International Journal of Food Science and Nutrition
www.foodsciencejournal.com
ISSN: 2455-4898
Received: 15-05-2022, Accepted: 30-05-2022, Published: 16-06-2022
Volume 7, Issue 3, 2022, Page No. 25-34

Quality evaluation of maize-coconut snack bars enriched with different levels of malted African breadfruit seed flour

Edima-Nyah Anne P[1*], Ekanem Moses C[2], Effiong Bartholomew N[1], Nwabueze Titus U[3], Ojimelukwe Philippa C[3]

[1] Department of Food Science and Technology, University of Uyo, Uyo, Nigeria
[2] Department of Food Technology, Akwa Ibom State Polytechnic, Ikot Osurua, Nigeria
[3] Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Nigeria

Abstract

The main objectives of this study were to develop maize-coconut based snack bars enriched with malted African breadfruit seed flour, and to evaluate the nutritional, microbial and sensory qualities of the snack bars. Six samples of snack bars were formulated with the blending ratio (Maize Flour: Coconut Grits: Malted African breadfruit seed Four) for S_0 (95:5:0), S_{20} (75:5:20), S_{25} (70:5:25), S_{30} (65:5:30), S_{35} (60:5:35) and S_{95} (0:5:95). The result of proximate composition showed significant increase of ash (2.83 – 4.08 %), fat (7.31 – 8.48 %), fibre (10.12 – 18.13 %) and protein (16.18 – 27.15 %), but decrease in carbohydrate (38.29 – 59.80) and calorific value (388.08 – 369.71 Kcal/100g), with increase in malted African breadfruit seed flour addition. Tannin (0.03 – 0.52 %), oxalate (0.08 – 0.44 mg/g), phytate (1.04 – 2.42 mg/g, saponin (0.98 – 7.35 %) and trypsin inhibitor activity (0.52 – 3.92 TIU/mg) content were low and the snack bars relatively safe for human consumption. Amino-acid profile revealed scores of 1.96 – 3.42 g/100g for total Sulphur containing amino-acids (TSAA), 6.21 – 7.17 g/100g in total aromatic essential amino-acids (ArEAA), 37.35 – 42.65 g/100g for total non-essential amino-acids (TNEAA), 31.97 – 39.05 for essential amino-acids (TEAA) and 71.64 – 81.70 for total amino-acids (TAA). Samples met the ICMSF specification having a total viable count (TVC) of 0.31 – 0.51 CFU/g and total mould count (TMC) of 0.08 – 0.48 CFU/g on microbial quality for safe consumption. Sensory qualities showed that snack bars developed with 20% malted African breadfruit seed flour (S_{20}) had the highest mean score in overall acceptability (7.73) and compared favourably with the Control (7.80) and was most preferred among the developed snack bars.

Keywords: snacks bar, maize, coconut, breadfruit, malting, amino acid

Introduction

Convenience plays an important role in the choices of food of many consumers today. The increasing demand for internet shopping, home delivery of groceries, microwave dinners, take-away meals and the likes, shows the prominent role of convenience in food choices determination. And providing consumers with healthy, nutritious, ready-to-eat foods, has been one of the major challenges. Snack bars, otherwise called Cereal bars are food products with a balanced option of minimally processed, rich in nutrients and good tastes (Edima-Nyah *et al*., 2019) [1]. They contain various ingredients such as cereals, nuts, fruits, chocolate, sweeteners and can be customized for various target groups such as protein rich, fibre rich, high or low calorie bars (Fabar and Yuyama, 2015)[2]. Snack bars are convenient alternatives as nutritious snacks in place of junk food by those who have very busy lifestyle with insufficient time for having proper in-between meals.

Maize (*Zea mays* L.) is a cereal with the highest production worldwide (Gwirtz and Garcia-Casal, 2014) [3], and is extensively cultivated in Nigeria. In sub-Saharan Africa, maize is a staple food. It feeds about 50 % of its population. It is an important source of protein, iron, vitamin B, carbohydrate and minerals. More than 40 different ways of consuming maize had been recorded in many countries in Africa (Nago *et al*., 1990) [4].

Coconut has a long and respected history, and is highly nutritious and rich in vitamins, minerals and fiber. It is regarded as a "functional food" because it provides many health benefits due to its nutritional content. The coconut palm is so highly valued by consumers as both a source of food and medicine that it is called "The Tree of Life." Several food uses or products exist for coconut. The primary product is copra, the white "meat" found adhering to the inner wall of the shell. It is dried to 2.5 % moisture content, shredded, and used in cakes, candies, and other confections (Okafor and Ugwu, 2014) [5]. Also, coconut oil is expressed from copra, which is used in a wide variety of cooked foods and margarine. Coconut provides a nutritional source of quick energy. It also boosts energy and endurance, enhancing physical and athletic performance (Bruce-Fife, 2010) [6].

African breadfruit *(Treculia. africana*) is an evergreen tree with great potentials as a source of nutrients to man. The seeds contain 8.00 % moisture, 13.56 % crude protein, 1.30 % fat, 2.80 % ash, 1.90 % crude fibre and 72.44 % carbohydrate (Nwabueze and Uchendu, 2011) [7]. Mineral elements such as potassium, magnesium, zinc is found in appreciable amount; however, sodium, calcium, iron and cupper contents are found in negligible amount (Osabor *et al*., 2009) [8]. The seeds of African breadfruit are commonly eaten as porridge when cooked with ingredients or roasted and eaten as snacks (Nwabueze *et al*., 2008) [9]. It has been reported that African breadfruit seed protein has a fairly well balanced amino acid composition with a comparatively higher level of lysine, compared to wheat protein (Makinde *et al*., 1985) [10]. Expanding the food applications for African breadfruit seeds would increase its versatility and utility.

Malting is a controlled germination process followed by controlled drying of the seeds. It promotes the development of hydrolytic enzyme with subsequent high activity. The processes modify the endosperm and produces characteristics flavour. It improves nutrient digestibility, especially protein and carbohydrate. Malting also improve vitamin and mineral bioavailability, alongside with amino-acid composition. Anti-nutritional factors such as phytates and tannins of malted foods are reduced, while an increase of the nutrient density is observed in malting. During malting, increase of reducing sugars is observed, and this could be due to starch hydrolysis by the amylases. This may cause little or no change in pH. Increase, if it occurs, could be due to solubilization of flour, or to structural changes in storage protein making them available to enzymatic attack. Sprouts (sprouted/ germinated food) are nutrient dense and are rich in vitamins, mineral, amino acids, protein (Shalim and Sudesh, 2003) [11].

