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Development and Quality evaluation of Snack Bars from African breadfruit (*Treculia africana*), Maize (*Zea mays*) and Coconut (Cocosnucifera) Blends

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Abstract This study was aimed at developing and assessing the proximate and anti-nutrient composition, microbial and sensory qualities of snack bars produced from blends of African breadfruit seed flour (AF), maize flour (MF), and coconut grits (CG). The blending ratios (AF:MF:CG) used for the study were 0:95:5, 20:75:5, 25:70:5, 30:65:5, 35:60:5 and 95:0:5. The result of proximate composition showed that protein (16.16 – 22.43%), ash (2.83 – 4.75%), fat (7.31 – 8.46%) and fibre (10.12 – 17.76%) content increased, while carbohydrate (42.16 – 59.82%) and energy (334.50 –369.71 Kcal/100g) content decreased with increasing addition of African breadfruit seed flour in the blend. Tannin (0.13 – 0.06%), oxalate (0.06 – 0.24 mg/g), phytate (1.07 – 3.61 mg/g), saponin (0.68 – 7.13%) and trypsin inhibitor (0.53 – 5.92 TIU/mg) contents were low and within the safe limit for human consumption. Microbial quality of the snack bars met the ICMSF Specification for safe consumption, with a total viable count (TVC) of 0.29 – 0.51x10^2cfu/g and mould count of 0.18 – 0.48 x10^2 cfu/g. No coliform was detected. Sensory characteristics showed that snack bars produced with 20% African breadfruit seed flour (20:75:5) had the highest mean score in overall acceptability and were the most preferred. It is evident from the study that acceptable snack bars of high nutritive value could be produced from blends of African breadfruit seed flour, maize flour and coconut grits with the 20:75:5 combination. This will increase the utilization of these locally grown crops and reduce wheat importation into the country.

Keywords Product development, sensory quality, snack bars, African breadfruit, fibre, protein

1. Introduction

Snack bars (commonly known as cereal bars) are made from a compressed mixture of cereals, nuts and dried fruits. Glucose syrup is the aggregator element of the bar ingredient providing rapid energy absorption. On the other hand, since cereal is a complex carbohydrate, the starch provides slower energy liberation, which can be absorbed for a longer period of time. The most commonly used ingredients in cereal bars are oats, wheat or rice and soy. A cereal bar is considered a practical choice for quick meal due to its high nutritional value [1]. Snack bars or cereal bars may be considered as fast foods that suit the diet food market due to their nutrition and energy content, especially for women, weekend athletes and professional athletes [2], and a healthy alternative to the most frequently consumed chocolate bars by sports enthusiasts [3].

The African breadfruit (*T. Africana*, commonly known as *ukwa* by the Igbos, *afon* by Yorubas, *ize* by Binis, *barafuta* by Hausas, *kwakwa* by Higidi and *ediang* by Efiks/Ibibios) is a tropical evergreen tree that has immense potential as a nutritional source for man [4]. It is very common in the western, eastern and southern part of Nigeria. The seeds contain 8.00% moisture, 13.56% crude protein, 1.30% fat, 2.80% ash, 1.90%crude fibre and 72.44% carbohydrate [5]. Mineral elements such as potassium, magnesium, zinc are found in appreciable amounts, while sodium, calcium, iron and cupper are found in negligible amounts [4]. It is reported that its protein has a fairly balanced amino acid composition with a comparatively higher level of lysine, compared to wheat protein [6]. The seeds of African breadfruit are traditionally consumed as porridge meal when cooked with ingredients or as snacks when roasted [7]. The flour of African breadfruit seeds can be used in soup thickening [8]. African breadfruit constitutes a strategic reserve of essential food nutrients that are available at some critical periods of the year when common sources of these nutrients are short in supply or out of season [9]. Expanding the food applications for African breadfruit seeds would increase its versatility and utility.

