikwe et al., 2001).

There is therefore a need to develop a highly digestible nutrient dense cook-ready convenience diet for the elderly such as those based on seeds of African breadfruit (*Treculia africana*). The African bread fruit tree is of the family Moraceae and is one of the four members of the genera *Treculia* and native to many tropical countries like West Indies, Ghana, Sierra Leone, Nigeria and Jamaica (Orwa et al., 2009). African breadfruit seed has been reported to be rich in carbohydrate, fat, minerals, vitamins, fibre and high quality protein. It also contains appreciable amounts of phytochemicals such as flavonoids, polyphenols, anthraquinones, saponins and cardiac glycosides (Fasasi et al., 2003, Osabor et al., 2009). It has been used severally in developing biscuits, breakfast meals and complementary foods (Ariahu et al., 1999, Nwabueze and Atuonwu, 2007)

Diet quality has a significant impact on physical cognitive condition, bone health, eye health, vascular function and the immune system (Tucker, 2010). Consequently developing an easily digestible ready-to-cook nutrient dense food and consumption of same can be valuable in improving the health and nutritional status of the elderly.

MATERIALS AND METHODS

Raw material inputs

African Breadfruit	(*Treculia africana*)
Bitter leaf	(*Vernonia amygdlina*)
Crayfish	(*Procambarus clarkii*)
Pepper	(*Capsicum spp*)
Iodized salt	
Milk flavor	
Vitamin/mineral mix	

Sourcing of raw materials

African Breadfruit Seeds (*Treculia africana*) and bitter leaf were obtained from Adazi Enu settlement in Anambra state, Nigeria. Crayfish (*Crocambarus clakii*), and pepper (*Capsicum spp*) were purchased from Umuahia main market in Abia state, Nigeria. Milk flavor was obtained from Edeel Nig Ltd Lagos, vitamin/mineral mix was sourced from Health plus Ltd Ikeja, Lagos.

Pre-Processing Operation

Preparation of *Treculia africana* Samples
Unmalted *Treculia africana* flavor (UTA)

The Unmalted *Treculia africana* flour (UTA) was prepared using the method described by Onweluzo and Nnamuchi (2009). Two kilograms of *Treculia africana* seeds were parboiled for 25 minutes and poured into 7mm sieve to drain. The seeds were immediately dehulled (using single disc mill) and subsequently winnowed (in a winnower: Bentall Superb 200L90). The hull-free seeds were washed thoroughly with clean water and cooked for 40minutes at 100^{0}C. Five matured leaves of fresh bitter leaf (vernonia amygdlina) were added to the seeds after 30minutes of cooking, cooled and oven dried at 100^{0}C for 24hours. The sample was milled with a blender, sieved and stored in a tight plastic container until used for product formulation and analysis. (Figure 1)

Malted *Treculia africana* flour (MTA)

The malted *Treculia africana* (MTA) flour was prepared by the method described by Nwabueze and Atonwu (2007). Two kilograms of African breadfruit were sorted, washed and steeped in clean water (three times the seed volume) at 28^{0}C for 36hours. The steep water was changed every 6hours with an hour interval. At the end of 36hours of cumulative steeping, the seeds were spread on a jute bag (earlier washed and sterilized with 0.10% sodium chloride in hot water (100^{0}C) to prevent mould growth). The seeds were thereafter allowed to germinate for 72hours during which they were washed every 24hours to prevent mould growth.

At the end of germination, the seeds were manually separated from the sprouts. The malted seeds were parboiled for 15minutes and poured into a 7mm sieve mesh size to drain. The seeds were de-hulled and winnowed. The hull-free seeds were washed thoroughly with clean water, cooked for 30minutes at 100^{0}C. The five matured leaves of the fresh bitter leaf plant were added to the seeds in the course of cooking (after 20minutes). It was then cooled, milled, sieved and stored in a tight plastic container until used for product formulation and analysis (Figure 2).

