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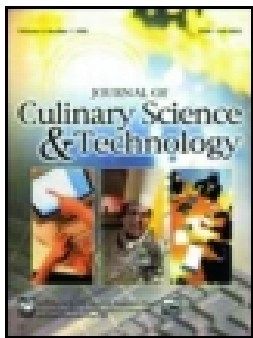


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Chemical and Sensory Characteristics of Extruded Snack from Selected Aerial Yam (*Dioscorea Bulbifera*) Cultivar and African Breadfruit (*Treculia Africana*) Seed

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ABSTRACT

This study determined the influence of extrusion cooking on chemical and sensory characteristics of a selected cultivar of aerial yam flour (AYF) and African breadfruit seed flour (ABF) blends. Blends (68:32, 84:16, 88:12, 56:44, 77:23, 53:47, 59:41, 74:26, and 64:36) of AYF:ABF were formulated using response surface methodology and chemically analyzed. Each blend was mixed with same quantities of ingredients, hydrated to 17.5% moisture, and extruded at barrel temperature (120°C) and screw speed (70 rpm). Extruded snacks were evaluated for some chemical and sensory properties. Data were analyzed using ANOVA at $\alpha_{0.05}$. Variation in blends significantly affected carbohydrate (76.58–69.55%), protein (8.80–13.59%), phenol (3.24–2.01 mg/g), and phytate (0.81–0.34 mg/g) contents of extruded snacks. Highest overall acceptability of the snack by the sensory evaluation panelists was 7.02. Extrusion cooking of flour blends of the selected cultivar of *Dioscorea bulbifera* and *Treculia africana* produced highly nutritious and acceptable snacks for human consumption.

ARTICLE HISTORY

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KEYWORDS

Aerial yam; African breadfruit; *Treculia africana*; snack food; hot extrusion

INTRODUCTION

Persistent food crisis is ubiquitous and should be urgently confronted with more food options in order to meet various human needs. Paradoxically, many foods are neglected due to paucity of information regarding their nutritional values amidst food insecurity. It is, therefore, imperative to look inwardly with a view to characterize more food materials for their composition. In-depth studies on these nutrient-dense but neglected food crops may provide an important contribution to the updates of food composition databases. Moreover, further nutrition-related studies could be spurred by obtaining reliable food composition data (Durazzo et al., 2017). One of such important but unpopular food materials is aerial yam (Olatoye & Arueya, 2019), which was originated from Africa and Southern Asia (Salehi et al., 2019). Notably, two types of storage organs are available in this plant, namely bulbils in the leaf axils

of the stem and tubers. Salehi et al. (2019) reported that aerial yam bulbils were used as a folk remedy to treat diarrhea and conjunctivitis, while its extract also exhibits anti-tumor activity. The rhizome of *D. bulbifera* L. known in traditional Chinese medicine as “Huang Yao Zi” was also reportedly used for the treatment of thyroid diseases and cancers (Salehi et al., 2019). Its traditional use in lowering glycemic index was documented as it can provide a more sustained form of energy and offer excellent prevention against obesity and diabetes (Ahmed et al., 2009; Suriyavathana & Indupriya., 2011). Aerial yam is often called potato yam, owing largely to its potato-like appearance though and is a high-yielding but under-exploited yam species (Ojinnaka, Okudu, & Uzosike, 2017). Besides low capital and labor requirements for its propagation, its high bulb-bearing propensity had been documented as well (Afiukwa & David, 2015). This species of yam reportedly contains all the food nutrients within the acceptable values for root and tuber (Sanful, Oduro, & Ellis, 2013). Comparably, some of the nutrient compositions of aerial yam are higher than those of commonly consumed yam species (Eka, 1985). Aerial yam cultivar flours can be a significant source of energy, with about 90% coming from carbohydrate alone. It is also a reservoir of some essential mineral elements. Possession of some ant nutrients and its hard-to-cook property were observed as major reasons for its limited utilization for food in the grown areas (Ogbuagu, 2008). These constraints in fact vary among cultivars, though not unsurmountable (Olatoye & Arueya, 2019). Thus, selection of aerial yam cultivar with low phytochemical composition may present a first step in the utilization of this crop for food product development. From previous research, credence was given to a cultivar (DBT3075) among 15 different cultivars in Nigeria (Olatoye & Arueya, 2019) in this respect. Indeed, this selection, coupled with intensive processing technique like extrusion cooking, can improve its digestibility and palatability. Hot extrusion cooking also is a technology known as high temperature-short time (HTST) process, which is capable of destroying undesirable enzymes, microorganism, ant nutrients, and heat-labile substances occurring in food substances with the potential to cause spoilage (Omohimi, Sobukola, Sarafadeen, & Sanni, 2013). Extrusion cooking had long been reported to overcome hard-to-cook phenomenon in stored beans (Steel, Sgarbieri, & Jackix, 1995). Severally, ready-to-eat snacks, such as salty and sweet snacks, co-extruded snacks and textured meat-like materials from defatted high-protein flours, have also been produced with the application of this technology (Omohimi et al., 2013), thus making it an ideal technology of choice in this study. However, the inclusion of protein sources in starchy food like yam-based diets has been advocated so as to prevent protein-energy malnutrition (Olatoye & Arueya, 2018). Hence, seed of African breadfruit, a lesser-known protein-rich source (18–23%) (Appiah, Oduro., Ellis, & Adu, 2012), could be used in combination with the aerial yam for nutritious snack food product development. It is a relatively cheap and nutritive source of food.