Maize (*Zea mays* L.) is the most important cereal in the world after wheat and rice with regard to cultivation [10]. In sub-Saharan Africa maize is a staple food for an estimated 50% population. It is an important source of carbohydrate, protein, iron, vitamin B, and minerals. Africans consume maize as a starchy base in a wide variety of porridges, pastes, grits, and beer. Whole maize contains about 11% protein, 4% fat, 3% fibre, 65% of starch and other carbohydrates and 1.5% of minerals [11].

Coconut is highly nutritious and rich in fiber, vitamins, and minerals. It is classified as a "functional food" because it provides many health benefits beyond its nutritional content. Coconut flour is a soft, flour-like product made from the pulp of a coconut meat, and a by-product of coconut milk processing [12]. Coconut flour is very high in fiber, with almost double the amount found in wheat bran and can be used much like wheat flour to make different forms of delicious breads, pies, cookies, cakes, snacks and desserts. It contains more calorie free fiber than other wheat alternatives. This flour also provides a good source of protein, although it does not contain gluten. Coconut flour improves digestion, helps to regulate blood sugar, protects against diabetes, helps to prevent heart disease and cancer, and aids in weight loss [13].

The utilization of non-wheat composite flour in the production of snacks can serve as an alternative means of diversifying these flours, add value to the products and reduce wheat importation. The present study was aimed at developing and assessing the proximate and anti-nutrient composition, microbial and sensory qualities of snack bars produced from African breadfruit (*Treculia africana*) flour, maize flour and coconut grit blends.

2. Materials and Methods

2.1. Materials Procurement

African breadfruit seeds were purchased from Ndoro market, Abia State. Maize, coconut and ingredients used for snack bar production (salt, margarine, milk powder, sodium bicarbonate, and nutmeg) were purchased from Umuahia main market in Umuahia, Abia State, Nigeria.

2.2. Material Preparation

2.2.1. Preparation of African breadfruit flour

Clean African breadfruit seeds were parboiled at 100^{o}C for 15 min, drained through stainless steel sieve and allowed to cool. The parboiled seeds were dried at 60^{o}C for about 5h and further toasted at 150^{o}C in a Precision Compact Oven (Model: PR305225M). The toasted seeds were milled with Victoria Grain Mill (Model Ref: 530025, Colombia) to flour. The whole African breadfruit flour was packaged in airtight plastic container, labeled and stored at ambient temperature (27±2°C) for subsequent use.

2.2.2. Preparation of Maize flour

Maize grains were sorted to remove extraneous materials and cleaned by winnowing. The cleaned maize were toasted at 150^{o}C in an oven, then milled using Victoria Grain Mill (Model Ref: 530025, Colombia) to flour. Maize flour was packaged in a clean dry plastic container, securely covered, labeled and stored at ambient temperature (27±2°C) for subsequent use.

2.2.3. Preparation of coconut grits

Coconuts were cracked to expel the liquid content. The coconut flesh (meat) were manually removed from the shell with the aid of a sharp pointed stainless steel knife. The flesh were grated manually (using a plastic grater) to shreds, to facilitate drying and subsequent toasting. The coconut shreds were dried at 60^{o}C and toasted at 150^{o}C in a Precision Compact Oven (Model: PR305225M). The toasted shreds were milled manually (using Victoria Grain Mill, Model Ref: 530025, Colombia) to full fat coconut grits. The grits produced was stored in airtight plastic container at ambient temperature (27±2°C) for subsequent use.

2.2.4. Formulation of Composite blends

Six composite flours with different proportions of African breadfruit and maize, with coconut grits were formulated and designated as A_0, A_{20}, A_{25}, A_{30}, A_{35} and A_{95}. The blending ratios are presented in Table 1.