Preparation of Adjuncts

Preparation of Adjuncts (crayfish and pepper)**:** One hundred grams of crayfish was washed and oven dried at 60^{o}C for 12hours. It was milled using a Hammer mill, sieved and packaged in an air tight container prior to use. Fifty grams of pepper was washed and oven dried at

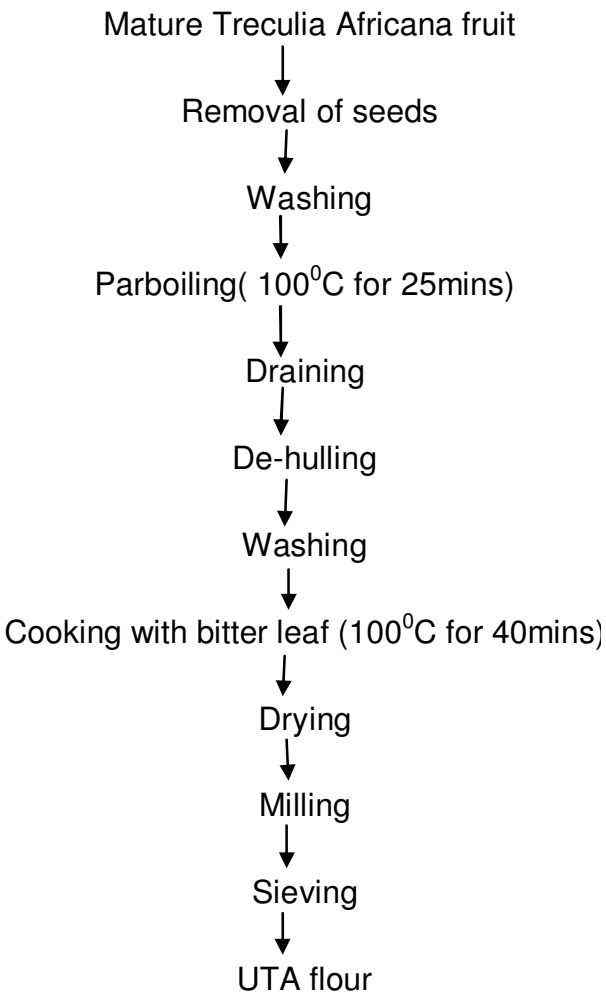

Figure 1. Flow diagram for the production of unmalted *Treculia Africana* flour (UTA)

60^{0}C for 12hours. It was then milled, sieved and packaged in air tight container until used for product formulation.

Product Formulation

One kilogram of unmalted *Treculia africana* (UTA) flour was blended with 50g of crayfish, 5g of pepper, 5g of vitamin/mineral mix and 5g of milk flavor to produce the geriatric food. Similarly 1kg of malted *Treculia africana* (MTA) flour was blended with 50g of crayfish, 5g of pepper, 5g of vitamin/mineral mix and 5g of milk flavor to produce another variant of the geriatric food.

Compositional/Nutrient Analysis

The proximate composition of the products (moisture, total ash, crude protein, crude fat and crude fibre) was determined using the methods of the AOAC (2000). Carbohydrate was determined by difference.

Moisture**:** The moisture content (%) in the samples was determined according to AOAC (2000). One gram of each sample was preweighed (W_1) in a beaker and placed in an oven at 105^{0}C for 24h. Thereafter the sample was removed from the oven, cooled in a desiccator and reweighed (W_2). The percentage moisture content was calculated according to the formula

Moisture (%) = $(w_1 - w_2)/w_1\ X\ 100$

Total ash**:** The total ash content was evaluated as total inorganic matter by incinerating the sample at 600^{0}C (AOAC, 2000). Two grams of each sample was weighed into a pre-weighed porcelain crucible and charred on an electric heater and thereafter transferred to a muffle furnace at 600^{0}C for 2hours. The crucible was removed from the muffle furnace, cooled in a desiccator and weighed. The ash content was calculated as follows

Ash (%) = ash weight (gm./sample weight (gm.) x 100

Crude protein: This was determined using the kjeldahl method (AOAC, 2000). Two grams of each sample was placed in a kjeldahl flask. Five grams of Na_2SO_4 plus one gram of $CUSO_4$ together with 25ml conc. sulphuric acid were added to the sample and digested for 1hr 20min.