In view of the benefit of malted seeds, and the increasing demand for convenience foods, the objective of this study was to develop nutritious snack bars utilizing malted African breadfruit seeds in the formulation along with maize and coconut to deliver a nutritious health product. Proximate composition and calorific value, anti-nutrient content, amino-acid profile, microbial load and sensory characteristics were determined to evaluate the acceptability of the product.

Materials and Method

Source of Raw Materials

African breadfruit seeds were purchased from Ndoro market, Abia State, Nigeria. Maize (white dent variety) was obtained from Uyo main market. Coconuts were obtained from a local farmer in Uyo, Akwa Ibom State, Nigeria.

Production of Maize Flour

Maize grains were processed into flour according to the procedures outlined Edima-Nyah *et al*., (2019) [1].

Production of Coconut Grits

Mature coconuts were harvested, dehusked and cracked. The coconut milk was collected in a cup while the coconut flesh (meat) were manually removed from the hard endocarp with the aid of a sharp pointed stainless steel knife. The procedures described by Edima-Nyah *et al*, (2019) [1] was adopted for the production of coconut grits.

Production of Malted African Breadfruit Seed Flour

Production of malted African breadfruit seed flour was carried out according to the method described by (Nwabueze and Uchendu, 2011) [7]. The seeds were washed with potable water and steeped for 24 h. The liquor was changed every 8 h to reduce microbial load and also prevent suffocation of the respiring embryo due to depletion of oxygen. The liquor was drained off at the end of steeping and the seeds were spread on a previously sterilized jute bag, placed on a laboratory bench. Germination was carried out at room temperature for seven [1] days. The sprouted seeds were kilned in an oven at 45 ^{o}C for 12 h to terminate germination and the temperature was later increased to 60 ^{o}C for 6 h for drying. The dried malted seeds were then toasted and milled to flour using a manual mill (Victoria Grain Mill, Model: 530025, Colombia). The flour was stored at ambient temperature (27±2 ^{o}C) in a clean, dry plastic container with a secured lid.

Formulation of Flour Blends

Six blends with different proportions of maize flour, coconut grits and malted African breadfruit seed flour were formulated and labelled S_0, S_{20}, S_{25}, S_{30}, S_{35}, S_{95}, as presented in Table 1.

Table 1: Flour Blend Formulations for Snack bars

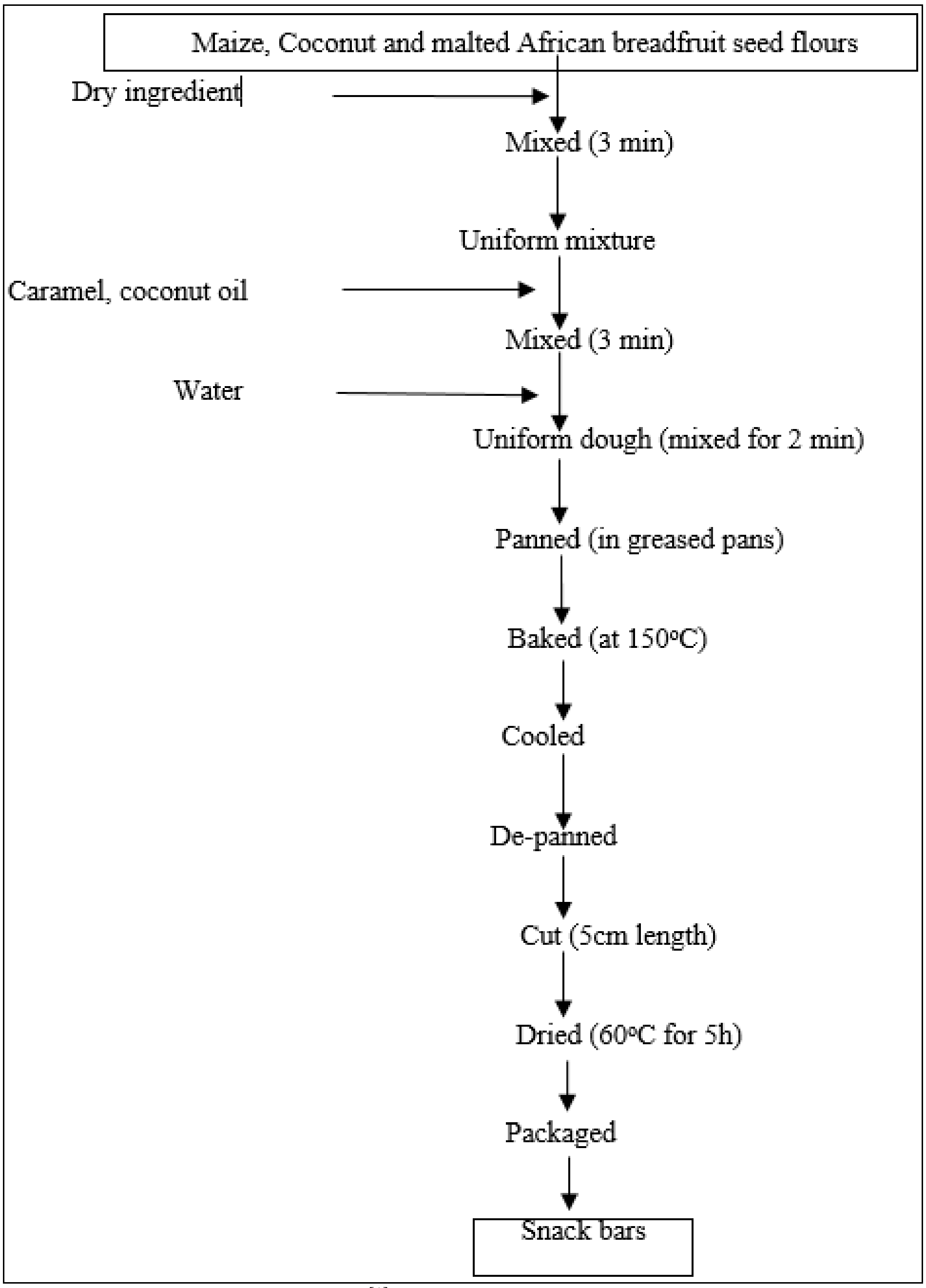
Samples	S_0	S_{20}	S_{25}	S_{30}	S_{35}	S_{95}
Maize flour	95	75	70	65	60	0
Coconut grits	5	5	5	5	5	5
Malted African breadfruit seed flour	0	20	25	30	35	95

Snack Bar Recipe

Six snack bar samples were prepared, each based on each of the composite flours previously blended. From each composite flour, 100 g of flour was weighed out. Also, 25 g of caramel, 15 g of margarine, 10 g of coconut oil, 5 g of milk powder, 2 g of baking powder, 2 g of nutmeg and 0.2 g of common salt were blended with 100 g of each composite flour. Each blend was mixed with 40 g of portable water.