Table 1: Formulation of composite flour (%)

Samples	A_0	A_{20}	A_{25}	A_{30}	A_{35}	A_{95}
African breadfruit seed flour	0	20	25	30	35	95
Maize flour	95	75	70	65	60	0
Coconut grit	5	5	5	5	5	5

A_0=0:95:5, A_{20}=20:75:5, A_{25}=25:70:5, A_{30}=30:65:5, A_{35}=35:60:5, A_{95}=95:0:5 for ABS:MF:CG blends

2.2.5. Ingredient formulation

The snack bar formulations (Table 2) consisted of dry ingredients (solid phase) and the liquid ingredients (binder phase). The dry ingredients included the African Breadfruit Seed flour, Maize Flour, Coconut Grit, salt, sodium bicarbonate, milk powder, margarine, and nutmeg flour. The liquid ingredients were caramel, coconut oil and water.

Table 2: Snack Bar formulations

Ingredients	Formulations					
	A_0	A_{20}	A_{25}	A_{30}	A_{35}	A_{95}
Dry ingredients (g/100g of flour)						
ABS	0	20	25	30	35	95
MF	95	75	70	65	60	0
CG	5	5	5	5	5	5
Salt	0.2	0.2	0.2	0.2	0.2	0.2
Baking powder	2	2	2	2	2	2
Milk powder	5	5	5	5	5	5
Margarine	15	15	15	15	15	15
Nutmeg flour	2	2	2	2	2	2
Liquid ingredients (g/100g of flour)						
Caramel	25	25	25	25	25	25
Coconut oil	10	10	10	10	10	10
Water	40	40	40	40	40	40

ABS=African breadfruit seed flour, MF=maize flour, CG=coconut grits, A_0=0:95:5, A_{20}=20:75:5,A_{25}= 25:70:5,A_{30}=30:65:5,A_{35}=35:60:5, A_{95}=95:0:5 for ABS:MF:CG blends

2.2.6. Production of snack bars

The snack bars were produced, as shown in Figure 1, according to the method described by Khouryieh and Aramouni (2013). 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 3min, water was incorporated slowly and the entire dough was mixed thoroughly for about 5min 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 tops and give the bars the desired shape. The dough were baked in an oven at 150^{o}C for 25min. They were cooled to about 60^{o}C, de-panned and cut into bars seizes: 5cm x 3cm x 2cm. The bars were further dried in an air-circulation oven at 60^{o}C for 6h to reduce the moisture content, cooled at ambient temperature (27±2^{o}C), packaged in high density polyethylene, labeled and stored for sensory evaluation and other determinations.