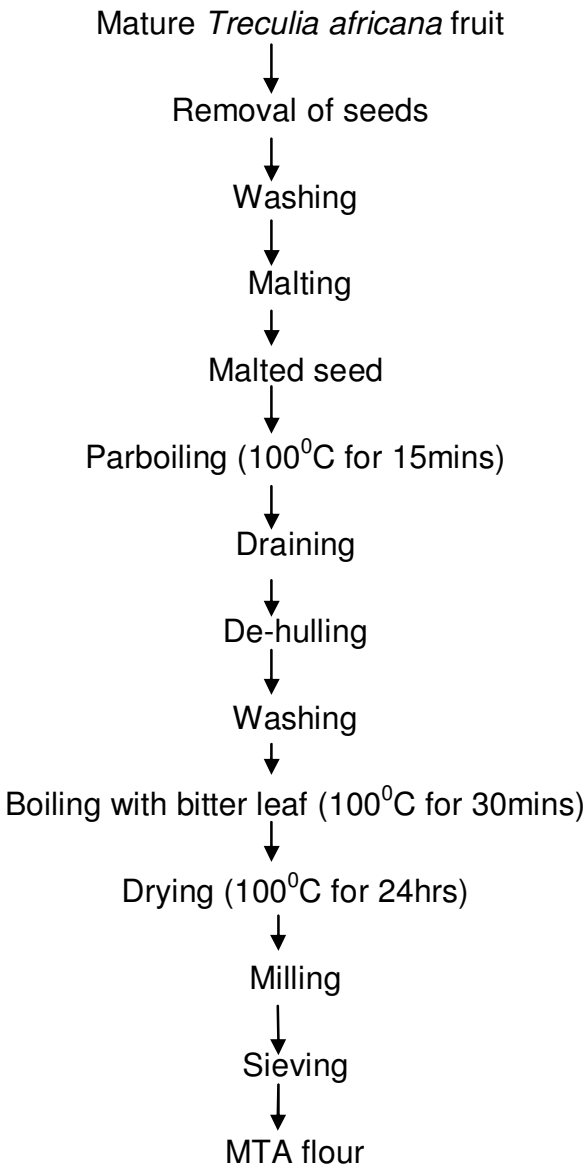

Figure 2. Flow diagram for the production of malted *Treculia africana* flour (MTA)

Deionized water was next added to the sample after allowing it to cool. A 25ml NaOH(40%), (conc.) was next added to the sample and the entire mix distilled, the liberating ammonia was then collected in boric acid. This volume was titrated with 0.1M hydrochloric acid. A control sample was prepared and treated in the same manner. The percentage protein was established as follows

Crude protein (%) = (sample titre –blank titre) x 14 x 6.25 x 100 /sample weight.

Crude fat: Crude fat was estimated by solvent extraction using a soxhlet extraction unit. One gram sample was weighed into an extraction thimble and covered with absorbent cotton. 50ml petroleum ether was added to a preweighed cup. Both thimble and cup were attached to the extraction unit. The sample was subjected to extraction with solvent for 30min followed by rinsing for 1½ hours. The pet. ether was evaporated from the cup passing through the condensing column. The residual fat extract in the cup was calculated using the following formula:

Crude fat (%) = (extracted fat/ sample weight) x 100

Crude fibre**:** One gram of each defatted sample was placed in a glass crucible and attached to the extraction unit. 150ml of boiling sulphuric acid solution (1.25%) was added. The sample was digested for 30 minutes and then the acid drained off. The sample was next washed in boiling distilled water. This was followed by addition of 150ml of sodium hydroxide (1.25%). The sample was digested for 30minutes, thereafter the alkali was drained off and the sample washed with boiling distilled water. Finally, the crucible was removed from the extraction unit and oven dried at 105^{0}C overnight. The samples were allowed to cool in a desiccator and weighed (W_1).

The sample was next ashed at 550^0C in a muffle furnace for 2hours, subsequently cooled in a desiccator and reweighed (W_2). The resulting fibre extract was expressed as percentage of the original undefatted.
Crude fibre (%) = Digested sample (W_1) – Ashed sample (W_2)/ W_1+ of sample x 100
Energy content: Energy content (obtained by calculation using the method described by Osborne and Voogf, (1978)) = [(4 x protein) + (4 x carbohydrate) + (9 x fat)] x 4.2 where protein, carbohydrate and fat are contents of the sample expressed in g/100 sample, 4,4 and 9 are representative indices for protein, carbohydrate and fat respectively while 4.2 is the conversion factor from calories to Joules. The determination was carried out in triplicates.

Mineral profile

One gram of each sample was digested with nitric acid and perchloric acid. Ten millitres of HNO_3 at gentle temperature was mixed with 1g of the sample (65^0C) for 20 minutes, followed by the addition of $HClO_4$ at high temperature (190^0C) till the solution became clear. The digested sample was transferred to 250ml volumetric flask and volume diluted to mark with distilled water and then filtered (Duhan et al., 2002). Aliquots of sample solution were loaded in the Atomic Absorption Spectrophotometer (Perkin Elmer, 2380, USA). The standard curve for each Mineral constituent of the samples were estimated for Cu, Zn, Ca, Mg and Fe by using the respective standard curve prepared for each element (AOAC, 2000). The mineral compositions of the samples were determined in duplicates.

