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Protein enriched breakfast meal from sweet potato and African yam bean mixes

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Abstract

Protein malnutrition is common in the developing countries due to gross intake of foods high in carbohydrate and lipids. Fortification and diversification of food crops are key players in reducing protein malnutrition and the associated health risks. This research evaluated nutritional components of breakfast food obtained from mixes of Sweet potato (SP) and African yam bean (AYB). SP and AYB were pressure cooked using autoclave at 121°C for 10 and 60 minutes, respectively. Blends of SP and AYB at 100:0, 90:10, 85:15, 80:20, and 70:30 were used to produce a tasty and ready-to-eat breakfast food. Products were analyzed for proximate compositions. Physical and sensory attributes of the products were evaluated. Significant ($p<0.05$) higher protein (5.10-8.83%), fat (0.49-0.84%) and ash (2.33-2.84%) values were observed in samples with inclusion of AYB than meal produced from 100% SP. The physical properties of ready-to-eat meal blended with AYB revealed substantial values in the bulk density (0.86-1.00%), swelling index (5.03-6.77%), water absorption (3.80-5.20%) and fat absorption (1.00-1.27%) capacities. Sample with 15% AYB inclusion had higher scores for taste, colour, flavour, and overall acceptability by panellists when compared with other fortified samples. The formulated food has increased protein contents with good functional and sensory attributes.

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Introduction

Sweet potato (*Ipomoea batatas* Lam) is a traditional tuber crop that can adapt to wide ecological range owing to its relatively short growing season and high yield potential on soils of low fertility (Hiroshi *et al.*, 2000). It is an important crop in Africa (Odebode *et al.*, 2008). It contains sufficient quantities of beta-carotene which is a precursor of vitamin A; a major requirement in diet of children for pregnant and nursing women. Sweet potato is a major food security crop in Nigeria with lots of potentials (Odebode, 2004). These potentials include processing the crop into flakes, confectioneries, flour, crisp and other indigenous products that can boost economy, food and nutrition security. Sweet potato contains significant amount of vitamin B and C and other important micronutrient such as iron (Haskell *et al*. 2004). The appreciable nutritional value of sweet potato especially the high carbohydrate, mineral and vitamin contents makes it an important choice for complementary meal. The tuber however, is deficient in protein.

In most developing countries, sweet potato is mostly consumed boiled or mashed and the potentials are grossly utilized. In order to increase the potentials of sweet potato and enhance its nutritional values, it is essential to combine it with food rich in plant proteins. African yam bean (AYB) (*Sphenostylis stenocarpa* Hochst. ex A. Rich.) (Fig.1) is a leguminous plant that is relatively rich in protein. It can supplement the protein requirements of many families throughout the year especially for low and medium income earners (Adebowale *et al.*, 2009). AYB contains significant amount of macromolecules and minerals that compare favourably with food legumes.

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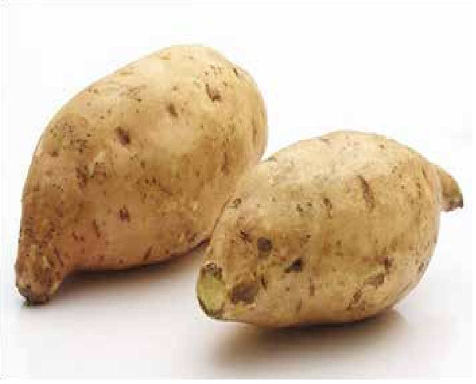

b

Fig. 1. (a) African yam bean (*Sphenostylis stenocarpa* Hochst. ex A. Rich.) seeds. (b) Sweet potato

It is a highly priced food legume in south eastern Nigeria (Asioro and Ani, 2011) owing to high crude protein content. Fortification of sweet potato with AYB is a good approach in reducing protein malnutrition.

Protein and Energy Malnutrition (PEM) is rampart among school children in tropical countries, particularly, Nigeria. This is due to gross consumption of food rich in carbohydrate but deficient in protein and micro nutrients. Diversification of food crops is important in reducing PEM and the associated health risks. This work evaluated physico-chemical properties of complementary meal from mixture of sweet potato and African yam bean.