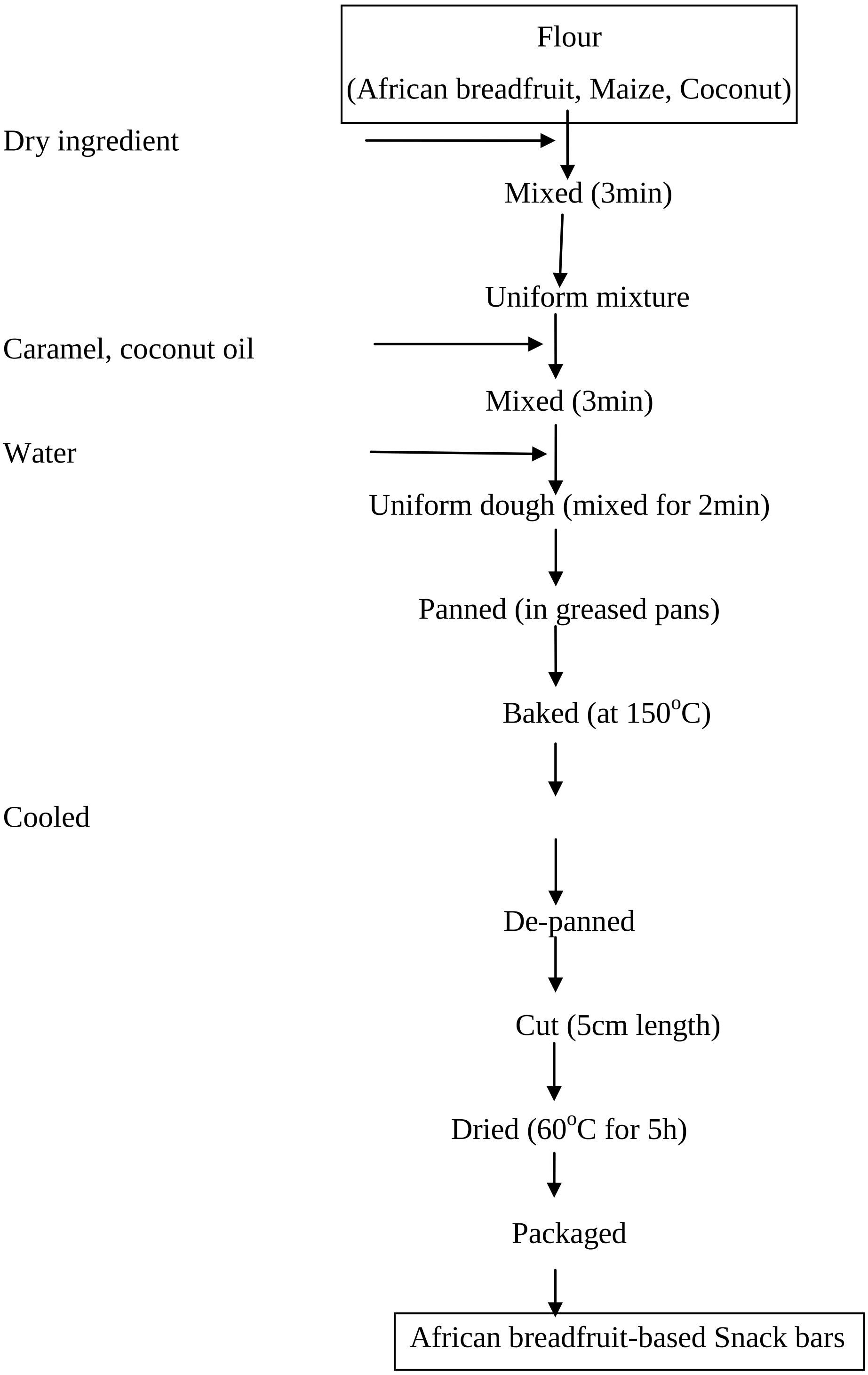

Figure 1: Flow diagram for the production of Snack bars from African breadfruit seed flour, maize flour and coconut grit blends

2.3. Methods of Analysis

2.3.1. Determination of Proximate Composition of Snack Bars

Moisture, ash, crude fat, crude fibre and crude protein were determined using the standard methods [15]. Carbohydrate content was calculated by difference [16], while Energy value was calculated using Atwater factor formula [17].

2.3.2 Determination of the Anti-nutrient Composition of Snack Bars

The tannin, phytate and trypsin inhibitor activity content of the snack bars were determined using the standard method [16]. The oxalate and saponin contents were determined using the solvent extraction gravimetric methods [15].

2.3.3 Microbiological Examination

Microbiological examinations were carried out using the pour plate method [15]. Total viable bacteria count (TVC), total mould count (TMC) and coliform counts (TCC) were estimated by multiplying the means of the total colonies by the dilution factor.

2.3.4. Sensory Evaluation of Developed Snack Bars

The sensory evaluation of produced snack bars was performed by 30 semi-trained panel of judges drawn from the Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Nigeria. All panelist were regular consumers of African breadfruit and snack products and were already familiar with quality attributes of snacks. The evaluation was conducted using the nine-point hedonic scale [11] ranging from 1(dislike extremely) to 9(like extremely). The samples were coded with three digit random numbers and presented in identical plates. Questionnaires for entering scores and portable water for mouth rinsing between tasting were made available to the panelists. Each of the sample was rated for appearance, shape, aroma, texture, taste, chewiness and overall acceptability.

2.4. Statistical analysis

Data obtained were subjected to a one-way Analysis of Variance (ANOVA) using IBM SPSS version 20 software. One-Way analysis of Variance (ANOVA) was used to determine significant differences at $p<0.05$. Means were separated using Duncan Multiple Range Test (DMRT).