Phytochemicals and Sundry Assay

Total Phenolic Content

The concentration of phenolic compounds in the sample powder was determined using the method of Singleton et al., (1999). The reaction mixture was prepared by mixing 1ml of ethanolic solution of extract, 2.5ml of 10% Folin ciocalteu's reagent dissolved in water and 2ml of 7.5% $NaHCO_3$ blank was prepared. The sample were thereafter incubated in a thermostat bath at 45^0C for 30min. The absorbance was determined using a spectrophotometer (spectrum Lab 752s) at 610nm on the sample (prepared in triplicate for each analysis). The same procedure was repeated for the standard solution of gallic acid and the calibraton line was constructed. The concentration of phenolics was read (mg/g) from the calibration line based on the measured absorbance. The content of phenolics in the sample was expressed in terms of gallic acid equivalent (mg of GA/g of extract).

Total Flavonoid Content

The total flavonoid content was evaluated according to the aluminum chloride colorimetric assay method of Zhishen et al., (1999). A small quantity (1ml) of the product extracts (0.5g dried product in 50ml 80% aqueous methanol) or standard solution of catechin (3, 6, 14mg/dL) was added to 10ml volumetric flask containing 4ml double distilled H_20. About 0.3ml 5% $NaNO_2$ was also added to the flask. After 5min, 0.3ml 10% $Alcl_3$ was further added. At the 6^{th} minute, 2ml of IM NaOH solution was added and the total volume was made up to 10ml with distilled water. The solution was mixed and the absorbance was measured against prepared reagent blank at 510nm. Total flavonoid content was expressed as mg catechin equivalents (CE)/g product sample. The samples were analyzed in triplicates.

Total Antioxidants Capacity

The total antioxidant activity of the formulated diet was evaluated by the formation of phosphomolybdenum complex according to the method of Prieto et al (1999). A small quantity of ethanolic solution (0.1ml) of the sample (100μg) solution was added to 1.9ml of reagent solution ((0.6M H_2SO_4, 28mM sodium phosphate and 4mM Ammonium molybdate). The blank solution contained only 2ml of reagent solution. The tubes were capped and incubated in a boiling water bath at 95^0C for 90mins. After the sample had cooled to room temperature, the absorbance of the aqueous solution of each was measured at 695nm in UV-visible spectrophotometer (Spectrum Lab 752s) against blank. Appropriate solution of ascorbic acid (0.2-2mM) were utilized as reference. Results of evaluation were expressed as ascorbic acid equivalents (milligrams per gram extract).

Reducing Power Potential

The reducing property of the food samples were determined by assessing the ability of the sample to reduce $FeCl_3$ solution as described by Palido et al (2000). One millilitre of the sample solution (0.5g of the sample homogenized in 20ml ethanol) was mixed with 2.5ml of 200mM sodium phosphate buffer (pH6.6) and 2.5ml of 1% (w/v) potassium ferrocyanide; the mixture was incubated at 50^0C for 20min, thereafter 2.5ml (10% w/v) Trichloroacetic acid was added and subsequently centrifuged at 650rpm for 10 mins. Two and half millilitres of the supernatant was mixed with equal volume of water and 0.5ml of ferric Chloride (freshly prepared). The absorbance was measured at 700nm using UV-Visible spectrosphotometer (Spectum Lab 752s). A higher

absorbance indicates a higher reducing power.

Free Radical Scavenging Ability

Using the method of Ursini et al (1994) the free radical scavenging ability of the product sample against DPPH (1,1- diphenyl-2 picrylhdrazyl) free radical was evaluated. An aliquot 0.2ml of sample solution (0.5g of the food samples homogenized in 20ml methanol) was mixed with 7.6ml of 0.4mM methanolic solution containing 1,1-DPPH radical. The mixture was left in the dark for 30mins before measuring the absorbance at 516nm.

pH

This was determined using the official methods of analysis of the association of analytical chemists (AOAC, 2000). Following standardization and equilibration of the pH meter (Model BA 50) the electrode was inserted directly into a 10% solution of the product sample and the pH read.