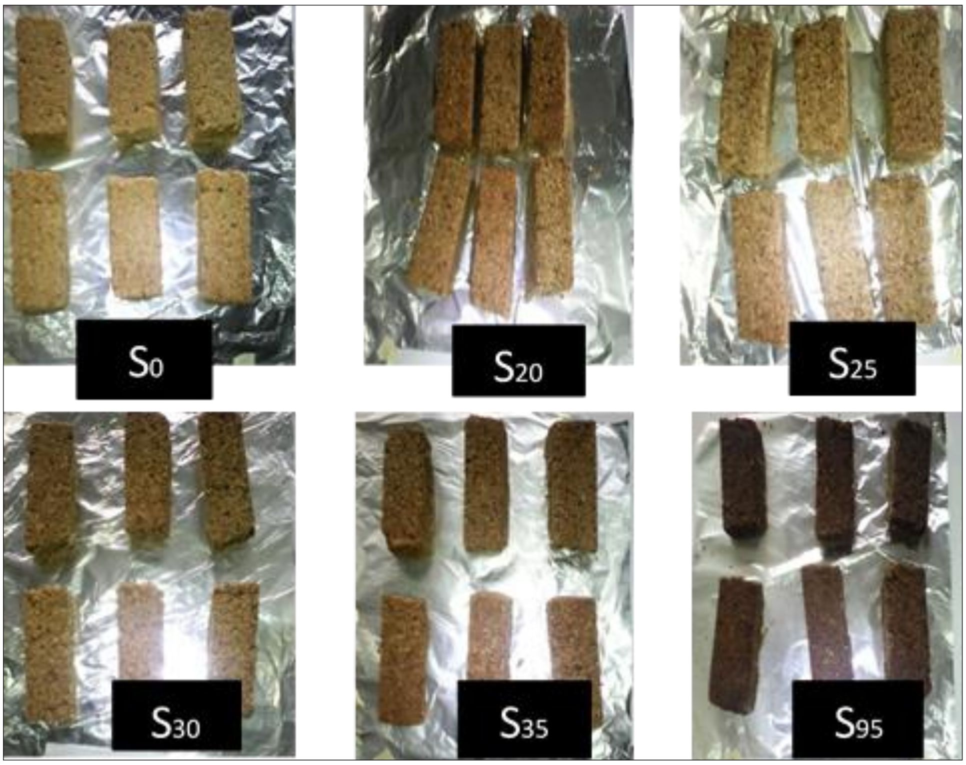
Production of Snack Bars

The snack bars were produced, as shown in Figure 3.4, according to the method described by Edima-Nyah *et al*,. (2019) [1]. The dry ingredients were manually mixed together in a stainless steel bowl for about 3min to obtain a uniform mixture. The liquid ingredients (caramel and coconut oil) were added and mixed for 3 min, water was incorporated slowly and the entire dough was mixed thoroughly for about 2 min to obtain a uniform dough. The dough was transferred into greased aluminum pans and compressed in the pans using a spatula to give a uniform mass. The pan covers were placed over them to smoothen the top and give the bars the desired shape. The dough was baked in an oven at 150 °C for 25 min. They were cooled to about 60 °C, de-panned and cut into bars seizes: 5 cm x 3 cm x 2 cm. The bars were further dried in an air-circulation oven at 60 °C for 6 h to reduce the moisture content, cooled at ambient temperature (27±2 °C) and packaged in a high density polyethylene. The packaged snack bars were labeled, sealed using an electronic sealing machine, Double Leopard (Model: SP 200H, Taiwan) and stored at ambient temperature in the laboratory for various determinations.



Source: Edima-Nyah *et al*., (2019) [1]

Fig 1: Flow chart for Snack bars production



Key:
S_0 =95:5:0, Maize: coconut: malted African breadfruit, S_{20} = 75:5:20, Maize: coconut: malted African breadfruit, S_{25} = 70:5:25, Maize: coconut: malted African breadfruit, S_{30} = 65:5:30, Maize: coconut: malted African breadfruit, S_{35} = 60:5:35, Maize: coconut: malted African breadfruit, S_{95} = 0:5:95 Maize: coconut: malted African breadfruit

Fig 2: Pictorial representation of the snacks bar.

Proximate Analyses
were carried out on the raw materials and the snack bars produced using standard methods of AOAC, (2005) [12] for moisture content, crude fat, crude protein, total ash, crude fiber and carbohydrate.

Determination of Calorific Value
Calorific value was calculated according to the method described by Osborne and Voogt, (1978) [13].

Determination of Anti-Nutrient Content
Tannin, phytate and trypsin inhibitor activity contents were determined using the standard spectrophotometric method described by Pearson (1976) [14]. Oxalate and tannin were determined by the method described by Oberleas, (1973) [15] and Onwuka, (2005) [16] respectively.

Determination of Amino-acid Profile
The amino acid profile of the Snack bars produced was determined using the method described by Benitez, (1989) [17]. The samples were dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Applied Bio-systems (PTH) Amino Acid Analyzer (model: 120A PTH, England).

Microbiological Examination
Microbiological analysis was carried out using the method of the International Commission on Microbiological Specification of Foods (ICMSF, 2009) [18]. A unit weight of a homogenate sample of each snack bar was aseptically mixed with 9ml of sterile distill water in a test tube. The mixture was diluted serially to the fourth diluents (10^4). Then, 1ml each was taken from the 2^{nd} (10^2) and the 4^{th} (10^4) diluents and used for the culture of moulds and bacteria respectively. In each case, the inoculum was aseptically placed on the surface of appropriate sterile medium (Sabroud Dextrose agar, SDA, for fungi and Nutrient agar for bacteria) and with the aid of a sterile glass hockey, it was spread over the surface of the medium. For bacterial count, the inoculated plates were incubated at 37 ^oC for 24-48 h, while the inoculated plates for mould count were incubated at 37 ^oC for 48 – 120h. The incubated plates were examined daily for growth, and on establishment of growth, the number of colonies on each plate was counted with the aid of a colony counter. The number of colonies in each plate examined was expressed as the colony forming unit (cfu) and the total viable count was calculated using the formular:

TVC (Cfu/g) = 1/v × N------------------------------ (1)

Where TVC = Total viable count, v = volume of inoculum, N = number of colonies counted.