3. Results and Discussion

3.1 Proximate Composition and Energy Values of Snack Bars

Table 3 shows the proximate composition and energy values of snack bars from African breadfruit seed flour, maize flour and coconut grits. Moisture contents ranged from 3.76% to 4.85%, with the Control (0%) and 35% African breadfruit based snack bars having the lowest and the highest values respectively. All samples generally had low moisture content, which implied that the snack bars could have an extended shelf life. Other authors reported higher moisture contents: 9.70% in African breadfruit based extruded snacks [18], 9.9 – 14.7% in cereal bars enriched with dietary fibre and omega3 [19] and 15.40 – 23.46% in cereal barsmade with different formulations of jackfruit seeds and jenipapo [20]. Moisture content of a food affects its stability and overall quality [11, 21]. Moisture content of snack bars (below 10%) is within the range of standard category [22]. These low values may indicate the suitability of the snack bars for storage and subsequent prevention of triglyceride degradation during the storage [23-24].

Ash content of a product is the residue remaining after destroying combustible organic matter. The ash content of snack bars ranged from 2.83 to 4.57%. Significant differences ($p<0.05$) existed in the ash content of all snack bars. These ash contents were lower than those reported (5.15%) in literature [18] for African breadfruit flour-soybean-corn snacks. Lower ash contents were reported by other researchers: 1.05-2.40% for breakfast cereals from local rice and defatted coconut [21], 0.57-1.42% for cereal bars from jackfruit and jenipapo [20], 1.9-2.4% for cereal bars enriched with linseed fibre [19] and 1.11-1.63% for broken rice and soybean residue cereal bars [25]. The ash content gives an overall estimate of the total mineral elements present in the food. Food with high ash content is expected to have high concentration of various mineral elements, which are expected to speed up metabolic processes, improve growth and development [26].

The crude fat content of snack bars ranged from 7.31% in the Control (0% African breadfruit flour) to 8.46% for 95% African breadfruit based snack bars. Crude fat content of snack bars were significantly different ($p<0.05$) from each other. Higher fat values were reported by some authors; 11.4 – 12.7% [19] for cereal bars, 14.00 – 18.13% [21] for local rice, soybeans and coconut breakfast cereals. Lower values (3.61 – 4.27%) were reported for jackfruit seed and jenipapo based cereal bars [20].

Crudefibre content of snack bars produced with different levels of African breadfruit seed flour ranged from 10.12 to 17.76%. Control snack bar, which is made of 0% African breadfruit, 95% maize and 5% coconut, showed lowest crude fibre content (10.12%). Fibre content increased with increasing amount of African breadfruit seed flour in the snacks bars, and were significantly different (p<0.05) from each other. Other researchers reported fibre content of cereal bars; 0.61 to 15.47% fibre in jenipapo-jackfruit seed based cereal bars [20], 5.17% fibrein soy-wheat cereal bars[3], 5.84% fibre in cashew based cereal bars [27], and 10.69% fibre in oat-based cereal bars [28]. Fibre is important for the removal of waste from the body thereby preventing constipation and many health disorders. Consumption of vegetable fibre has been shown to reduce the cholesterol level, risk of coronary heart diseases, colon and breast cancers and hypertension. It also enhances glucose tolerance and increases insulin sensitivity.