“Afon,” as it is often called in south-west, and “ukwa” in the south-east of Nigeria, is nutritionally similar to soybean (Appiah et al., 2012; Runsewe, Olowu, Olanrewaju, & Akinsode, 2001) and compares with its essential amino acid contents as follows: lysine, leucine, threonine, and valine, (Nwabueze, 2007). Its efficacy in the nutritional rehabilitation of malnourished children was reported by Runsewe et al. (2001). Its fat content ranged from 9 to 12% and predominantly comprised of unsaturated fatty acid. The fatty acid composition of its seed compared favorably with those of melon-seed, soybean, and groundnut oil (Ekpeyong, 1985). It is also a relatively good source of iron, calcium, potassium, and riboflavin (Ifeoma, Chukwunonso, Obinna, & Bryan, 2010). Literature is replete with results of successful application of these crops as foods. Application of extrusion technology in snacks production from other crops is also available. However, information on nutritional and sensory characteristics of extruded product from a specific cultivar of aerial yam and its blend with African breadfruit seed is sparse. The study may provide in-depth information regarding the utilization potentials of the crops as human food and thereby increase the food basket of the nation and hence help in combating food insecurity in sub-Saharan Africa. The objective of this study, therefore, was to develop and characterize an extruded snack from blends of aerial yam cultivar DBT 3075 and African breadfruit seed.

MATERIALS AND METHODS

Sources of Materials

A selected aerial yam cultivar (DBT3075), based on previous study, was obtained from Genetic Resource Center (GRC), International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria. African breadfruit seed was purchased at Ojo-Alaba market, Lagos State, Nigeria. Vanilla flavor, pepper, sucrose, and vegetable oil were purchased at Bodija Market, Ibadan Nigeria. A single screw extruder, fabricated by NASOD Engineering Ltd., Ogun State, Nigeria was used. The configuration of the extruder is L/D ratio of 304:18.5, screw diameter of 18 mm, power of 2HP, 19.5 mm die opening, and barrel length of 304 mm. The specific mechanical energy and torque of the extruder were 0.1182 kw hr/kg and 7.79 Nm, respectively. Extrusion cooking was carried out at Food Processing Laboratory, Department of Food Science and Technology, Federal University of Agriculture, Abeokuta, (FUNAAB), Nigeria.

Production of Extruded Snack From Aerial Yam and African Breadfruit Seed Flour Blends

Aerial yam bulbils and African breadfruit seed were processed into aerial yam flour (AYF) and African breadfruit seed flour (ABF), respectively. Response

Table 1. Central Composite Rotatable Design (CCRD) for the Blends of Aerial Yam Flour (AYF) and Africa Breadfruit Seed Flour (ABF) for Snacks Production

Trials	Coded values		Actual values (%)	
	AYF (x_1)	ABF(x_2)	AYF (%)	ABF(%)
1	0.00	0.00	68.00	32.00
2	1.00	-1.00	84.00	16.00
3	0.00	- α	88.00	12.00
4	0.00	+ α	56.00	44.00
5	-1.00	-100	77.00	23.00
6	0.00	0.00	68.00	32.00
7	0.00	0.00	68.00	32.00
8	-1.00	1.00	53.00	47.00
9	0.00	0.00	68.00	32.00
10	- α	0.00	59.00	41.00
11	0.00	0.00	68.00	32.00
12	+ α	0.00	74.00	26.00
13	1.00	1.00	64.00	36.00

surface Methodology was used to determine the experimental design and the combination levels in producing the extruded AYF-ABF-based snacks. From preliminary studies, five-coded levels, two-factor central composite rotatable design was constructed with design-Expert (Version7b1.1, Statease, Minneapolis, Mn) (Design-Expert, 2005) as described by Montgomery (2005). The two basic ingredients used for the extruded snacks from AYF-ABF blends are; AYF (55–85%) and ABF (15–45%). The five coded levels of AYF: - α (43.79%), -1(50.00), 0(65.00) +1(80.00) and + α (86.21) and ABF: - α (8.79%) -1(15.00), 0(30.00) +1(45.00) and + α (51.21) were incorporated into the design resulting into 13 combinations (runs) with two blocks. The central point of the design was repeated five times to calculate the reproducibility of the method. Blends of AYF:ABF (68:32, 84:16, 88:12, 56:44, 77:23, 53:47, 59:41, 74:26, and 64:36) were formulated in 13 runs, including five central points (68:32) as shown in Table 1. The blends were chemically (proximate composition and phytochemicals) evaluated and then mixed with pre-determined amount of additives (Figure 1). The moisture content was adjusted to 17.5% with material balance (Omeire, 2013) and the dough subjected to hot extrusion at barrel temperature (120°C) and the screw speed (70rpm). Extrudates were obtained and cut from the orifice of the extruder unto an open pan covered with aluminum foil. The extrudate was transferred into a hot air oven to further dry at 70°C for 4 h, and then allowed to cool for 1 h before being sealed in polyethylene bags, pending analysis.