Titratable Acidity

Three grams of each sample was dissolved in 30ml of water and filterate was subsequently obtained. About 25ml of the filterate was transferred into 125ml conical flask with two drops of phenolphthalein added. A 25ml burette was filled with 0.1N NaOH and adjusted to the zero mark. The filterate was titrated with 0.1N NaOH until the indicator changed to pink and the volume noted. Titratable acidity was calculated as percent lactic acid (AOAC, 2000).
% acidity = A x N x 0.009
A = average titre value
N = Normality of NaOH [0.1]
0.009 = Equivalent factor for lactic acid

Functional properties

Water absorption capacity (WAC): The WAC for both samples was determined using the method described by Beuchat (1977). One gram of each sample was mixed with 10ml of distilled water and shaken for one minute. The samples were allowed to stand for 30 minutes and centrifuged at 3500rpm for 30 minutes at room temperature. The supernatant was decanted and the volumes of water determined. Water absorption capacity were expressed as volume of water absorbed/g flour.
Viscosity: Viscosity was determined on 10% dispersion of each product blend using Ferranti Viscometer (model VL). The dispersion was converted into porridge by heating at 100^0C for 5minutes. Viscosity was measured at 40^0C.

Bulk density: Bulk density was determined according to the method of Nwabueze and Iwe (2006). Samples were placed in a 25ml graduated cylinder and gently tapped on top several times until there was no further diminution. The observed weight and the volume of the sample was recorded. The procedure was repeated two times for each sample and the bulk density was computed as g/ml of the sample.
Bulk density:

$$\frac{weight\ of\ sample\ (g)}{volume\ of\ sample\ (ml)}$$

Sensory Evaluation

A porridge was prepared for each sample by boiling 1 part (vol) of product to 4 parts (vol) of water (a water dispersion mix) for 5minutes at 100^0C with the addition of Iodized salt (to taste). The consumer preference test for colour, flavor, taste, constitency, appearance and overall acceptability was carried out by a 30 man panel made up of elderly people (65 years and above) on a nine point hedonic scale where 1 represents the highest rating (like extremely), 5 represents mid-rating (neither like nor dislike) and 9 represents the lowest rating (dislike extremely).

ANIMAL STUDIES

Experimental Animals

Adult Albino rats (190-300g) used in this study were obtained from the Animal house, department of clinical pharmacy, university of Ibadan. The animals were used after an acclimatization period of 7days in a well ventilated room under the prevailing condition of 70% relative humidity, temperature of 30 ± 4^0C and 12hour light/darkness cycle. They were housed in standard cages.

Basal Diet

The animals were maintained on standard animal pellets (protein 21% , fat 3.8% , Fibre 6.0% Calcium 0.8%, phosphorus 0.8% and potable water ad libitum).

Acute Toxicity

The fixed dose procedure of Boyd (1976) and Organization for European cooperation and development (O.E.C.D) as described by (Botham, 2004) was followed. Porridge as described earlier were prepared from the more preferred sample (MTP) and administered (Intubate feeding) to the Rats (five per group) in four groups with single dose ranging from 2000-8000mg/kg body weight of

Table 1. Mean scores for sensory properties of MTP and UTP Geriatric products

Sample	Aroma	Taste	Mouthfeel	Appearance	Overall acceptability
MTP	3.45[a]	3.00[a]	4.30[a]	3.05[a]	3.68[a]
UTP	4.95[b]	5.15[b]	4.35[a]	4.70 [b]	4.80[b]

N.B Mean scores not followed by the same alphabet are significantly different (p>0.05).

Rat following acclimatization. The fifth group of five served as control. After 24hours, the animals were inspected for appearance of signs of toxicity and possible deaths.

Sub-Acute Toxicity

The intubate feeding reported continued daily for 14days immediately after which the animals were sacrificed. Visual observations for changes in nature of stool, eye colour, behaviour and possible mortality were made every day during the two weeks feeding trial. Possible weight gain or loss was also determined.

Biochemical Assay

Using blood obtained from the rats just before sacrifice, the following parameters were determined: Alkaline phosphatase (ALP), Serum Urea(blood urea nitrogen), Alanine amino transferase (ALT), Creatinine and Aspartate amino transferase (AST). Randox test kits (Randox Laboratories Ltd, UK) were used for the analysis of these parameters.

Data Analysis

The data generated was statistically analysed and the means separated using Duncan's multiple range (SPSS 17.0 computer package).

