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Chemical composition and sensory evaluation of potato-sprouted Africa yam beans based complementary food fortified with palm weevil

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Abstract
This work evaluated nutritional components of complementary food obtained from mixes of sweet potato (SP), African yam bean (AYB) and palm weevil (PW). SP and AYB were pressure-cooked using autoclave at 121º C for 10 and 60 minutes, respectively. Four blends coded Control (100% Sweet potato) CF1 (80% sweet potato: 15% Africa yam bean: 5% palm weevil). CF2 (70% Sweet potato: 20% Africa yam bean: 10% palm weevil) and CF3 (60% sweet potato: 25% Africa yam bean: 15% palm weevil). The blends were analyzed for proximate compositions and functional and sensory attributes. 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 and PW than meal produced from 100% SP. The functional properties of ready-to-eat meal blended with AYB and PW 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 and 5% PW inclusion had higher scores for taste, colour, flavour, and overall acceptability by panelists when compared with other fortified samples. The formulated food has increased protein contents with good functional and sensory attributes.

Keywords: Chemical composition, African yam bean (AYB), palm weevil (PW)

Introduction

Complementary feeding for infants refers to the timely introduction of safe and nutritional foods in addition to breast-feeding i.e. clean and nutritionally rich additional foods introduced at about six months of age (Yusufu *et al*., 2013) [36]. The World Health Organization has described the complementary feeding period as “the period during which other foods or liquids are provided along with breast milk” and states, “any nutrient-containing foods or liquids other than breast milk given to young children during the period of complementary feeding are defined as complementary foods (ESPHGAN, 2008) [13]. Complementary foods that are introduced in a timely manner, and are nutritionally adequate, safe, and appropriately fed-along with continued breast feeding are critical to the nutrition, health and development of infants and young children between 6-24 months of age. The World Health Organization (WHO) defines “timely” as at six months of age, “adequate” as meeting the child’s nutrient requirements, “safe” as hygienically prepared, stored and fed, and “appropriately fed” as fed responsively or feed in a manner that responds to a child’s signals of hunger and satiety. The introduction of complementary food has been known as weaning, which comes from the Anglo-Saxon word „weanian‟, meaning to accustom (ESPHGAN, 2008) [13]. However the word weaning has come to be associated with complete cessation of breast feeding, and there is no reason to suggest or imply that mothers should stop breast feeding when complementary feeding is started. For this reason, the term complementary feeding is preferred. This latter term means that breastfeeding continues and other foods are introduced to complement or add to the nutritional intake provided by breast milk or infant formula (Anonymous, 2008) [7].

The formulation and development of nutritious complementary foods from locally and readily available raw materials has received a lot of attention in many developing countries (Ijarotimi and Ashipa, 2006) [17]. In most developing countries, complementary diets are derived mainly from local staples such as cereals and tubers, with animal proteins used as supplements. However, since animal proteins are expensive, attempts have been made to identify alternative sources of protein, especially from insects. Cereals and legumes, individually or as composites, are the main source of nutrients for weaning children in developing countries (Almeida-Dominguez *et al*., 1993) [6]. Evidence indicates that it is quite possible to improve the nutrient quality and acceptability of these cereals and legumes and exploit their potentials as human foods by adopting newer scientific processing methods. The commonly used cereals; wheat, rice and maize together comprise at least 75% of the world‟s grain production. Cereals provide more than 60% of energy. They are generally low in protein and are limiting in some essential amino acids, particularly lysine and tryptophan but provide adequate amounts of methionine and cysteine, which are sulphur-containing amino acids (Ijarotimi and Famurewa, 2006) [18]. Legumes on the other hand, are important sources of proteins, carbohydrates, dietary fiber and minerals and are useful sources of B vitamins consumed worldwide (Martin *et al.*, 2010) [25]. Legumes are known to contain lysine in a quantity that exceeds the requirements for humans but with low content of sulphur containing amino acids (Mishra *et al*., 2014) [28].