Chemical Analyses

Determination of proximate composition and metabolizable energy

Proximate composition of samples was determined by official method of analysis (AOAC, 2005). The samples were analyzed for moisture, protein,

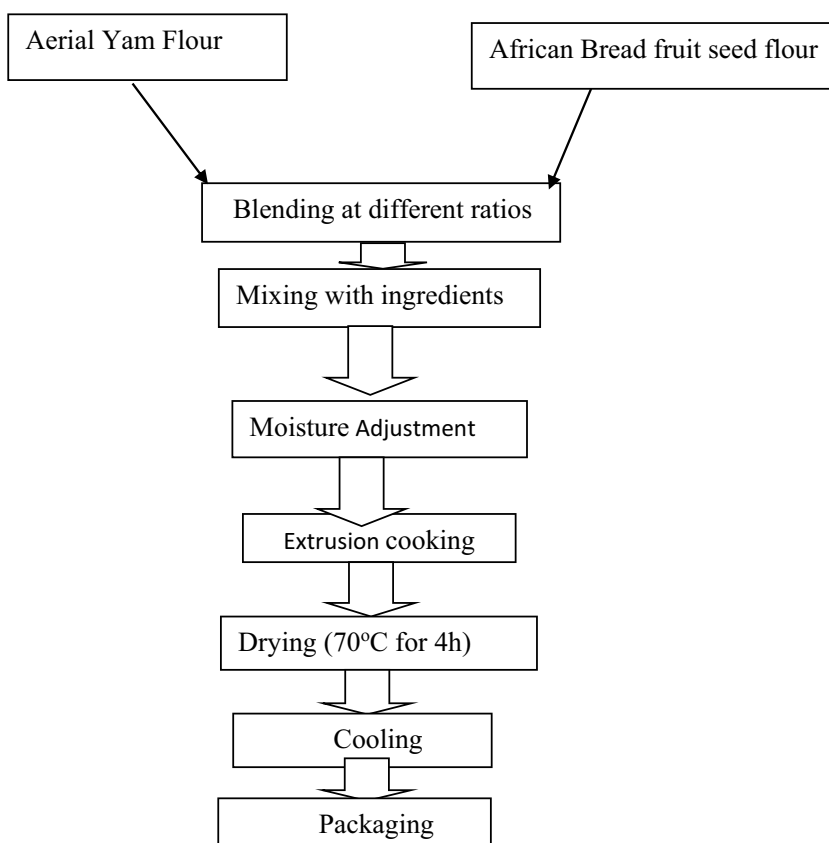


Figure 1. A graphical scheme of production of extruded snack from aerial yam and African breadfruit seed flour blends. Source: (Olatoye & Arueya, 2018).

fat, ash, fiber, and carbohydrate (by difference). The energy value was determined by the method described by Maclean et al., (2003) shown in Equation (1).

$$\begin{aligned} & \text{Energy value in kilojoules per 100g} \\ & = (\% \text{carbohydrate} \times 17 + \% \text{protein} \times 17 + \% \text{fat} \times 37) \end{aligned} \quad (1)$$

Determination of phytochemical contents

Total phenol. This was determined by the Folin-spectrophotometer method (AOAC, 2005). Total phenol was extracted by dissolving 200 mg of the sample in 10 ml concentrated methanol, thoroughly shaken for 30 min at room temperature and centrifuge at 500 rpm for 15 min. One milliliter portion of the extract was treated with equal volume of folin-ciocalteam reagent, followed by the addition of 2% Na_2CO_3 solution. Standard phenol solution was prepared and diluted to the desired concentration. Standard solution, 1 ml, was also treated with the F-D reagent and Na_2CO_3 solution. The intensity of the resulting

blue coloration was measured in a spectrophotometer at 560 nm wavelength, hence the absorbance. Measurement was made with a reagent blank at zero.

$$[\% \text{phenol} = 100 \times A_{ux} C_x W_t / (W_x A_{sx} V_a)] \quad (2)$$

where W = weight of sample, Au = absorbance of test sample, As = absorbance of standard phenol sample, C = concentration of standard phenol sample, Vt = total extract volume, Va = volume of extract analyzed.

Flavonoid contents. Method described by Koleva, Teris, Linseen, Groot and Evstatieva (2002) was used. Five gram (5 g) of flour sample was refluxed for 40 min and allowed to cool, and then filtered. The filtrate was treated with equal volume of ethyl acetate, and the moisture was transferred into a separation funnel. The flavonoid extract recovered by filtration with the aid of weighed filter paper. The weight was obtained after oven drying and cooling in a desiccator. The weight was expressed as percentage of weight analyzed and was thereby calculated as thus:

$$\% \text{flavonoid} = \frac{W_2 - W_1}{W_{\text{of sample}}} \times 100 \quad (3)$$

where W_2 and W_1 represent weight of extract in ethyl acetate portion before and after drying, respectively, and W_t = initial weight of sample.