Material and methods

Sample preparation

Sweet potato were sorted, washed, peeled, sliced and cooked at 121^{o}C for 10 minutes in an autoclave, cooled and mashed. AYB was sorted, weighed, washed, and coarse milled to remove hulls and cooked in an autoclave at 121^{o}C for one hour. The samples were mixed in ratios of 100:0, 90:10, 80:20, and 70:30 of Sweet potato and AYB, respectively. The obtained ratios were mashed together and passed through 2 mm die aperture to obtain a product with shape similar to extrudate. The obtained product was thinly spread on a pre greased stainless steel tray, dried and toasted in an oven at 70^{o}C for 4 hours. Dried samples were cooled at ambient temperature. Samples were pulverized and packaged in air tight plastic containers for further analyses.

Analyses

Proximate analysis

Proximate compositions of samples were determined according to the official methods of Association of Official Analytical Chemists (AOAC, 2005). Moisture content was estimated using oven drying AOAC, 925.10 method, protein was estimated using Kjeldahl method (AOAC, 960.52), soxhlet extraction method was used for crude fat (AOAC 2003.03), crude fiber was estimated gravimetrically and dry ashing was used to estimate ash content (AOAC, 923.03). Carbohydrate content was determined by difference as described by Lee-Hoon and Norhidayah (2016).

Physical attributes determination

Swelling capacity was determined by quantifying the ratio of swollen volume of a unit weight of each sample to its initial volume in a graduated measuring cylinder (Takashi and Sieb, 1988). One gram of the sample was weighed into a tarred 20 ml graduated cylinder, followed by the addition of 10 ml of distilled water which was gently mixed. The slurry obtained was placed in a water bath and heated at 95°C for 30 min. Samples were occasionally stirred to prevent clumping. Centrifugation of samples was done at 3000 rpm for 10 minutes after they have been well pre-heated. The filtrate obtained after centrifugation was dried at 50°C for 30 minutes, cooled and weighed. The bulk density was determined by filling a 10 ml cylinder with samples and the bottom was tapped until constant volume was obtained (Okezie and Bello, 1988). Bulk density was calculated as weight of sample per unit volume of sample (g/ml).

The method of Sosulski *et al.* (1976) was adopted in determining Water Absorption Capacity (WAC). A portion of 2 g sample was dispersed in 200 ml of distilled water. The contents were agitated for 30 seconds every 10 minutes; after agitating for five times, it was centrifuged at 4000 rpm for 20 min. The supernatant was gently decanted, and content of the tube drained at angle 45° was weighed. The WAC was expressed as percentage increase of the sample weight.

Similar procedure was repeated for oil absorption capacity with slight modifications. One gram of the sample was mixed with 10 ml of refined vegetable oil for 60 sec; the mixture rested at ambient temperature for 10 min and, centrifuged at 4000 rpm for 30 min. The top layer of oil was carefully decanted, drained and then weighed. Oil absorption was calculated as percentage increase of the sample weight.

Sensory evaluation

Sensory evaluation was conducted by 20 semi-trained panellists. The complementary meal was served in a white disposable plastic cups. The product was tested for colour, taste, texture, aroma, and general acceptability using 9-point hedonic scale according to the method of Akinwande, *et al.* (2014). The coded samples prepared from different levels of sweet potato and African yam bean were served to panellists who evaluated the meal for each sensorial parameter based on their degree of likeness using 9 point hedonic scale with 9=like extremely, 5=neither like nor dislike and 1= dislike extremely.

Statistical analyses

Results obtained analyzed using Statistical Package for the Social Sciences version 15 software (SPSS Inc., Chicago, IL, USA). The results were mean values of three individual replicates ± the standard deviation (SD). Data obtained were subjected to analysis of variance (ANOVA) and means separated with Duncan multiple range test at a significance level of $p < 0.05$.