Sensory Evaluation

A 30-member consumer acceptance panel (semi-trained) was drawn from the staff and student population of the College of Applied Food Science and Tourism, of Michael Okpara University of Agriculture, Umudike, Nigeria, to evaluate the sensory characteristics of the snack bars. This number is considered adequate for rough product screening and for evaluating acceptance and/or preference in a laboratory environment (Stone and Sidel, 1985) [19]; (Nwabueze *et al*., 2008) [9]. A 9-point hedonic scale questionnaire with 9=like extremely, 5=neither like nor dislike and 1=dislike extremely was adopted according to literature (Lawless and Heymann, 1998) [20]. Each snack bar was assigned a 3-digit code and presented in a white ceramic plate in a white lighted and quiet laboratory environment. Samples were served in a randomized order with portable water and spit-cup for rinsing of mouth in-between tasting of samples to minimize rating errors, due to carryover of perceived attributes of previous samples (Nwabueze *et al*., 2008) [9]. Sensory attributes evaluated by the panelists were product appearance, aroma, texture, taste, chewiness and overall acceptability.

Analysis of Data

All experiments were conducted in triplicates and data obtained were analyzed with IBM SPSS version 20 software using Two-Way analysis of Variance (ANOVA) to determine significant differences at $P<0.05$ between means. Means where significantly different were separated using Duncan Multiple Range Test at $P<0.05$.

Results and Discussion

Proximate composition and Caloric Value

Proximate composition and energy values of maize-coconut snack bars enriched with malted African breadfruit seed flour are shown in Table 2. Moisture contents ranged from 3.76 to 4.82 %, which was within the range of standard category and suitable for storage without triglyceride degradation (Feili *et al*., 2013) [21]. These values were lower than that reported (9.70%) by James and Nwabueze (2013) [22] for African breadfruit based extruded snacks. Silva de Paula *et al*., (2013) [23] reported higher moisture content (9.9 - 14.7 %) in cereal bars enriched with dietary fibre and omega3.

Crude fat content of snack bars was within the range of 7.31 % for S_0 and 8.48 % in S_{95}. Significant ($P<0.05$) differences existed in all the formulations. The fat contents were similar to that reported (7.31 – 8.46 %) by Edima-Nyah *et al.*, (2019) [1] for whole African breadfruit seeds-corn-coconut snack bars. Silva de Paula *et al*. (2013) [23] reported higher lipids values (11.4 - 12.7 %) for cereal bars. Lower crude fat contents (3.61 - 4.27 %) were reported by Torres *et al*., (2011) [24] for jackfruit seed and jenipapo based cereal bars. Dietary fat that provides essential fatty acids has been shown to enhance the taste and acceptability of foods, slows gastric emptying and intestinal motility thereby prolonging satiety and facilitating the absorption of liquid soluble vitamins (Usman *et al*., 2015) [25].

Ash content of snack bar ranged from 2.83 to 4.08 %, and showed significant differences ($P<0.05$) in all. These ash contents were lower than that reported in literature (5.15 %) by James and Nwabueze (2013) [22] for African breadfruit-soybean-corn snacks. Lower ash contents were reported by other researchers: 0.57-1.42 % by Torres *et al*,. (2011) [24] for cereal bars from jackfruit and jenipapo and 1.9-2.4 % by Silva de Paula *et al.* (2013) [23] for cereal bars enriched with linseed fibre. Ash content gives an overall estimate of the total mineral elements present in the food. Food with high ash content, according to Elinge *et al.*, (2012) [26], is expected to have high concentration of various mineral elements, which are expected to speed up metabolic processes, improve growth and development.

Crude fibre and protein content increased significantly from 10.12 to 18.13 % and 16.16 to 27.15 % respectively, with increasing substitution of malted African breadfruit flour in the snack bars. Crude fibre content of snack bars were higher than those of cereal bars enriched with linseed dietary fibre and omega3 (Silva de Paula *et al*., 2013) [23]. Fibre is important for the removal of waste from the body thereby preventing constipation and many health disorders (Adebayo *et al*., 2013) [27]. Edima-Nyah *et al.* (2019) [1] reported protein content (16.16 – 22.43 %) a little lower to this research in whole African breadfruit-maize-coconut snack bars. The increase observed could be as a result of malting the African breadfruit seeds. Increase in protein by malting could also be due to solubilization of flour and to structural changes in storage protein (prolamines and glutelins) making them available for enzymatic attack (Nwabueze and Atuonwu, 2007) [28]. Proteins play a part in the organoleptic properties of the sample and also act as a source of amino acids in the food.

Carbohydrate content of the snack bars decreased with increasing amount of malted African breadfruit seed flour in the blends ranged from 38.29 to 59.82 %. It was observed that, 0 % had the highest value of carbohydrate while the 95 % African breadfruit based snack bars showed the lowest value. The carbohydrate contents were significantly ($P<0.05$) different at all blend levels. James and Nwabueze (2013) [22] reported carbohydrate content (54.10 %) similar to these snacks. Carbohydrate content ranges of 57.9 to 65.1 %, for cereal bars from linseed were reported by Silva de Paula *et al.* (2013) [23]. Torres *et al*,. (2011) [24], reported 59.61-61.47 % carbohydrate for cereal bars developed using exotic fruits.

Calorific value of the malted African breadfruit based snack bars ranged from 338.08 to 369.71 Kcal/100g. It was observed to decrease with increasing amount of ABS in the snacks. Values were significantly ($P<0.05$) different for all the snacks formulated. James and Nwabueze (2013) [22] reported higher energy value (382.80

Kcal/100g) for African breadfruit seeds-soybean-corn extruded snacks. Lower values (277.02-278.99 Kcal/100g) were reported by Torres *et al*,. (2011) [24]. Linseed based cereal bars showed higher energy values, 392.7-407.7 Kcal/100g (Silva de Paula *et al.*, 2013) [23].

Table 2: Proximate composition and Calorific values of Maize-Coconut based snack bars produced with different levels of malted African breadfruit seed flour

Snack bars	Moisture content %	Ash %	Crude Fat %	Crude Fibre %	Crude Protein %	Carbohydrate %	Energy value Kcal/100g
S_0 (control)	3.76±0.02^f	2.83±0.01^f	7.31±0.02^f	10.12±0.10^f	16.18±0.02^f	59.80±0.01^a	369.71±0.11^a
S_{20}	4.36±0.01^d	3.50±0.01^e	7.63±0.03^e	15.75±0.01^e	19.93±0.04^e	48.83±0.05^b	343.71±0.01^b
S_{25}	4.73±0.04^b	3.55±0.02^d	7.75±0.01^d	16.68±0.01^d	23.97±0.01^d	43.32±0.01^c	338.91±0.01^c
S_{30}	4.82±0.12^a	3.88±0.01^c	7.87±0.01^c	16.72±0.04^c	24.16±0.01^c	42.55±0.02^d	337.67±0.03^e
S_{35}	4.55±0.01^c	4.05±0.01^b	8.22±0.12^b	17.63±0.01^b	24.51±0.01^b	41.04±0.01^e	336.18±0.01^f
S_{95}	3.87±0.11^e	4.08±0.11^a	8.48±0.10^a	18.13±0.01^a	27.15±0.10^a	38.29±0.11^f	338.08±0.12^d

Values are Means ± standard deviation of duplicate determinations. Means within the column with different superscript are significantly different at P<0.05.
S_0 =95:5:0, S_{20} = 75:5:20, S_{25} = 70:5:25, S_{30} = 65:5:30, S_{35} = 60:5:35, S_{95} = 0:5:95 of Maize: Coconut: Malted African breadfruit seed flour blends.