Tannin contents. Folin-Denis colorimetric method described by Kirk and Sawyer (1998) was used. Five grams of the sample flour was dispersed in 50 ml of distilled water, shaken, allowed to stand for 30 min at 28°C and filtered through Whatman No. 42 grade of filter paper. Standard tannic acid solution was prepared, and 2 ml from it and equal volume of distilled water was dispersed into a separate 50 ml volumetric flask. Then, 2 ml each of the sample extracts were put in their respective labeled flask. The contents of each flask was mixed with 35 ml distilled water and 1 ml of the Folin Denis reagent, followed by addition of 2.5 ml saturated Na_2CO_3 Solution. With distilled water, content of each flask was made up to 50 ml and incubated at 28°C for 90 min. Absorbance was measured in a spectrophotometer (Jenway 6305 uv) at 760 nm using the reagent blank to calibrate the instrument at zero.

$$\% \text{tannin} = \frac{100}{W} \times \frac{a_u}{a_s} \times c \times \frac{v_t}{v_a} \quad (4)$$

W = weight of sample, Au = absorbance of test sample, As = absorbance of the standard tannin solution. C = concentration of standard tannin solution. Vt = total volume of extract, Va = volume of extract analyzed.

Phytate content. Method of Young and Greaves (1990) was used. Four grams of the sample was soaked in 100 ml of 2% HCl for 3 h and filtered. The filtrate

(25 ml) was placed in the conical flask. A 5 ml of 0.3% ammonium thiocyanate solution was added as an indicator, and 53.3 ml of distilled water was also added to give it proper acidity. The entire mix was titrated with standard FeCl_3 solution until a brownish yellow color persists for 5 min.

$$[\text{Phytate in mg}/100\text{mg} = \text{titre value} \times 564.11.] \quad (5)$$

Oxalate content. This was determined according to Day and Underwood (1986). One gram of sample was weighted into separate plastic bottles followed by the addition of 75 ml of 0.1 N H_2SO_4 , thoroughly mixed and allowed for an hour extraction. The entire content was filtered and 25 ml of the filtrate titrated with 0.1 ml KMnO_4 at (80–90°C) until a purple color was observed.

$$\text{Oxalate in mg}/100\text{g titre} = \text{value} \times 0.9004 \quad (6)$$

Alkaloid content. Method of Harborne (1973) was used. Five grams of sample was dispersed in 100 ml of 10% acetic in ethanol solution, properly shaken (every 30 min) and allowed to stand for 4 h at room temperature. The mixture was filtered, and the filtrate (Extract) was concentrated by evaporation to a quarter of its original volume. The extract was treated with drop-wise addition of concentrated NH_3 solution to precipitate the alkaloid. The dilution was done until the NH_3 was in excess. The alkaloid precipitate was removed by filtration using weighed Whatman No. 42 filter paper. After washing with 1% NH_4OH solution, the precipitate in the filter paper was dried at 600° and weighed after cooling in a desiccator.

$$\% \text{Alkaloid} = \frac{W_2 - W_1}{(W_{\text{of Sample}}) \times 100} \quad (6)$$

where W_1 = weight of empty filter paper; W_2 = weight of filter paper + alkaloid ppt

Sensory Evaluation

Hedonic test was conducted on extrudates of AYF and ABF blends using untrained panelists, ($n = 50$). The panelist comprises of undergraduate students who are habitual snack consumers. Panelist were asked to adjudge the snacks based on degree of their preference for appearance, taste, flavor, crispness, hardness, and overall acceptability. They were asked to score them on a 9-point Hedonic scale, where 9 represented = like extremely, 8 = like very much, 7 = moderately like, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much and 1 = dislike extremely as described by Peryam and Pilgrim (1957). Data obtained were

analyzed using analysis of variance technique, and Duncan multiple range test was used to separate the means.

Statistical Analysis of Data

All tests were replicated, and data obtained were statistically analyzed using a one-way analysis of variance (ANOVA) and means were separated by Duncan's Multiple Range Test (DMRT) using the Statistical package for social science (SPSS) IBM Version 21.0 package (Armonk, New York). Significance was accepted at 0.05 probability level.

RESULTS AND DISCUSSIONS

Effects of Extrusion Cooking on Proximate Composition and Metabolizable Energy of AYF and ABF Blends

Proximate composition of AYF:ABF blends and corresponding extruded snacks was presented in Figure 2a,b, respectively. Moisture contents (MC) of the snack samples ranged between 5.97% and 6.59% (Figure 2b) and were comparably lower than (7.69–8.22%) obtained for the flour blends (Figure 2a). It shows that extrusion cooking reduces the amount of moisture in the flour blends. Extrusion cooking was reported to reduce the moisture content of a product by increasing its solute concentration, hence discourages microbial growth and thereby extending its shelf life (Anuonye, Jigam, & Ndaeko, 2012). Conversely, the crude protein contents of the extruded snack samples ranged from 8.80 to 13.59% and was significantly higher ($p \leq 0.5$) than the range (6.82–11.31%) obtained for the flour blends. The increase in protein content may be attributed to higher solute