Results and discussion

Proximate composition

The moisture content of the samples ranged from 8.79 to 10.49%. Sweet potato sample (100 %) was significantly ($p<0.05$) higher than samples supplemented with AYB. The lowest value was obtained in sample with 20% AYB supplementation. Variations in the moisture content obtained in the developed products could probably be due to the drying condition (Akinwande *et al*., 2014).

Protein values obtained ranged from 4.25 to 8.83% (Table I). Protein contents of samples increased with increase in levels of AYB substitution. This agreed with the report of Yusufu *et al.* (2013) who reported significant increase in the protein level of complementary food prepared from sorghum, AYB and Mango mesocarp flour blends. Akinwande *et al.* (2014) also observed increase in the protein content of ready-to-eat breakfast cereals from blends of whole maize and African Yam Bean. The protein contents of AYB fortified sample increased significantly ($p<0.05$) when compared with sweet potato sample with no inclusion of AYB. High contents of protein observed in fortified samples will reduce the problem of protein malnutrition and increase potential of plant protein. Ukegbu *et al*. (2015) reported that protein from plant sources is considerably cheaper than the ones obtained from animal sources.

The ash contents of samples ranged from 2.33 to 2.84%. Inclusion of AYB in sweet potato increased the ash content of all samples. Significantly higher value (2.84) was recorded in sweet potato with 15% AYB inclusion followed by sample with 20% AYB (2.66) and the lowest values in control sample (Table I). Values of crude ash obtained varied from one sample to another, although, higher ash contents were observed in samples with 15, 20, and 30% AYB inclusion. This could be as a result of high proportion of AYB in the composite flour which is rich in mineral such as iron, calcium and phosphorus (Ndidi *et al*., 2014). Higher values obtained in sample with 15% of AYB could be due to bioavailabilty of the mineral in the mixes.

Table I. Proximate contents of breakfast meal produced from sweet potato and African yam bean blends

Sample %SP:%AYB	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	Carbohydrate (%)
100:0	10.49± 0.02^{a}	4.25± 0.24^{e}	0.45± 0.03^{c}	2.37± 0.02^{d}	4.63± 0.15^{a}	77.80± 0.35^{b}
90:10	8.96± 0.02^{d}	5.10± 0.02^{d}	0.49± 0.03^{c}	2.33± 0.03^{d}	4.32± 0.10^{b}	78.80± 0.14^{a}
85:15	9.10± 0.01^{c}	6.10± 0.02^{c}	0.56± 0.02^{b}	2.84± 0.01^{a}	4.27± 0.15^{b}	77.13± 0.14^{c}
80:20	8.79± 0.05^{e}	6.81± 0.02^{b}	0.81± 0.02^{a}	2.66± 0.02^{b}	3.35± 0.05^{c}	77.59± 0.10^{b}
70:30	9.32± 0.08^{b}	8.83± 0.03^{a}	0.84±0.04^{a}	2.51± 0.03^{c}	3.52± 0.10^{c}	74.99± 0.07^{d}

Means with the same superscript within the same column are not significantly different ($p>0.05$).
SP=Sweet Potato; AYB= African Yam Bean

Table II. Physical properties of the breakfast meal produced from sweet potato and African yam bean blends

Sample %SP:%AYB	WAC (g/ml)	OAC (g/ml)	Swelling capacity (g/ml)	Bulk density (g/ml)
100:0	4.13± 0.31^{bc}	0.50± 0.10^{c}	5.03± 0.15^{d}	0.86± 0.05^{c}
90:10	4.53± 0.31^{b}	1.27± 0.12^{ab}	5.47± 0.15^{c}	0.88± 0.05^{bc}
85:15	5.20± 0.20^{ab}	1.23± 0.15^{ab}	5.90± 0.10^{b}	0.94± 0.05^{ab}
80:20	4.53± 0.30^{b}	1.40± 0.20^{a}	6.03± 0.15^{b}	0.99± 0.05^{a}
70:30	3.80± 0.20^{c}	1.00± 0.20^{b}	6.77±0.25^{a}	1.00± 0.05^{a}