Anti-Nutrient Content

Table 3 summarized the content of tannin, oxalate, phytate, saponin and trypsin inhibitor activities of maize-coconut based snack bars enriched with malted African breadfruit seed flour. A range of 0.23 – 0.52 % for tannin, 0.06 – 0.44 mg/g for oxalate, 1.97 – 2.42 mg/g for phytate, 2.98 – 7.35 % for saponin, and 0.53 – 3.92 TIU/mg for trypsin inhibitor activities. As observed in the table, the anti-nutrient content increased significantly (p<0.05) with increasing substitution of malted African breadfruit seed flour, from S_0 to S_{95}. Edima-Nyah *et al*., (2019) [1] reported higher content of tannin (0.13 – 0.60 %), phytate (1.07 – 3.61 mg/g), trypsin inhibitor activity (0.53 – 5.92 TIU/mg), and lower values of oxalate (0.06 – 0.24 mg/g) and saponin (0.68 – 7.13 %) in snack bars from whole African breadfruit seed, maize and coconut flour blends. The difference in these results could be due to the difference in the processing treatments given to the African breadfruit seeds. Tannin content were within safe limits of 90mg/100g in humans. Safe level of oxalate is reported as 15 – 30 g/100g (Maseta *et al*., 2016) [29], and the snack bars could not have been toxic since it is below the limit. Oxalates, at higher doses, could combine with calcium to form insoluble salts, which causes obstructions in the kidney tubes and may lead to formation of kidney stones (Coe *et al*., 2005) [30]. Maximum tolerable dose of phytate and trypsin inhibitor factor in human body are 250 – 500 mg/100g (Bushway *et al*., 1984) [31] and 200mg/g (Liener, 1994) [32] respectively. Adeboye *et al*., (2013) [33] reported that trypsin inhibitor activity could form complexes with trypsin enzymes, and impair its proteolytic activity, thereby reducing the availability of amino-acids for metabolic processed. All the anti-nutrients assessed were within the safe limit, and the snack bars could not have been toxic for consumption under meal portion.

Table 3: Anti-nutrient content of Maize-Coconut based snack bars produced with different levels of malted African breadfruit seed flour.

Snack bars	Tannin (%)	Oxalate (mg/g)	Phytate (mg/g)	Saponin (%)	Trypsin Inhibitors (TIU/mg)
S_0 (control)	0.03^e±0.10	0.08^f±0.02	1.04^d±0.01	0.98^f±0.02	0.52^f±0.02
S_{20}	0.35^d±0.02	0.23^e±0.01	1.60^f±0.03	3.90^e±0.02	2.65^e±0.10
S_{25}	0.37^c±0.01	0.27^d±0.02	1.93^e±0.02	3.93^d±0.01	2.91^d±0.01
S_{30}	0.42^b±0.01	0.34^c±0.01	2.05^c±0.02	4.19^c±0.01	3.07^c±0.03
S_{35}	0.43^b±0.02	0.36^b±0.01	2.17^b±0.02	5.11^b±0.10	3.31^b±0.01
S_{95}	0.52^a±0.01	0.44^a±0.04	2.42^a±0.01	7.35^a±0.03	3.92^a±0.01

Values are mean ± standard deviation of duplicate determinations.
Means in the same column with different superscript are significantly different at p<0.05.
S_0 =95:5:0, S_{20} = 75:5:20, S_{25} = 70:5:25, S_{30} = 65:5:30, S_{35} = 60:5:35, S_{95} = 0:5:95 of Maize: Coconut: Malted African breadfruit seed flour blends.

Amino-acid Profile

Results of the amino-acid profile of maize-coconut snack bars enriched with malted African breadfruit seed flour are presented in Table 4. The amino-acid with the highest concentration and highest non-essential amino-acid was glutamic acid with values ranging from 11.05 to 12.78 g/100g protein. The highest concentration of the essential amino-acids was leucine (5.66-6.97 g/100g protein), followed by valine (3.33- 4.80 g/100g protein). Amino-acid with the least composition in all the samples was cysteine (0.85-1.59 g/100g protein).

Total sulphur-containing amino-acids (TSAA = methionine + cysteine) was between 1.96 and 3.42 g/100g protein, while total aromatic essential amino-acids (ArEAA = phenylalanine + tyrosine) ranged from 6.21 to 7.17

g/100g protein. Sample S_0 (Control) had the highest score in TSAA (3.42) and ArEAA (7.17), and was significantly ($P < 0.05$) higher in leucine and phenylalanine. This is in line with the report that maize is rich in leucine, but limiting in lysine (Iheokoronye and Ngoddy, 1985) [34]. Total essential amino-acid (TEAA) was lower (31.97 - 39.05 g/100g protein) than total non-essential amino-acids (TNEAA: 37.35 - 42.65 g/100g protein). Total amino-acid (TAA) of the snack bars ranged from 71.64 to 81.70 g/100g protein. Abasiekong *et al*., (2016) [35] reported close values of TSAA (1.82 – 2.76 g/100g) and TAA (70.57 – 92.30 g/100g) in African breadfruit based complementary foods. TAA values were above 566 mg/g of egg, a reference protein (Abasiekong *et al*., 2016) [35].

All the snack bars formulated with malted ABS met the DRI, (2002) [36] recommendation for valine (4.10 g), threonine (3.50 g) and isoleucine (3.20 g). Also, all snack bars met the amino-acid requirement pattern for human adults [37] [38]: lysine (1.6), threonine (2.8), valine (2.5), methionine (1.0), isoleucine (1.3), leucine (1.9), phenylalanine + tyrosine (1.9) in g amino-acid/100g protein. These snack bars could therefore be recommended as good source of protein for adults.