Crude protein content ranged from 16.16 to 22.43% in snack bars produced with African breadfruit seed flour. The lowest protein content was recorded in Control snack bars. Protein content increased with increasing amount of African breadfruit seed flour in the snack bars. Significant differences (p<0.05) existed in the crude protein content of all the blend formulations. Lower values, 11.4 to 12.7% protein, was reported in linseed based cereal bars [19], 15.31% in functional cereal bars with high protein and vitamins [29], and 8.12-12.43% in broken rice-soybean extract residue food bars[25]. 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 addition of African breadfruit seed flour in the blends and ranged from 42.16 to 59.82%. The carbohydrate contents were significantly different (p<0.05) at all levels of blending. James and Nwabueze (2013) reported carbohydrate content (54.10%) similar to these snacks. Carbohydrate contents of similar range has been reported in literature [18 - 20] for snacks and cereal bars. Energy value of snack bars produced with different levels of African bread fruit seed flour ranged from 334.50 to 369.71Kcal/100g. This decreased with increasing amount of African breadfruit flour in the snack bars. The energy values were significantly different (p<0.05) for all the snacks formulated. Similar carbohydrate and energy values were reported in food bars produced from agro-industrial waste [25]. Higher energy value (382.80Kcal/100g) was reported for African breadfruit seeds-soybean-corn extruded snacks [18]. Linseed based cereal bars also showed higher energy values, 392.7 – 407.7Kcal/100g [19].

Table 3: Proximate composition and energy values of snack bars produced with different levels of whole African breadfruit seed flour

Snack bar*	Moisture content %	Ash content %	Crude Fat %	Crude Fibre %	Crude Protein %	Carbohydrate %	Energy value Kcal/100g
0 (control)	3.76±0.02e	2.83±0.01f	7.31±0.02f	10.12±0.10f	16.16±0.02f	59.82±0.01a	369.71±0.11a
20	4.82±0.01b	3.98±0.00e	7.53±0.01e	15.85±0.02e	18.82±0.01e	49.00±0.04b	339.05±0.01b
25	4.30±0.14d	4.05±0.01d	7.62±0.10d	16.58±0.01d	18.93±0.02d	48.52±0.01c	338.38±0.01c
30	4.62±0.01c	4.11±0.02c	7.75±0.02c	16.83±0.04c	18.97±0.01c	47.72±0.01d	336.51±0.02d
35	4.85±0.01a	4.25±0.01b	8.08±0.01b	16.97±0.01b	21.17±0.01b	44.68±0.11e	336.12±0.10e
95	4.62±0.03c	4.57±0.04a	8.46±0.02a	17.76±0.01a	22.43±0.01a	42.16±0.01f	334.50±0.01f

Values are Means ± standard deviation of triplicate determinations.

Means within the same column with different letters are significantly different at p<0.05.

* = % Whole African breadfruit seed flour in the snack bars with 5% coconut grit, made up to 100% with maize flour.

On the other hand, lower energy values (277.02 – 278.99Kcal/100g) were also reported [20] in jenipapo-jackfruit seed based cereal bars. Energy in food helps the body in the maintenance of basic body functions such as breathing, circulation of blood, physical activities and thermic effect.

3.2 Anti-nutrient composition of snack bars

Table 4 shows the tannin, oxalate, phytate, saponin and trypsin inhibitor activities composition of snack bars. The compositions ranged from 0.31 to 0.60% for tannin, 0.06 to 0.29 mg/g for oxalate, 1.07 to 3.61 mg/g of phytate, 2.98 to 7.13% of saponin and 0.53 to 5.92 Tiu/mg of trypsin inhibitor activities. All the anti-nutrients assessed increased with increasing addition of African breadfruit seed flour in the snack bars. Control samples were significantly different form all other snack bars and had the lowest anti-nutrient contents, while the snack bars produced with 95% African breadfruit seed flour had the highest anti-nutrient contents. Tannin content of snack bars were lower than those reported [18] for African breadfruit-soybean-corn extruded snacks (1.50%), and was also within the safe limit (90mg/100g) for human consumption [30, 31].Oxalate content of the snack bars could not have been toxic under meal portion since the safe level in man is 15-30g/100g food consumed [32]. This is important because, oxalate, when present in the body, combines with divalent cations of iron and calcium to form their insoluble salts. These salts cause obstructions in the kidney tubules and consequently lead to the formation of kidney stones [18, 32]. Phytate content of snack bars were higher than those of extruded African breadfruit snacks (0.06mg/100g) as reported in literature [18]. This is probably because extrusion cooking is reported to have additional effect in reduction of anti-nutrient factors due to the heat treatment involved, since most of the anti-nutrients are heat labile. The maximum tolerable dose of phytate in the body is 250-500mg/100g [33]. Trypsin inhibitor activities of snack bars could be safe since the lethal dose in man is 200mg/100g [34]. This is important because trypsin inhibitor activity factor was found to form complexes with trypsin enzymes thereby impairing its proteolytic activity, which in turn reduces availability of amino-acids for metabolic processes [35].