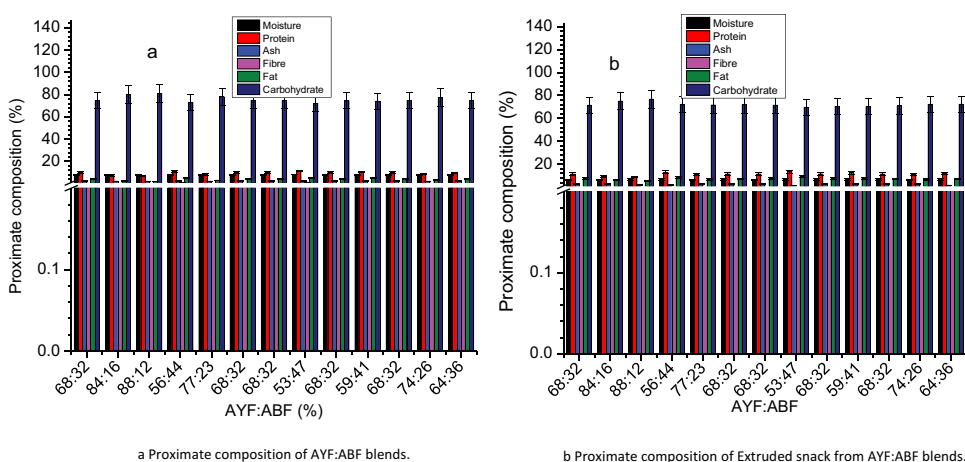


Figure 2. (a) Proximate composition of AYF:ABF blends. (b) Proximate composition of extruded snack from AYF:ABF blends.

concentration of flour blends, when exposed to extrusion conditions. The nutritional quality of the protein in the extruded material can either improve or damage by various mechanisms, (Lasekan, Lasekan, Idowu, & Ojo, 1996) on exposure to high temperature, high shear, and high-pressure. However, this result was similar to that of Oluwole, Awonorin, Henshaw, Elemo, and Ebuehi (2013) in a study involving hot extrusion of water yam and Bambara groundnut. The increase in protein content is a plus as protein can contribute to growth and repair of worn-out tissues in the human diet (Baah, 2009). Similarly, crude ash content ranged from 1.33 to 2.69 in the extruded snack (Figure 2b) and was slightly higher than the range of ash content in flour blends (2.04–2.44%) (Figure 2a). The range of ash content of this product was very close to the range (2.63–2.49%) recorded by Oluwole et al. (2013). Ash content is a reflection of the mineral status. Hence, essential minerals, which are known for their regulatory activities in body system, can possibly be derived from this snack when consumed.

The crude fiber contents of the snack food (0.78–0.99%) (Figure 2b) were marginally different ($p \leq 0.5$) from those of the flour blends (0.56–1.05%) (Figure 2a). Extrusion cooking was not responsible for the low fiber content of the products, perhaps the flour types and their blends were generally inefficient sources of fiber. Fiber intake has been linked with decreased chances of colon cancer as well as constipation. The fat content (6.40–9.07%) (Figure 2b) were significantly ($p < .05$) higher in the snacks than the blends (1.76–5.47%) (Figure 2a). These values were generally lower than the range (13.37–21.50%) reported by (Gabriel & Faith, 2014), but higher than (2.81–3.85) and (1.20–1.28) reported by (Ogunmodimun, Ijarotimi, & Fagbemi, 2015) and (Oluwole et al., 2013), respectively. The relatively increase in the fat content of the snacks can be associated with heat from extrusion. Dietary fats rich ostensibly in essential fatty acids (EFA) have been shown to enhance the taste and acceptability of foods, slow gastric emptying and intestinal motility, thereby prolonging satiety and facilitate the absorption of lipid-soluble vitamins (FAO, 2010). The lipid components also contribute to the texture (mouthfeel), flavor, and aroma of foods. Carbohydrate content of the extruded snacks ranged from 69.55 to 76.58% (Figure 2b) indicating a high energy food-source. When compared with those of their blends (71.69–80.87%) (Figure 2a), these figures were reduced after extrusion cooking. This together with the higher metabolizable energy (1647.13–1733.38 KJ/100 g) (Figure 3) and other nutritional parameters showcases a range (1557.77–1644.60 KJ/100 g) (Figure 3) obtained for the flour blends was reasonable for food product of high macronutrients, (carbohydrate, protein, and fat). Similar report (1707.2 KJ energy per 100 g of diet) was documented by Oluwole et al. (2013). The knowledge of energy value of foods as it emanated from different macromolecule may be very helpful in dealing with challenge on nutritional status (Merrill & Watt, 1973). Evidently, extrusion cooking of AYP/ABF blends resulted in snack food with adequate protein, ash, fats, and metabolizable energy, with reduced moisture content, crude fiber, and carbohydrate.