Means with the same superscript within the same column are not significantly different (p>0.05).
SP=Sweet Potato; AYB= African Yam Bean; WAC = Water Absorption Capacity; OAC = Oil Absorption Capacity

Table III. Sensory evaluation of the breakfast meal produced from sweet potato and African yam bean blend

Sample %SP:%AYB	Colour	Taste	Texture	Aroma	After Taste	Overall acceptability
100:0	7.90± 1.55^{a}	9.60± 1.39^{a}	5.90± 2.57^{a}	6.70± 1.63^{a}	7.80± 1.28^{a}	8.00± 0.86^{a}
90:10	5.95± 1.96^{bc}	6.15± 1.59^{b}	5.55± 2.06^{a}	5.60± 1.88^{ab}	6.05± 1.85^{b}	5.85± 0.99^{b}
85:15	6.30± 1.75^{b}	6.45± 1.23^{b}	6.40± 2.09^{a}	5.75± 2.22^{ab}	6.05± 1.36^{b}	6.55± 1.47^{b}
80:20	4.95± 1.64^{c}	6.25± 1.45^{b}	5.95± 2.09^{a}	5.10± 1.89^{bc}	5.85± 1.73^{b}	5.80± 1.32^{b}
70:30	2.70± 2.20^{d}	4.85± 2.03^{c}	5.35± 2.72^{a}	3.95± 1.67^{c}	5.05± 2.11^{b}	3.35± 1.69^{c}

Means with the same superscript within the same column are not significantly different (p>0.05).
SP=Sweet Potato; AYB= African Yam Bean; WAC = Water Absorption Capacity; FAC = Fat Absorption Capacity

The carbohydrate contents on the other hand ranged from 74.99-78.80% and sample with 10% AYB inclusion had the highest sample with 30% AYB inclusion, the least. The results obtained differed significantly from one another. Akinwande *et al*. (2014) reported no significant increase in carbohydrate contents of breakfast meal produced from blend of whole maize and African yam bean. High values of carbohydrate obtained in this study confirm that sweet potato is energy giving food as confirmed by Abubakar *et al.* (2010).

The fat contents ranged from 0.45-0.84% and it significantly increased with increase in AYB inclusion. The highest value was obtained from the sample with 30% AYB inclusion and the least from control sample which is the 100 % sweet potato; this implies that foods prepared from this blend would provide additional source of energy hence reducing PEM. The trend of fat content obtained in this report agreed with the findings of Igbabul *et al.* (2014) who reported increase in fat of complementary meal produced from wheat, sweet potato and hamburger bean flour blends.

Crude fibre decreased as concentrations of AYB increased. Control sample is significantly different from samples with 15-20% level of AYB inclusion. Ukegbu *et al*. (2015) also reported decrease in fibre content of pap made from cereal as concentration of AYB increased. Igbabul *et al.* (2014) however reported increase in crude fibre of complementary food from wheat, sweet potato and hamburger bean flour blends. This is due to higher fibre contents in food materials used for the flour blends.

Physical properties

Table II provides the physical properties of sweet potato and AYB meal which determines the importance of food material for various food applications. The bulk density increased significantly with increase in the AYB inclusion. The values ranged from 0.86-1.00 g/ml. The highest value was obtained from sample with 30% AYB inclusion (1.00g/ml) and the least was obtained from the control sample (0.86g/ml). Udensi and Eke (2000) reported that higher bulk density is desirable due to greater ease of dispersibility and reduction in paste thickness of gruel. Bulk density is generally affected by the particle size and it is greatly used in estimating the packaging requirement and material handling requirement (Karuna *et al*., 1996).

Swelling capacity of the sample significantly increased as level of AYB in the mixture increased. It ranged from 5.0-6.77% and was highest in sample with 30% AYB while the lowest value was recorded in 100% sweet potato product. This agreed with the report of Igbabul *et al.* (2014) who reported increase in the swelling capacity of meal produced from sweet potato and hamburger bean flour blends. Higher swelling index as reported by Ikpeme-Emmanuel *et al.* (2012) indicated higher WAC and can increase volume of gruels during cooking. Swelling can change hydrodynamic attributes of food by impacting characteristics such as body, thickening and increase in viscosity to foods which results production of a thick viscous gruel. The swelling capacity of flours depends on size of particles, types of variety and types of processing methods or unit of operation.