Table 4: Anti-nutrient content of snack bars produced with whole African Breadfruit Seed Flour

Snack bars*	**Tannin (%)**	**Oxalate (mg/g)**	**Phytate (mg/g)**	**Saponin (%)**	**Trypsin Inhibitors (TIU/mg)**
0	$0.13^{e}\pm0.01$	$0.06^{f}\pm0.01$	$1.07^{f}\pm0.01$	$0.68^{f}\pm0.02$	$0.53^{f}\pm0.02$
20	$0.38^{d}\pm0.01$	$0.12^{e}\pm0.01$	$2.10^{e}\pm0.03$	$5.33^{e}\pm0.01$	$5.08^{e}\pm0.02$
25	$0.47^{c}\pm0.01$	$0.14^{d}\pm0.02$	$2.14^{d}\pm0.08$	$5.56^{d}\pm0.02$	$5.13^{d}\pm0.01$
30	$0.56^{b}\pm0.02$	$0.17^{c}\pm0.02$	$2.98^{c}\pm0.02$	$5.63^{c}\pm0.01$	$5.19^{c}\pm0.02$
35	$0.59^{a}\pm0.01$	$0.19^{b}\pm0.01$	$3.08^{b}\pm0.01$	$7.02^{b}\pm0.01$	$5.26^{b}\pm0.01$
95	$0.60^{a}\pm0.01$	$0.24^{a}\pm0.03$	$3.61^{a}\pm0.03$	$7.13^{a}\pm0.02$	$5.92^{a}\pm0.02$

Values are Means ± standard deviation of triplicate determinations.

Means in the same column with different superscript are significantly different at $p<0.05$.

*= % Whole African breadfruit seed flour in the snack bars with 5% coconut grit, made up to 100% with maize flour.

3.3 Microbial Quality of Snack bars

The result of the microbial examination of snack bars shows total viable count (TVC) range of $0.29 \times 10^{2} – 0.51 \times 10^{2}$cfu/g, with 25% African breadfruit flour-based showing the lowest while 35% based showed the highest. Higher total plate count were reported, ($1.5 – 7.0 \times 10^{2}$ cfu/g) in honey-cassava-wheat bread [36], and (15.33×10^{5}cfu/g and 17.53×10^{5} cfu/g) for pineapple and cherry cakes respectively[37].Total mould count (TMC) ranged from $0.18 \times10^{2} – 0.48 \times10^{2}$ cfu/g, which was lower than others in literature:10×10^{1} to 14×10^{1} cfu/g in cereal bar based on Amazon fruits [38], 2.67×10^{5}cfu/g and 3.33×10^{5} cfu/g in pineapple and cherry cakes respectively [37], and $0.6 – 4.0 \times 10^{2}$ cfu/ml in honey-cassava –wheat bread [36]. The differences in these values are probably due to the moisture content and the post-production/handling processes of these snacks. Also, the low values of bacterial and mould count in the snack bars, in general, could be attributed to high heat treatment such as baking, and low moisture content of the snacks. Low moisture content is linked to good keeping quality and extended shelf life of food products [11, 21]. Coliform was not detected in the snack bars. Absence of coliform in the snacks is desirable and indicates that the snack bars were produced under hygienic conditions. TVC and TMC values obtained in all the snack bars were within the acceptable limits (10^{5} cfu/g and 10^{3}cfu/g respectively) 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 [39]. Therefore, the snack bars were therefore safe for consumption.