Table 4: Amino-acid profile of Maize-Coconut based snack bars produced with different levels of malted African breadfruit seed flour

Amino acid (g/100g protein)	Snack Bars						FAO/WHO/ UNU (1973) Adult (g/100g)	RDA (1989) Adult (g/100)
	S_0 (control)	S_{20}	s_{25}	S_{30}	S_{35}	S_{95}		
Essential								
Cysteine	0.85±0.01^{f}	1.28±0.00^{e}	1.31±0.00^{d}	1.36±0.01^{c}	1.47±0.00^{b}	1.59±0.00^{a}	NM	NM
Histidine	2.11±0.01^{c}	1.91±0.01^{e}	1.92±0.00^{e}	1.98±0.00^{d}	2.17±0.01^{b}	2.31±0.00^{a}	1.70	NM
Isoleucine	3.40±0.01^{e}	4.21±0.00^{d}	4.26±0.00^{c}	4.27±0.00^{c}	4.34±0.00^{b}	4.60±0.00^{a}	4.00	1.3
Leucine	7.00±0.00^{a}	5.66±0.00^{e}	5.67±0.00^{e}	6.24±0.00^{c}	6.02±0.01^{d}	6.65±0.00^{b}	6.70	1.9
Lysine	2.45±0.01^{f}	3.78±0.00^{e}	3.81±0.02^{d}	3.89±0.00^{c}	4.21±0.01^{b}	4.26±0.01^{a}	5.50	1.6
Methionine	1.12±0.01^{d}	1.13±0.00^{d}	1.17±0.00^{c}	1.29±0.01^{b}	1.30±0.02^{b}	1.83±0.01^{a}	3.50	1.0
Phenylalanine	4.08±0.01^{a}	3.90±0.00^{b}	3.86±0.00^{c}	3.81±0.02^{d}	3.46±0.01^{e}	3.81±0.01^{d}	6.00	1.9
Threonine	3.27±0.01^{f}	4.11±0.01^{e}	4.13±0.01^{d}	4.16±0.01^{c}	4.27±0.00^{b}	4.62±0.02^{a}	3.30	2.8
Tryptophan	0.97±0.01^{d}	0.94±0.00^{e}	0.98±0.00^{d}	1.26±0.00^{c}	1.37±0.00^{b}	1.48±0.01^{a}	NM	NM
Tyrosine	3.10±0.01^{b}	2.98±0.00^{c}	2.92±0.00^{d}	2.91±0.01^{d}	2.75±0.00^{e}	3.28±0.01^{a}	NM	1.9
Valine	3.62±0.01^{f}	4.39±0.01^{e}	4.45±0.00^{d}	4.80±0.02^{a}	4.56±0.02^{c}	4.62±0.00^{b}	4.40	2.5
TEAA	31.97	34.29	34.48	35.97	35.74	39.05		
Non-essential								
Alanine	3.94±0.01^{c}	3.49±0.00^{f}	3.62±0.00^{e}	4.02±0.00^{b}	3.78±0.00^{d}	4.17±0.00^{a}		
Arginine	5.59±0.01^{e}	5.07±0.01^{f}	5.63±0.00^{d}	6.29±0.01^{b}	5.86±0.01^{c}	6.62±0.01^{a}		
Aspartic acid	7.19±0.01^{b}	6.64±0.02^{e}	6.72±0.01^{d}	7.09±0.00^{c}	7.18±0.00^{b}	7.63±0.01^{a}		
Glutamic acid	11.61±0.01^{b}	11.66±0.00^{b}	11.44±0.01^{c}	11.37±0.01^{d}	11.05±0.01^{e}	12.78±0.00^{a}		
Glycine	4.23±0.01^{b}	3.94±0.01^{c}	3.90±0.00^{d}	3.89±0.01^{d}	3.80±0.01^{e}	4.42±0.01^{a}		
Proline	3.65±0.01^{a}	3.25±0.01^{d}	3.31±0.00^{c}	3.55±0.00^{b}	3.55±0.01^{b}	3.65±0.01^{a}		
Serine	3.73±0.01^{a}	3.30±0.01^{e}	3.32±0.00^{d}	3.36±0.00^{c}	3.40±0.00^{b}	3.38±0.00^{c}		
TNEAA	39.94	37.35	37.94	39.57	38.62	42.65		
TAA	72.91	71.64	72.42	75.54	74.36	81.70		
TSAA (met+cys)	1.97	2.41	2.48	2.65	2.59	3.42		
ArEAA (Phe+Tyr)	7.18	6.88	6.78	6.72	6.21	7.09		
TEAA/TAA (%)	44.45	47.86	47.61	47.61	48.06	47.79		
TEAA / TNEAA	0.82	0.91	0.91	0.90	0.92	0.91		

NM – Not mentioned. TEAA= total essential amino-acid, TNEAA= total non-essential amino-acid, TAA= total amino-acid, TSAA= total sulphur-containing amino-acid, ArEAA=total aromatic essential amino-acid.

S_0 =95:5:0, S_{20} = 75:5:20, S_{25} = 70:5:25, S_{30} = 65:5:30, S_{35} = 60:5:35, S_{95} = 0:5:95 of Maize: Coconut: Malted African breadfruit seed flour blends.

Microbial Quality

Total viable count (TVC) of maize-coconut snack bars enriched with malted African breadfruit seed flour ranged from 0.31 to 0.51 $\times 10^1$ CFU/g (Table 5). Edima-Nyah *et al*., (2019) [1] recorded higher TVC (0.29×10^2 – 0.51×10^2 CFU/g) in whole African breadfruit seed based snack bars. Offia Olua and Edide (2013) [39] also reported higher bacterial count for pineapple (15.33×10^5 CFU/g) and cherry (17.53×10^5 CFU/g) cakes. A total plate count of 1.5 – 7.0 $\times 10^2$ CFU/mL was reported for honey-cassava-wheat bread (Adebayo *et al*., 2013) [27]. Contaminations in the snack bars may have occurred during handling processes, before the microbiological examinations. The values of TVC obtained in all the snack bars were within the acceptable limits prescribed by the International Commission on Microbiological Specification of Foods (ICMSF) and recommendation for products of this nature (10^5 Cfu/g) in good manufacturing practice (ICMSF, 2009) [18].

Total mould count (TMC) of the snack bars ranged from 0.08×10^1 to 0.48×10^1 CFU/g. Higher TMC were reported by Faber and Yuyama (2015) [2] in cereal bars produced with amazon fruits (10×10^1 to 14×10^1 CFU/g), and Edima-Nyah *et al*., (2019) [1] in snack bars from whole African breadfruit seed flour with maize and coconut blends (0.18×10^2 – 0.48×10^2 CFU/g). The differences in these values are probably due to the moisture content and the post-production/handling processes of these snacks. However, TMC obtained for the snack bars were within acceptable limits for products of this nature as recommended by ICMSF for good manufacturing practice (10^3 CFU/g) (ICMSF, 2009) [18]. Therefore, these snack bars were safe for consumption.

Table 5: Total viable count (TVC) and total mould count of Maize-Coconut based snack bars produced with different levels of malted African breadfruit seed flour.