The WAC ranged from 3.80-5.20 g/ml. The sample with 15% AYB inclusion had the highest WAC. This implies that inclusion of AYB confers high water binding capacity to sweet potato flour (Table II). Kulkarni *et al.* (1991) and Ajanaku *et al.* (2012) reported that high water binding capacity improves the reconstitution ability. Mbofung *et al.* (2006) also reported that the water absorption capacity of any flour depends on its starch content. The report of Menon *et al.* (2015) showed that fortification of refined flour with legume based flour increased water absorption capacity. However, the lowest value obtained in sample with 30% AYB inclusion could be due to interaction in starches of sweet potato and AYB which affected the water absorption capacity. Hoover and Sosulski (1986) opined that variation in water absorption capacity of food samples may be caused by differences in the level of binding of hydroxyl groups that form hydrogen bonds and covalent bonds between starch chains.The oil absorption capacity ranged from 0.50-1.40 g/ml. The oil absorption capacity is important as it improves the mouth feel and retains the flavor (Igbabul *et al*., 2014).

Sensory evaluation

Sensory evaluation of the breakfast meal showed some of the products were well accepted (Table III). Control sample (100% sweet potato) had higher scores in all attributes (colour, taste, aroma, aftertaste and general acceptability) evaluated followed by sample with 15% inclusion of AYB. This indicates production of breakfast cereal with up to 15% AYB is acceptable. The sample with 30% AYB inclusion received the least acceptance rating from the panellists due to the colour and taste which could be as a result of its beany flavour.

Conclusion

The formulated breakfast meal had appreciable protein content and good functional properties when compared with control. Up to 15% of AYB inclusion was accepted by panelists. Inclusion of plant protein especially the underutilized ones in local food formulations is a good approach in improving food and nutrition security in developing countries. It will also promote utilization of these neglected legumes.

References

Abubakar HN, Olayiwola IO, Sanni SA and Idowu MA (2010), Chemical composition of sweet potato (*Ipomea batatas Lam*) dishes as consumed in Kwara state, Nigeria, *Intern Food Res. J.* **17**: 411-416.

Adebowale YA, Henle T and Schwarzenbolz U (2009), Acetylated and succinylated derivative of African Yam Bean (AYB), *J. Mobile Comm.* **3**: 15-22.

Ajanaku KO, Ajanaku CO, Edobor-Osoh A and and Nwinyi OC (2012), Nutritive value of sorghum ogi fortified with groundnut seed (*Arachis hypogaea* L.), *Am. J. Food Technol.* **7**: 82-88.

Akinwande BA, Babarinde GO, and Ajeigbe OP (2014), Production and evaluation of ready-to eat breakfast cereals from blends of whole maize and African yam bean (*Sphenostylis stenocarpa*), *Elixir Food Sci.* **72**: 25-28. DOI:org/10.1111/jfpp.12060

AOAC (2005), Official methods of Analysis, Association of Officiating Analytical Chemists, 18th Ed. Gaithersburg, Maryland, Method 925.10, 960.25 and 2003.03.

Asioro FU and Ani AO (2011), Effect of processing methods on the physiochemical properties and anti-nutritional factors on African Yam Bean (AYB) products, *Afr. J. Plant Sci.* **2**: 23-27

Haskell MJ, Jamil KM, Hassan F, Peerson JM, Hossain, MI, Fuchs GJ and Brown KH (2004), Daily consumption of Indian spinach (Basella alba) or sweet potatoes has a positive effect on total body vitamin A stores in Bangladeshi men, *Am. J. Clin. Nutr*. **80**, 705–714.