RESULTS

Compositional/Nutrient Analysis

The fat and carbohydrate content for MTP were 11.56% and 49.15% respectively and were lower than that of UTP-12.84%, 51.63%. The moisture, protein, crude fibre and ash contents of MTP were 10.17%, 19.6%, 3.18% and 5.82% respectively and indeed were correspondingly higher than those for UTP with values of 9.28%, 18.39%, 3.16% and 4.70 in the same order. The energy content of the UTP (1661.69KJ/100g) was higher and significantly different ($p > 0.05$) from that of MTP (1591.8 kj/00g). The mineral profile of the MTP were also significantly higher in content that of the UTP. The calcium, magnesium, iron, copper and zinc content (mg/100g) were 416.2, 171.75, 3.95, 1.5 and 4.75 respectively while that of UTP in the same order were 389.40, 85.7, 3.35, 0.405 and 3.43.

Phytohemicals and Sundry Assay

The MTP had a total phenolic content that was moderately higher (5.63mg/g) than that observed in the case of UTP samples (4.3mg/g). This is at variance with the flavonoid component of the MTP which was more than double (1.59mg/g) that of UTP (0.67mg/g).

Total antioxidant capacity of MTP (14.2mg/g) contrasts sharply with that obtained for UTP (12.1mg/g). The reducing power potential of the UTP was higher (5.04mg/g) than that of the MTP (4.82mg/g) though not significantly different ($P<0.05$). The DPPH (1,1-Diphenyl-1-picrylhydrazyl) Radical scavenging Activity of UTP is indeed higher (11.30%) when compared with 8.40% for MTP.

Evaluation of pH showed a slightly more acidic malted Treculia product (MTP) (6.20) as against the UTP's value of 6.46. A similar trend was obvious from the figures for titratable acidity – MTP (0.07%), UTP (0.09%).

Functional properties

The water absorption capacity (WAC) of the malted Treculia product (MTP) was much lower (2.54ml/g) than that of the unmalted variant (UTP) 3.27ml/g indicating about 22% decrease. However their viscosities (MTP – 2.3RVU, UTP-2.6RVU) were not significantly different from each other ($P < 0.05$). It was also observed that their bulk densities (MTP-0.96g/ml, UTP-1.07g/ml) compared favourably.

Sensory evaluation

The sensory attributes of malted and unmalted *Treculia africana* seed based Geriatric products evaluated are presented in Table 1. All the sensory scores on a 9 point hedonic scale with 1 (like extremely) and 9 (dislike extremely) indicated that the MTP samples was more preferred. Mean scores for MTP ranged from 3.00 (taste) to 4.30 (mouthfeel) in contrast to scores for UTP which ranged from 4.35 (mouthfeel) to 5.15 (taste). The sensory attributes of MTP and UTP samples were significantly

Table 2. Mean weights of the test animals from D_0 to D_{21}

Treatment (mg/kg/day)	D_0 mean wt (g)	D_7 mean wt (g)	D_{14} mean wt (g)	D_{21} mean wt (g)
GRP A (8000)	312	322	364	380
GRP B (6000)	252	262	296	324
GRP C (4000)	234	244	268	290
GRP D (2000)	220	230	246	264
GRP E(control)	200	210	216	226

N.B Figures under treatment column represents feed dosage evaluated

Table 3. Some biochemical parameters of the test animals

Treatment mg/kg/day	AST(μkat/L)	ALT(μkat/L)	AP(μkat/L)	UREA (μmol/L)	CREATININE (μmol/L)
GRP A (8000)	0.66	0.48	1.97	1281.8	70.7
GRP B (6000)	0.57	0.44	2.00	1370.2	88.4
GRP C (4000)	0.63	0.45	2.14	1281.8	70.7
GRP D (2000)	0.68	0.47	1.99	1414.4	70.7
GRP E (control)	0.69	0.47	1.88	1458.6	57.5

N.B AST- Aspartate Aminotransferase, ALT, = Alanine Aminotransferase, ALP = Alkaline phosphase; Figures under treatment column represents the feed dosage evaluated

different from each other (P>0.05) with the exception of mouthfeel.

TOXICOLOGICAL EVALUATION

All the rats in control and test sample groups survived throughout the test period of 14days. At the dose levels tested, no unpleasant clinical signs was observed in the surviving rats. There were no noticeable changes in the nature of stool, urine, eye colour, and behaviour in the Rat groups. Also no mortality was recorded.