Snack bars	TVC x 10^1 CFU/g	TMC x 10^1 CFU/g
S_0 (control)	$0.31^d \pm 0.12$	$0.48^a \pm 0.03$
S_{20}	$0.38^c \pm 0.03$	$0.28^c \pm 0.08$
S_{25}	$0.42^b \pm 0.01$	$0.36^b \pm 0.03$
S_{30}	$0.38^c \pm 0.02$	$0.22^c \pm 0.07$
S_{35}	$0.51^a \pm 0.01$	$0.08^e \pm 0.01$
S_{95}	$0.50^a \pm 0.03$	$0.12^d \pm 0.01$

Values are mean ± standard deviation of replicated determinations. Means in the same column with different superscript are significantly different at $p<0.05$.

S_0 =95:5:0, S_{20} = 75:5:20, S_{25} = 70:5:25, S_{30} = 65:5:30, S_{35} = 60:5:35, S_{95} = 0:5:95 of Maize: Coconut: Malted African breadfruit seed flour blends.

Sensory Qualities

Table 6 summarized the mean scores of hedonic sensory properties of maize-coconut based snack bars produced with different levels of malted African breadfruit seed flour. The panelist mean score for appearance ranged from 5.80 to 7.96. Samples S_{20}, S_{25} and S_{30} were not significantly ($p<0.05$) different from the Control, S_0, while S_{35} and S_{95} were statistically the same, but different from the Control both statistically and physically. Appearance, according to Feili *et al*., (2013) [21], is one of the important factors in sensory evaluation. Average hedonic scores for aroma, which were determined by the sense of smell, ranged from 6.10 to 7.30. Sample S_{20} had the highest score while S_{95} scored the least, and was significantly ($p<0.05$) different from all other snack bars formulated. Mean sensory score for taste was between 6.30 and 7.36, with sample S_{20} ranking highest while S_{35} were the lowest.

Texture of snack products is one of the most important characteristics affecting consumer acceptance (Nwabueze *et al*., 2008) [9], sometimes embraces appearance (Eduardo *et al*., 2013) [40], and could be used by consumers as an indicator of food safety as well as an indicator of food quality. Mean hedonic scores for texture was between 6.03 and 7.10. Control snack bars (S_0) were significantly ($P<0.05$) different from other snack bars and ranked highest (7.10). Average sensory score for chewiness ranged from 6.40 to 7.13 with the Control snacks (S_0) ranking the highest. Scores decreased with increasing substitution of malted African breadfruit seed flour in the blends.

Mean sensory score on overall acceptability, which ranged from 6.69 to 7.80, gave a general idea of the panelists' total impression towards the snack bars. The control (S_0) and S_{20} were statistically the same and ranked highest with mean score 7.80 and 7.73 respectively, and consequently, most accepted and preferred. Samples which received scores of above 5 (neither like nor dislike) were considered acceptable. Therefore, all the snack bars developed with malted African breadfruit seed flour were acceptable to the consumers.

Table 6: Sensory Properties of Maize-Coconut based Snack bars produced with different levels of malted African breadfruit seed flour.

Snack bar	Appearance	Aroma	Taste	Texture	Chewiness	Overall acceptability
S_0 (control)	7.80 ± 1.06^a	7.03 ± 1.09^{ab}	7.30 ± 1.36^a	7.10 ± 0.88^a	7.13 ± 0.86^a	7.80 ± 0.94^a
S_{20}	7.96 ± 1.18^a	7.30 ± 0.87^a	7.36 ± 1.31^a	6.63 ± 0.92^{ab}	6.83 ± 1.31^a	7.73 ± 1.06^a
S_{25}	7.63 ± 0.92^a	7.23 ± 1.13^a	7.33 ± 1.15^a	6.46 ± 1.67^{ab}	6.66 ± 1.30^{ab}	7.23 ± 0.77^{ab}
S_{30}	7.56 ± 1.19^a	6.93 ± 1.17^{ab}	7.30 ± 0.95^a	6.26 ± 1.43^b	6.56 ± 1.37^{ab}	7.16 ± 0.94^{ab}
S_{35}	6.50 ± 1.61^b	6.33 ± 2.03^{bc}	6.30 ± 1.31^c	6.03 ± 1.37^b	6.46 ± 1.40^{ab}	6.69 ± 1.21^b
S_{95}	5.80 ± 2.70^b	6.10 ± 1.37^c	6.46 ± 1.40^b	6.48 ± 1.35^{ab}	6.40 ± 2.38^{ab}	6.70 ± 1.41^b

Values are mean± SD of 30 panelists. Means with different superscript in the same column are significantly different at $P<0.05$

S_0 =95:5:0, S_{20} = 75:5:20, S_{25} = 70:5:25, S_{30} = 65:5:30, S_{35} = 60:5:35, S_{95} = 0:5:95 of Maize: Coconut: Malted African breadfruit seed flour blends.

Conclusion

Malted African breadfruit seed flour was used to enrich maize-coconut based snack bars. The substitution of malted African breadfruit seed flour at different levels significantly increased ash, fat, fibre and protein content of the snack bars. Essential amino acid content of snack bars met the recommended daily allowance (RDA) for adult humans. Sensory evaluation showed that acceptable snack bars could be produced with 20, 25 and 30 percent malted African breadfruit seed flour, substituted in maize-coconut blends. Therefore, this knowledge could be used to make commercial products. The introduction of such new product could improve the utilization of the food crops, economy of the country, health and the overall well-being of the people.

Statement of Competing Interest

The authors have no competing interest.