Table 5: Microbiological Counts of Snack Bars Produced with Different Levels of African Breadfruit Seed Flour

Snack bar*	Total Viable Count (TVC) (x 10^2cfu/g)	Total Mould Count (TMC) (x 10^2cfu/g)	Total Coliform Count (TCC) (x 10^2 cfu/g)
0	0.31±0.12[d]	0.48±0.03[a]	-
20	0.33±0.01[d]	0.18±0.11[e]	-
25	0.29±0.13[e]	0.18±0.10[e]	-
30	0.38±0.11[c]	0.22±0.01[d]	-
35	0.51±0.01[a]	0.40±0.12[b]	-
95	0.47±0.03[b]	0.32±0.01[c]	-

Values are Means ± standard deviation of triplicate determinations.
Means within the same column with different letters are significantly different at $p<0.05$.
* % Whole African breadfruit seed flour in the snack bars with 5% coconut grit, made up to 100% with maize flour

3.4 Sensory Properties of Snack Bars

Sensory properties of snack bars produced with whole African breadfruit seed flour is shown in Table 6. Mean panelist score ranged from 5.00 to 8.33 for appearance, 6.00 to 7.16 for shape, 5.73 to 7.76 for aroma, 5.36 to 7.56 for taste, 5.96 to 7.30 for texture, 6.33 to 7.46 for chewiness and 5.63 to 7.80 for overall acceptability. Similar overall acceptability score (5.70 to 7.80) was reported in date-based fibre enriched fruit bars[40], while overall acceptability scores ranging from 6.9 to 7.5 was reported in linseed based cereal bars enriched with fibre and omega3 [19]. Higher overall acceptability score of 8.18 was reported for multi-millet extruded snacks [41]. Mean hedonic scores for all sensory attributes of snack bars decreased with increasing addition of African breadfruit seed flour. Control snack bars were significantly different ($p<0.05$) from other formulations only in appearance and chewiness. Snack bars produced with 20% African breadfruit seed flour and Control (0% African breadfruit flour) were statistically ($p>0.05$) the same in taste and overall acceptability, and were therefore the most preferred snack bars.

Table 6: Sensory Properties of Snack bars Produced with different Levels of Whole African breadfruit seed flour[1,2]

Snack Bar*	Appearance	Aroma	Taste	Texture	Chewiness	Overall acceptability
0 (control)	8.33±0.99[a]	7.76±1.04[a]	7.56±1.27[a]	7.30±1.51[a]	7.46±1.25[a]	7.80±0.85[a]
20	6.96±1.21[b]	7.33±0.80[ab]	7.36±0.99[a]	6.96±1.18[ab]	6.83±1.11[b]	7.76±0.61[a]
25	6.73±1.41[b]	6.90±1.06[bc]	7.36±0.96[a]	6.76±1.38[ab]	6.70±1.14[b]	7.06±0.73[b]
30	6.56±0.81[b]	6.60±0.93[c]	6.60±1.27[b]	6.26±1.11[bcd]	6.56±0.97[b]	6.60±1.16[c]
35	6.43±0.97[b]	6.60±1.32[c]	6.33±1.02[b]	6.06±1.77[cd]	6.50±1.10[b]	6.53±0.62[c]
95	5.00±2.13[c]	5.73±2.21[d]	5.36±2.17[c]	5.96±1.42[cd]	6.33±1.70[b]	5.63±1.71[d]

[1]values are mean ± SD of 30 panelists.
[2]means with different superscript in the same column are significantly different at $p<0.05$.
* % African breadfruit flour in the snacks with 5% coconut grit, made up to 100% with maize flour.

Conclusion

The study has shown that it is possible to use composite of African breadfruit seed flour, maize flour and coconut grit blends to produce snack bars of high nutritional value. Acceptable snack bars could be produced with 20% African breadfruit seed flour, 75% maize flour and 5% coconut grits. Also, the use of these locally grown crops to produce non-gluten snack bars will go a long way in reducing the Nation's reliance on wheat importation thereby reducing the amount of foreign exchange used in wheat importation.

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