Weekly body weight: The weekly body weights of all the animals from day 0 to day 21 (D_0 to D_{21}) are shown in Table 2. There was progressive increase in the mean body weights of rats in the entire group throughout the study. The mean weight of the animals in the control and test groups on day 0 ranged from 200g – 312g. At the end of the acclimatization period, there was approximately 5% increase in the mean weights of all the animals including control and test groups. After the feeding trial of 7days (D_{14}) for test samples, group B had the highest percentage increase in mean weight (17.4%), followed by A (16.7%), C (14.5%), D (11.8%) and E (8%). At the end of the dosing period (D_{21}), the percentage mean weight gain of group B animals were highest (28.8%) followed by C (23.9%), A (21.8%), D (20%) and E (13%) in this order.

Biochemical assay: The results of clinical chemistry is as shown in Table 3. The AST levels in all the test groups were lower than that of the control (0.69μkat/L). The ALP level of animals in group C were highest (2.14 μkat/L) followed by groups B, D and A. All were higher than the control (1.88 μkat/L).

The urea levels of all the test groups were lower than the control (1458.6 μmol/L). The creatinine level of group B animals was highest (88.4 μmol/L) and that of the control was lowest (57.5 μmol/L). The creatinine level of groups A, C and D animals were the same (70.7 μmol/L).

DISCUSSION

The observed decrease in fat and carbohydrate component of the malted *Treculia africana* based products (MTP) when compared with the unmalted variant may be attributable to the effect of malting. During this phenomenon hydrolytic enzymes in the seeds are activated coupled with the mobilization of soluble substances into roots and shoots to enhance actual germination. This may likely explain the drop in the level of those nutrients evident in malted samples. These observations are in harmony with those of Gernah et al (2011) who reported a drop in carbohydrate and fat component of maize following malting. The minimum amount of carbohydrate in the human diet that is needed to avoid ketosis is of the order of 50g/day in adults (WHO, 2002). Therefore to meet the minimum daily requirement for carbohydrate about 100-150g of MTP or UTP are required.

The increased protein content in MTP samples could be the result of mobilization of storage Nitrogen in the malted *Treculia africana* seeds to aid germination. A similar report on the effect of malting on protein along with moisture, crude fibre, and ash content of *Treculia africana* seeds have been reported by Nwabueze and Atuonwu (2007). The 19.61% protein content of MTP is sufficient in meeting the recommended daily intake of an elderly person fed solely on it (WHO, 2002). In order for instance to meet the 74.8g daily protein requirement of an elderly person of 68kg body weight about 312-382g of MTP would have to be consumed. Protein intake is an important determinant of muscle mass and function (Castenada, 1995). The energy content of the Geriatric product is also noteworthy. In meeting, the daily energy needs of the elderly, about 628.5-791.6g of MTP and 601.7-758.3g of UTP is advocated for consumption. In practical terms, higher quantities may be required owing to incomplete nature of metabolism of energy-giving nutrients by the human body culminating in available lower metabolic energy (Fasasi et al, 2003). Consequently other energy foods can be used to supplement these products in order to meet the energy requirement of the elderly. Older adults comprise a very heterogeneous population including both very healthy, active individuals but frail, institutionalized individuals all with variable requirement (Ledikwe et al, 2001). The mineral composition of the Geriatric product is also quite remarkable. Undoubtedly malting improves the overall nutritional value of food as it converts insoluble nutrients such as proteins to soluble components, increasing the levels of essential ammo acids such as lysine as well as Vitamins B and C (Fasasi et al, 2003). The enhanced high mineral profile of the product may be related to the addition of multi-vitamin and mineral mix. The elderly requires some 300-350g of MTP or UTP samples to meet the various essential mineral requirements including calcium, magnesium, iron, copper and Zinc.

The lower total phenolic content observed with MTP samples may be attributable to the increased activity of polyphenol oxidase and other catabolic enzymes (Osuntogun et al, 1989). Plant extracts containing high levels of polyphenols such as Gallic acid or its equivalent can potentially scavenge excessive free radicals such as superoxide anion and peroxy radicals in the human body thereby protecting human cells or tissues against oxidative stress (Norshazila et al, 2010). Increased flavonoid content following malting as observed in this study has also been noted with buckwheat seed where a nearly 1.5 fold rise was recorded within just three days of germination (Zhou et al., 2011). The nutritional value of dietary flavoniods has long been appreciated. Hertog et al. (1993) reported a reduction in the risk of death from coronary heart disease in man when mean baseline flavonoid intake was 25.9mg daily in regularly consumed foods.