Hiroshi I, Hirorko S, Noriko S, Satoshi I, Tadahiro T and Akio M (2000), Nutritive evaluation of chemical composition of leaves, stalks and stem of sweet potato (Ipomea *batatas* Poir), *Food Chem*. **68** (3): 359-367.

Hoover R and Sosulski F (1986), Effect of cross linking on functional properties of legume, *Starches/Stärke* **38**: 149-155. DOI:org/10.1002/star.19860380502

Igbabul BD, Bello F and Ekeh CN (2014), Proximate composition and functional properties of wheat, sweet potato and hamburger bean flour blends, *Glob.* Adv. *Res. J. Food Sci. Technol*. **3**(4): 118–124.

Ikpeme-Emmanuel, CA, Ekpeyong IO and Igile GO (2012), Chemical and protein quality of soybean (*Glycine Max*) and tiger nut (*Cyperus escullentus)* based weaning food, *J. Food Res.* **1**(2): 246-254.

Karuna D, Noel G and Dilip K (1996), Production and use of raw potato flour in Mauritian traditional foods, *Food Nutr. Bull.* **17**(2): 12-14. DOI:org/10.1177/ 15648 2659601700210

Kulkarni KD, Kulkarni DN and Ingle UM (1991), Sorghum Malted and soya bean weaning food formulations: Preparation, functional properties and nutritive value, *Food Nutr. Bull.* **13**: 322-327. DOI:org/ 10.1002/jsfa.1060

Lee-Hoon H and Norhidayah CD (2016), Effect of watermelon rind powder on physicochemical, textural, and sensory properties of wet yellow noodles, *CyTA J. Food* **14**(3): 465-472.

Mbofung C, Aboubakar MF, Njintang YN, Bouba AA and Balaam FF (2006), Physicochemical and functional properties of six varieties of taro (*Colocasia esculenta* L. Schott) flour, *J. Food Technol*. **4:** 135-142.

Menon L, Majumdar SD and Ravi U (2015), Development and analysis of composite flour bread*, J. Food Sci. Technol.* **52**(7): 4156-4165.

Ndidi US, Ndidi CU, Olagunju A, Muhammad A, Billy FG and Okpe O (2014), Proximate, antinutrients and mineral composition of raw and processed (boiled and roasted) *Sphenostylis stenocarpa* seeds from Southern Kaduna, Northwest Nigeria, *ISRN Nutri*.1-9.

Odebode SO (2004), Acceptability of Sweetpotato "sparri" and its potentials for enhancing food security and economic empowerment of rural women in Southwestern Nigeria, *Nig. J. Rural Sociol.* **2:** 104-112.

Odebode SO, Egeonu N and Akoroda MO (2008), Promotion of sweet potato for the food industry in Nigeria, *Bulgarian J. Agric. Sci.* **14**: 300-308.

Okezie BO and Bello AB (1988), Physiochemical and functional properties of winged bean flour and isolate compared with soy isolate, *J. Food Sci.* **53**(11): 450-454.

Sosulski FW, Humbert ES, Bui K and Jones JO (1976), Functional properties of rapeseed flour concentrates and isolates, *J. Food Sci.* **41**: 1348-1354.

Takashi S and Sieb PA (1988), Paste and gel properties of prime corn and wheat starches with and without native lipids, *Cereal Chem.* **65:** 474-483.

Udensi A and Eke O (2000), Proximate composition and functional properties of flour produced from *Mucuna cochinensis* and *Mucuna utles*. Proceedings of the 1st Annual Conference of the College of Agriculture and Veterinary Medicine, Abia State University, pp 170–174.

Ukegbu PO, Uwaegbute AC and Nnadi MC (2015), Organoleptic and Nutritional Evaluation of African Yam Bean (Sphenostylis stenocarpa) Flour Enriched Complementary Foods, *Sch. J. Agric. Vet. Sci.* **2**(2A): 97-101.

Yusufu PA, Egbunu FA, Egwujeh SID Opega GL and Adikwu MO (2013), Evaluation of complementary food prepared from sorghum, African yam bean and mango mesocarp flour blends, *Pak. J. Nutrit.* **12**(2): 205-208.