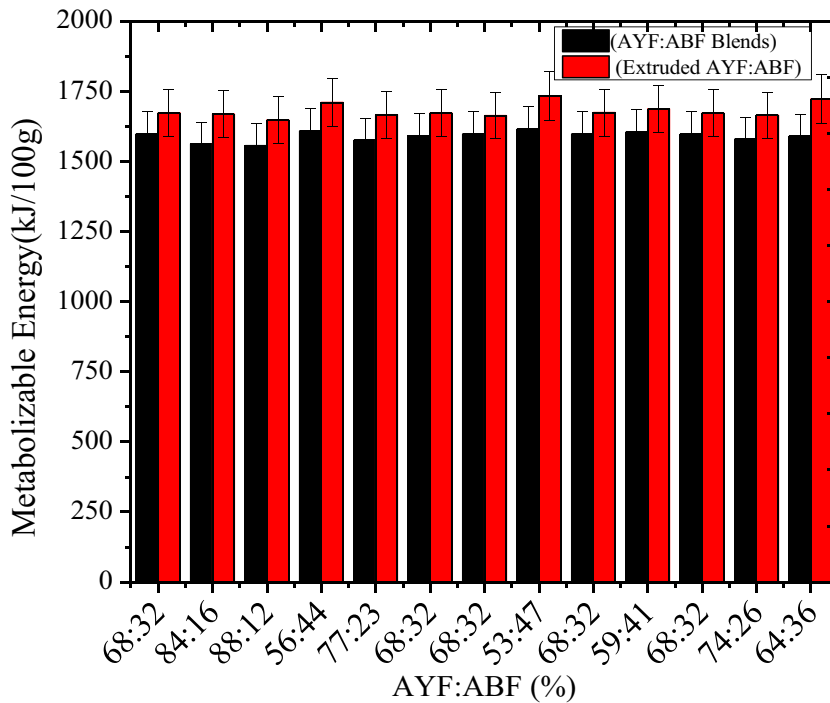


Figure 3. Metabolizable energy contents of AYF/ABF blends and its extruded snack.

Phytochemical Contents of Extruded Snacks From Blends of AYF and ABF

Phytochemical contents of AYF:ABF blends and their extruded snacks are shown in [Figure 4a,b](#), respectively.

Total phenol

The total phenol content of the snack in [Figure \(4b\)](#) ranged from 2.01 mg/g to 3.24 mg/g and was lower than the range (5.42 to 7.92 mg/g) obtained from the flour blends ([Figure 4a](#)). The reduction was equivalent to 59.92–62.92% and was in agreement with reports from earlier studies on effects of extrusion cooking on anti-nutritional factors of plant foods. ((Anuonye et al., [2012](#); Charunuch, Limsangouan, Prasert, & Wongkrajang, [2014](#)). High phenol contents could inhibit the activities of digestive and hydrolytic enzymes such as amylase, trypsin, chymotrypsin, and lipase. This inhibitory effect may be lesser in this snack than in their corresponding flour blends because of the reduced phenolic content.

Flavonoids

The flavonoid contents of the extrudates ranged between 0.78 and 1.20 mg/g and were surprisingly higher than that of the flour blends (0.38–0.56 mg/g). This behavior was similar to those of Kavita et al. ([2015](#)), in a temperature-dependent studies of some onion cultivars. It was reported that quercetin and

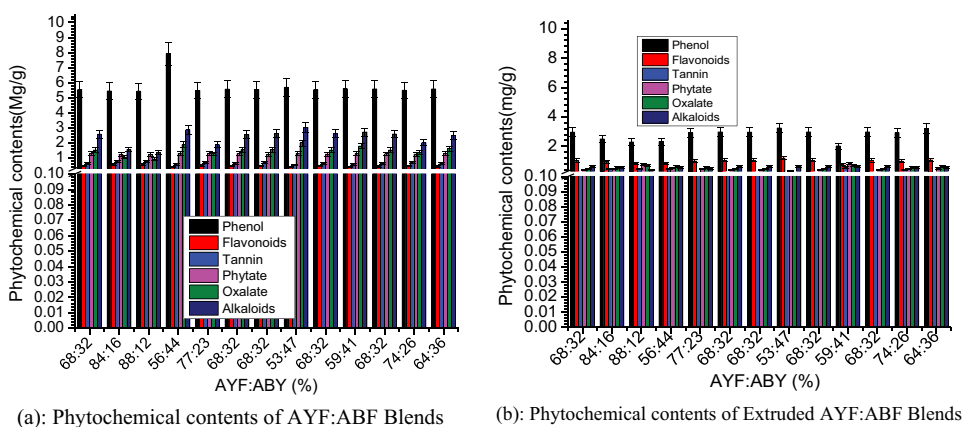


Figure 4. (a) Phytochemical contents of AYF:ABF blends. (b) Phytochemical contents of extruded AYF:ABF blends.

its glucoside contents, as well as total flavonoids concentrations increased up to 120°C and then plummeted at 150°C. This increase may be attributable to free interactions among flavonoid precursors (Kavita et al., 2015). Conversion or release of glucosides or bound phenolic into free phenolic derivatives or formations of complexes by reaction with metals may be possible causes of this behavior (Pokorny & Schmidt., 2003). Notably, flavonoids had been reported to be an anti-dote for some heart diseases. Some flavonoids such as hesperidin, apigenin, luteolin, and quercetin are reported to possess anti-inflammatory and analgesic effects (Appiah et al., 2012). Flavonoids are also known to affect the function of enzyme systems critically involved in the generation of inflammatory processes, especially tyrosine and serine-threonine protein kinases. Indeed, flavonoids presence in this snack could be regarded as a plus.