This suggest that a minimum of 17 grams of MTP and 39 grams of UTP sample might sufficiently meet the dietary flavonoid requirement against coronary heart disease. The stronger reducing potential of the UTP samples over the MTP variant is a function of its higher absorbance at high concentration. It was assessed based on their relative ability to reduce Fe^{3+} to stable Fe^{2+}. Malting appears to slightly lower this particularly ability. The reducing capacity of compounds serves as an indicator of potential antioxidant property (Meir et al., 1995).The relatively high total antioxidant capacity (MTP – 14.2mg/g; UTP – 12.9mg/g) may make this diet better serve as a potential dietary antidote for degenerative diseases often associated with aging (Hyson, 2011). It has often been said that substances with a measure of antioxidant capacity can inhibit mutation and cancer in view of their inherent abilities to scavenge the radicals or induce antioxidative enzymes (Hochstein et al., 1988). The higher potential of the UTP sample diets rather than MTP to get rid of free radicals in the body is underscored by it's DPPH (1, 1-Diphenyl-1-Picryldrazyl) radical scavenging activity of 11.3%. Malting may in some way have diminished this activity, since that is the only operation that distinguishes it from the MTP variant.

Water absorption decreased in the malted product (MTP) by about 22% and is attributable to increased presence of some hydrophilic protein or polar amino residues (Nwabueze and Atuonwu, 2007). A similar observation was reported with malted sorghum (Tatsadjieu et al 2004). Undoubtedly good water absorption capacity of food ensures faster and easier reconstitution and preparation of ready-to-cook foods since this contributes to product cohesiveness (Adetuyi et al. 2009). The lower viscosity associated with MTP could be traceable to the action of hydrolytic enzymes that developed during germination. These may have hydrohyzed the starch fraction in the *Treculia africana* seeds converting them to dextrins and maltose with less swelling capacity during cooking (Ayemor and Ocloo, 2007). Bulk density reduced by about 10% in the MTP samples when compared with UTP. Malting makes seeds more tender and easier to mill culminating in smaller particle sized products; hence reduced bulk density. This is a significant consideration in contemplating packaging sizes.

The consumer preference for the MTP over UTP in most sensory attributes is obvious from the mean scores. Malting may be a major factor in this, going by similar conclusion reached following comparative sensory and proximate evaluation of Kunu Zaki (a Nigerian beverage) made from germinated and ungerminated composite cereal grains (Oluwajoba et al, 2013).

The outcome of the animal studies largely dispels safety concerns associated with malting (WHO, 1998), including aflatoxin production, bacterial contamination and osmotic diarrhea due to hydrolysis of starch into simple sugars and oligosaccharides. The results

established the fact that the food product is not only safe for consumption but also nutritious. The increase in weight of the rats in the test groups over those in the control is an indication that the diet may have a salutary effect on growth. Gain in body weight is a measure of the nutritive value of dietary protein (Kalyani et al, 2012). The feed dosage at 6000mg/kg/day might possibly represent the optimum feed intake for the highest growth rate. The relative decrease of the Aspartate amino transferase ((AST) and Alanine amino transferase (ALT) activities in the test groups when compared to the control may be a reflection of the lower protein content of the diet (19.61%) in relation to the control (21%). Low protein intake reduces the activity of the liver enzymes- Aspartate aminotransferase and Alanine aminotransferase (Peter and Harper, 1985). As enzymes involved in amino acid metabolism, AST and ALT are key markers in liver disease (Ebuehi and Mbara, 2011). Obviously their concentrations simply shows that the diet has no deleterious effect on the liver. The higher Alkaline phosphatase (ALP) activity among the test groups over the control may be related to the nature and fraction of the lipid component of the diets (test diet – 11.56%, control diet – 3.8%) considering similar observations with fish oil and corn oil enriched diets (Stenson et al, 1989). A comparative evaluation of urea and creatinine levels in all the groups suggests that the diet may not have impacted negatively on renal function.

CONCLUSION

The seeds of African breadfruit (*Treculia africana*) subjected to malting can indeed be further processed with bitter leaf (*Vernonia amygdlina*), crayfish (*Procambarus clarkii*), pepper (*Capsicum spp*) and fortified with vitamins and minerals. The resulting cook-ready food product is nutrient dense, rich in phytonutrients and therefore holds great promise as a Geriatric diet for the developing world.

Declaration of Interest

We have no affiliation whatsoever to any organization or body with direct or indirect interest in this work.

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