References

1. Edima-Nyah AP, Nwabueze TU, Ojimelukwe PC. Development and quality evaluation of snack bars from African breadfruit (Treculia Africana), maize (Zea mays) and coconut (Cocos nucifera) blends. Journal of Scientific and Engineering Research,2019:6(5):74-83.
2. Fabar MA, Yuyama LKO. Functional Dietary Cereal Bar based on Amazon fruits. Journal of Nutrition and Food Science,2015:5(2):354-359.
3. Gwirtz JA, Garcia-Casal MN. Processing maize flour and corn meal food products. Annals of New York academy of Sciences,2014:1312:66-75.
4. Nago CM, Devautour H, Munchnic J. Technical Resources of Food Processing Micro Enterprises in Benin. Agritrop,1990:14(3):7-11.
5. Okafor GI, Ugwu FC. Production and evaluation of cold extruded and baked ready-to-eat snacks from blends of breadfruit (Treculia africana), cashew (Anacardium occidentale) and coconut (Cocos nucifera). Food Science and Quality Management,2014:23:65-77.
6. Bruce-Fife ND. Coconut Dietary Fiber: A New Dietary Supplement**.** Piccadilly Books, Ltd. Collorado, 2010.
7. Nwabueze TU, Uchendu CB. African breadfruit (Treculia africana) seed as Adjunct in Ethanol production. European Journal of Food Research and Review,2011:1(1):15-22.
8. Osabor VN, Ogar DA, Okafor PC, Egbung GF. Profile of the African Breadfruit (Treculia africana). Pakistan Journal of Nutrition,2009:8(7):1005-1008.
9. Nwabueze TU, Iwe MO, Akobundu ENT. Physical characteristics and acceptability of extruded African breadfruit-based snacks. Journal of Food Quality,2008:31(2):142-155.
10. Makinde AN, Elemo BO, Arukwe U, Pellet P. Ukwa seed (Treculia africana) protein. Journal of Agriculture and Food Chemistry,1985:33:70-72.
11. Shalim H, Sudesh J. Effect of soaking and germination on nutrient and anti-nutrient content of fenugreek (Trignoella foenum grecum.L) seeds. Journal of Food Biochemistry,2003:27:165-170.
12. AOAC Official Methods of Analysis, 18th Ed. Association of Official Analytical Chemists, Washington D.C, USA, 2005.
13. Osborne DR, Voogt P. Analysis of nutrients in foods. Academic Press, New York, 1978, 237.
14. Pearson D. *The Chemical Analysis of Food*. Seventh edition. Church-hill, London, 1976, 353-354.
15. Onwuka GI. Food Analysis and Instrumentation: Theory and Practice. Naphtali Prints, Lagos. Nigeria, 2005, 19-38.
16. Oberleas D. *Toxicants occurring naturally in foods. Strong, F. ed*. National Academy of Science, Washington D.C, 1973, 363-371.
17. Benitez LV. Amino acid and fatty acid profiles in aquaculture nutrition studies, In S.S. De Silva (Ed.). Fish Nutrition Research in Asia. Proceedings of the third Asian Fish Nutrition Network Meeting Asian Fish Society Special Publication.4, 166p, Manila, Philippines, 1989, 23-35.
18. ICMSF Sampling for microbiological analysis: Principles and specific applications, Blackwell Scientific publications, 2009, 206-211.
19. Stone H, Sidel JL. Sensory Evolution Practices. Academic Press, Inc. San Diego, C. A, 1985.
20. Lawless HT, Heymann H. Sensory evaluation in quality control. In sensory Evaluation of Food: Principles and Practices. Chapman and Hall, New York, NY, 1998, 548-584.
21. Feili R, Zzaman W, Abdulla WN, Yang TA. Physical and sensory analysis of high fibre bread incorporated with jackfruit rind flour. Journal of Food Science and Technology,2013:1(2):30-36.
22. James S, Nwabueze TU. Quality Evaluation of Extruded Full Fat Blend of African Breadfruit-soybean-corn snack. International Journal of Scientific and Technological Research,2013:2(9):212-216.
23. Silva de Paula N, Natal DIG, Ferreira HA, Dantas MI, Martino HSD. Characterization of cereal bars enriched with dietary fibre and omega 3. Reviews of Children Nutrition,2013:40(3):269-273.
24. Torres ER, Castro ES, Felix de Santana R, Cardoso JC, Soares CMF, Lima AS. Cereal bar development using exotic fruits. In: Proceeding of 11th ICEF conference on Engineering and Food, “Food Process Engineering in a Changing World”, Athens, Greece, 2011.

25. Usman GO, Ameh UE, Alifa ON, Babatunde RM. Proximate composition and anti-nutrient properties of breakfast cereal made from blends of local rice, soybean and defatted coconut flours. Journal of Nutrition and Food Science,2015:s11:6-11.
26. Elinge CM, Muhammad A, Atiku FA, Itodo AU, Peni IJ, Sanni OM *et al*. Proximate, Mineral and Anti-nutrient composition of pumpkin (Cucurbita pepo L) seed extract. International Journal of Plant Research,2012:2(5):146-150.
27. Adebayo OR, Farombi AG, Oyekanmi AM. Proximate, mineral and Anti-nutrient Evaluation of Pumpkin pulp (Cucurbita pepo). International Organization of Scientific Research Journal of Applied Chemistry,2013:4(5):25-28.
28. Nwabueze TU, Atuonwu AC. Effect of Malting African Breadfruit (Respectively, Treculia africana) seeds on flour properties and Biscuit Sensory and Quality characteristics as Composite. Journal of Food Technology,2007:5(1):42-48.
29. Maseta E, Mosha TCE, Laswai H, Nyaruhucha CN. Nutritional Quality, mycotoxins and anti-nutritional factors in quality protein maize-based supplementary foods for children in Tanzania. International Journal of Sciences,2016:5(7):37-44.
30. Coe FL, Evan A, Worcester E. Kidney stone disease. Journal of Clinical Investigations,2005:115(10):2598-2608.
31. Bushway RJ, Bureau JL, McGann DP. Determination of organic acid in potatoes by high performance liquid chromatography. Journal of Food Science,1984:49:75-77.
32. Liener IE. Implications of anti-nutritional components of soybean foods. Critical Reviews in Food Science and Nutrition,1994:34:31-67.
33. Adeboye AS, Babajide JM, shittu TA, Omemu AM, Oluwatola OJ. Effect of Honey as partial sugar substitution on pasting properties, consumer preference and shelf stability of cassava-wheat composite bread. Nigerian Food Journal,2013:31(1):13-22.
34. Iheokoronye AI, Ngoddy PO. Integrated Food Science and Technology for the Tropics. McMillan publishers Limited. London, 1985, 86-103.
35. Abasiekong KS, Akobundu ENT, Nwabueze TU. Amino-acid Qualities and Calculated Nutritional indices of African breadfruit based complementary foods. In: The proceedings of the 2nd South-East Regional Food Summit (ReFoST), Umuahia, Obasi, N. E., Akobundu, E. N. T., Nwabueze, T. U., Oti, E., Abasiekong, K. S. and Ezema, C. N. (eds.). Nigerian Institute of Food Science and Technology, 2016, 6-7.
36. DRI, Daily Recommended Intake Energy and protein requirement. In, Report of a Joint FAO/WHO/UNU Expert Consultation, Geneva, WHO Technical report series, 2002, (1024).
37. RDA. Recommended Dietary Allowance, 10th ed. National Research Council, National Academy Press, 1989.
38. Nwabueze TU. Nigeria solubility index and amino acid composition of African Breadfruit (T. Africana) blends. Nigerian Food Journal,2007:25(1):23-35.
39. Offia Olua BI, Edide RO. Chemical, microbial and sensory properties of candied-pineapple and cherry cakes. Nigerian Food Journal,2013:31(1):33-39.
40. Eduardo M, Svanberg U, Oliveira J, Ahrne L. Effect of cassava flour characteristics on properties of cassava-wheat-maize composite bread types. International Journal of Food Science,2013:5:1-10.