Tannin

The tannin contents of the snacks ranged between 0.12 and 0.56 mg/g and were significantly ($P < .05$) reduced by 29.11 to 77.36%, following extrusion cooking. Lewu, Adebola, and Afolayan (2010) came to a similar conclusion in his studies involving extrusion cooking. Tannins are traditionally associated with complexes formation with proteins and reduced digestibility and palatability of foods (Eka, 1985). However, intensive processing methods like cooking are known to reduce its concentration in food (Lewu et al., 2010). Hence, the observed tannin reductions in these snacks with extrusion cooking was as expected. This may improve the digestibility and palatability of proteins.

Phytate

The phytate contents of the snack samples ranged between 0.34 and 0.81 mg/g, and also had a significant reduction (37.21–72.36%) after hot extrusion. This

high percentage reduction of phytic acid in the extruded snacks is desirable, since bioavailability of minerals especially Zn and Fe are bound to improve (Anuonye et al., 2012).

Oxalate

Oxalate content ranged between 0.29 and 0.71 mg/g and on application of extrusion processing, dropped by 64.50–67.78%. Oxalate, if present in high concentration may increase the risk of renal calcium absorption, inflammation, and occasional toxicity (Osagie, 1992). Probability of such inflammatory toxicity upon consumption of this snack may be absent.

Alkaloid

Extrusion cooking also significantly reduced the alkaloid concentrations of various blends of AYF/ABF (1.37–3.04%) to (0.50–0.65%) for the snacks. Alkaloid content of the snack samples ranged from 0.50 to 0.65% as against 1.37–3.04% for flour blends. Gastrointestinal upsets and neurological disorders have been attributed to some alkaloids, but not all its entirety (Eka, 1985). Intensive processing is capable of eliminating these defects and thereby bringing about their safety.

Sensory Properties of Extruded Snacks From AYF/ABF Flour Blends

Sensory parameters of the snack samples were significantly ($P < .05$) influenced, except hardness as shown in Table 2.

Color

Color intensity decreases with increase in ABF and sample C, which contained only 12% ABF adjudged the best by the panelist in terms of color. Gabriel and Faith (2014) in cold extruded and baked snack from blends of African breadfruit seed, cashewnut, and coconut also documented similar results. This may be attributable to a fairly dark color of AYF coupled with the effect of processing method, most especially, the extrusion cooking temperature (Anuonye et al., 2012). Great importance had been attributed to color in proper judgment of snack's sensory. This is because it provides basic information about the suitability of raw material used for its preparation and its formulation and product quality (Abu-Salem & Abou-Arab, 2011; Olayiwola, Folaranmi, Adebowale, Onabanjo, & Sanni, 2012).

Taste

Taste preference increases with supplementation of ABF for AYF up to (26%) and ranged from 5.44 to 6.58. Samples B and L with AYF:ABF blends (84:16) and (74:26), respectively, were averagely scored the least and highest by the assessors. Perhaps, ABF contains more sugar than the AYF, which has been

Table 2. Sensory Properties of Extruded AYF/ABF Snack

Sample	AYF: ABF	Color	Taste	Crispness	Flavor	Hardness	Over all acceptability
A	68:32	6.02 ± 1.57 ^{bc}	6.20 ± 1.32 ^{ab}	6.38 ± 1.59 ^{ab}	5.96 ± 1.58 ^b	6.50 ± 1.59 ^a	6.64 ± 1.16 ^{ab}
B	84:16	5.20 ± 1.99 ^d	5.44 ± 1.54 ^c	6.10 ± 1.37 ^b	5.70 ± 1.64 ^b	6.38 ± 1.65 ^a	5.94 ± 1.56 ^c
C	88:12	7.00 ± 1.34 ^a	6.38 ± 1.58 ^{ab}	6.22 ± 1.72 ^b	6.22 ± 1.85 ^{ab}	6.34 ± 1.49 ^a	6.88 ± 1.32 ^a
D	56:44	5.66 ± 1.45 ^{cd}	6.08 ± 1.52 ^{abc}	6.48 ± 1.39 ^{ab}	6.18 ± 1.44 ^{ab}	6.90 ± 1.53 ^a	6.50 ± 1.53 ^{abc}
E	77:23	5.98 ± 1.45 ^{bc}	5.78 ± 1.49 ^{bc}	5.90 ± 1.71 ^b	5.90 ± 1.71 ^b	6.36 ± 1.37 ^a	6.34 ± 1.30 ^{abc}
F	68:32	6.08 ± 1.48 ^{ab}	6.10 ± 1.53 ^{abc}	6.00 ± 1.58 ^b	5.86 ± 1.62 ^b	6.22 ± 1.56 ^a	6.40 ± 1.41 ^{abc}
G	68:32	6.06 ± 1.72 ^{ab}	6.16 ± 1.63 ^{ab}	5.98 ± 1.98 ^b	5.84 ± 1.61 ^b	6.22 ± 1.69 ^a	6.54 ± 1.50 ^{abc}
H	53:47	6.08 ± 1.59 ^{bc}	6.08 ± 1.59 ^{abc}	5.98 ± 1.53 ^b	5.84 ± 1.63 ^b	6.20 ± 1.61 ^a	6.48 ± 1.40 ^{abc}
I	68:32	6.00 ± 1.55 ^{bc}	6.56 ± 1.37 ^{ab}	6.08 ± 1.58 ^b	5.92 ± 1.65 ^b	6.20 ± 1.62 ^a	6.36 ± 1.27 ^{abc}
J	59:41	5.60 ± 1.78 ^{cd}	6.24 ± 1.59 ^{ab}	6.16 ± 1.28 ^b	5.80 ± 1.99 ^b	6.40 ± 1.63 ^a	6.10 ± 1.64 ^{bc}
K	68:32	6.16 ± 1.61 ^{bc}	6.02 ± 1.56 ^{abc}	6.10 ± 1.66 ^b	5.88 ± 1.70 ^b	6.18 ± 1.60 ^a	6.40 ± 1.48 ^{abc}
L	74:26	6.46 ± 1.61 ^{ab}	6.58 ± 1.42 ^a	6.92 ± 1.56 ^a	6.74 ± 1.35 ^a	6.80 ± 1.64 ^a	7.02 ± 1.24 ^a
M	64:36	5.64 ± 1.74 ^{cd}	6.22 ± 1.36 ^{ab}	6.02 ± 1.89 ^b	6.22 ± 1.52 ^{ab}	6.60 ± 1.55 ^a	6.38 ± 1.59 ^{ab}

Means with the same superscript in the same column are not significantly different ($P \leq 0.05$)

A = F = G = I = K = central points, which repeated itself five times to calculate the reproducibility of the method.

reported to be higher in better principles (alkaloids, oxalate etc.) (Ogbuagu, 2008). Apparently, panelists prefer moderate inclusion of ABF in AYF as it could mask the bitterness in AYF and improve the taste of the snacks.

Crispness

Crispness of the snack samples were adjudged to be decreased with higher supplementation of ABF for AYF. This attribute ranged between 5.90 and 6.92, with sample E and L being scored the lowest and highest by the consumer panelist. Perhaps, this result was as a consequence of increase in cohesive forces between the peptide bonds as protein level increases (Abu-Salem & Abou-Arab, 2011; Aluko., Brai, & Adalore, 2013).

Flavor

Samples were significantly different ($P < .05$) in flavor scores and ranged between 5.70 and 6.74. However, this range shows a good acceptance level for the product, since ≥ 5 on 9-point Hedonic scale. Usually, the assessment of flavor is done by the combination of taste and Aroma. Flavor is the main criterion that determines the likeness or otherwise of a product (Abu-Salem & Abou-Arab, 2011). The product was, therefore, greatly liked by the panelist from flavor view points, with sample L being liked the most.

Hardness

The hardness scores of the snacks as adjudged by the panelist ranged between 6.18 and 6.80 and were not significantly different ($P < .05$) between the samples. Hardness is a measure of physical effort required to cause a material to break. This property in food materials is commonly dependent on available moisture within the food system and a reflection of its dryness. It may be suggested that there is a reasonable level of uniformity in the hardness

of these snack samples. It appears that extrusion cooking evidently improved the hardness of the snack samples optimally. This implied that storage life of the snacks may be prolonged (Gabriel & Faith, 2014).

Overall Acceptability

There was no outright rejection for any of the samples considering the overall acceptability with scores ranging between 5.94 and 7.02. This indicated that all the snack samples were generally acceptable for all evaluated parameters as none scored below the minimum acceptable rating of 5 on a 9-point hedonic scale (Iwe, 2002; Peryam & Pilgrim, 1957). The highest overall acceptability score (7.02) of the snack by the sensory evaluation panelists was for the 26% supplementation of ABF for AYF. This implied that consumers preferred snacks made of ABF and AYF in the ratio 26:74. In order to evaluate the quality of food, detectable sensory attributes of food by human senses can be evaluated. This can also serve as references for selections of food.

CONCLUSIONS

Extrusion cooking of AYF/ABF blends yielded snacks with adequate protein, ash, fats, and metabolizable energy but had concomitant reductions in moisture content, low in crude fiber and carbohydrate content. Following extrusion cooking generally, the levels of all the phytochemicals, (except flavonoids) dropped. The flour blends of DBT 3075 cultivar of *Dioscorea bulbifera* and *Treculia africana* produced high caloric, nutritious, and acceptable snacks for human consumption. Additionally, the very low anti-nutrient concentration and high overall consumer acceptability suggest a promising safe palatable snack food (from underutilized crops) with great contributory potentials in combating food insecurity in sub-Saharan Africa.

Disclosure statement

No conflict of interest is hereby declared by the author(s).

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