Due to increasing cases of malnutrition in most developing and under-developed countries as a result of difficulties in providing sufficient food, most especially protein (Aylward and Morgans, 1995) [9], insects are being presented as an attractive alternative protein source as they are natural foods of many vertebrates, human inclusive (DeFoliart, 1999) [12]. Insects are not a traditional food in Western culture, but there is a growing public interest in their nutritional importance. The cultural practice of entomophagy (use of insect as food) is an old and well-established custom in non-industrialized regions of the world. It is exercised traditionally in 113 countries all over the world and more than 2,000 insect species that are considered edible have been counted to date (Jongema, 2012) [20]. The practice of Entomophagy in Nigeria has significantly reduced protein deficiency in the country (Omotoso, 2006) [30]. Edible insects have been reported to be part of the traditional cuisine of many nations (Bednarova *et al.*, 2013) [11] and because they are easy to breed, reproduce rapidly, have low environmental footprints, they have become an important and valuable source of nutrition not only in the developed countries as well (Kinyuru *et al.*, 2013) [22]. They have been discovered to be a rich source of various nutrients such as iron, zinc and calcium. Insects commonly consumed in Nigeria are locust, termites, ants, grasshoppers, weevils, beetles, crickets and caterpillars. Generally, edible insects have been found to be good sources of proteins, fat, energy, vitamins and minerals. According to Agbidiye *et al.* (2009) [3], consumption of 100 g of caterpillars provides 76 % of the daily-required amount of proteins in adults. In Southwestern Nigeria, grubs of palm weevil are roasted or fried and hawked by the roadside. The larvae is a delicacy served as snacks or taken with carbohydrate foods (Omotoso, 2006) [30]. The larvae of the African Palm Weevil (*Rhychophorus phoenicis*) live and feed on the trunk of the raffia palm. They burrow in the crown of the palm, feed on the young tissues, and sometimes destroy the growing point until the palm dies. The adult palm weevils have a plump, yellowish-cream body with a soft-ridged texture and a hard-shelled head (Beckerman, 1977) [10]. In light of this, they are regarded as pests but the grubs are highly valued delicacies in the rain forest regions of Nigeria. Forms of utilization include boiling, roasting, frying or eaten raw (Onyeike *et al.*, 2005) [31]. The main aim of this study will be to develop and evaluate chemical qualities, consumer acceptability and shelf life potato-fermented African yam bean based complementary food fortified with *Phychophorous phoenicis* (Palm Weevils).

Materials and Methods

Source of raw materials: The Sweet potato was obtained from the farm research farm of the institution. Africa yam bean and palm weevil were obtained from Oja Oba, Ire, Osun State.

Preparation of flour from the sweet potato: Sweet potatoes weighing 78.25 kg were sorted, peeled, chipped and dried in a hot air oven at 60 °C for 12 h. Weight of chipped sweet potatoes before drying was noted to be 49 kg. The dried sweet potato chips were then milled in a hammer mill into flour.

Preparation of flour from African yam bean: The purchased dry seeds (African Yam bean) were cleaned and sorted to remove extraneous materials and damaged seeds. About 2kg of the seeds were soaked in 2 litres of water for 48 hours. They were then dried at 60ºC for 8 hours in a carbolite electric oven and then ground into fine flour using attrition mill, it was labeled and stored in an air tight container to be further analysed.

Formulation of complementary food: Based on the macronutrients of the individual flours with reference to the levels of macronutrients required of complementary foods as developed by Codex Alimentarius Commission as desceibed by Ade-Omowaye *et al.* (2008) [2], material balance was used to estimate the minimum amount of each portion of flour to meet the standard. A range for the various proportions was therefore developed and mixture design (from the Statsgraphics Centurion software) used to formulate the complementary food blends.

CF1: 80% sweet potato: 15% Africa yam bean: 5% palm weevil.

CF2: 70% Sweet potato: 20% Africa yam bean: 10% palm weevil.

CF3: 60% sweet potato: 25% Africa yam bean: 15% palm weevil.

Proximate Composition: The proximate composition of the samples were carried out as described below using the standard method (A.O.A.C, 2005) [8] the samples are carried out in different method ash content, moisture content, crude fiber content, protein content, fat determination.

Functional properties measurement

Water and oil absorption capacity: The water and oil capacities were determined by the method of Sosulski *et al.* (1976) [33]. 2g of the samples were mixed with 10ml distilled water or refined soybean oil contained in a 25ml centrifuge tube and allowed to stand at ambient temperature (20-30°C) for 20 minutes then was centrifuged for 30 minutes at 2000Xg. The supernatant was decanted, excess moisture, oil was removed by draining for 25 minutes at 50°C, and sample was reweighed. Water and oil absorption capacity was expressed as percent water or oil bound per gram flour.

Determination of bulk density: The bulk density was determined using the method described by Okaka and Potter (1977) [32]. A 50g of samples was put into 100ml graduated cylinder, the cylinder was tapped for 5 minutes and the bulk density was calculated as weight per unit volume of sample.

Sensory Evaluation of product samples: A ten-man panelists comprising of staff and student of Osun State Polytechnic, Ire, Osun state was used and selection was made because of familiarity with complementary foods. The samples were presented to the panelists in a randomized order and were evaluated for appearances, taste, aroma, consistency and overall acceptability on a 7-point hedonic scale (Lamond, 1977) [24].

Statistical Analysis: Data was generated in triplicate, analysis was done using Analysis of Variance (ANOVA) of the statistical package for social sciences (SPSS version 10.0 for windows), and means were separated using Duncan's multiple range test.

Results and Discussion

Table 1: Proximate contents of complementary food produced from sweet potato African yam bean and palm weevil blends

Sample %SP:%AYB: PW	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	Carbohydrate (%)
Control (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}
CF1 (80:15:5)	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}
CF2 (70:20:10)	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}
CF3 (60:25:15)	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}

Control= 100% Sweet Potato; CF1= 80% sweet potato: 15% Africa yam bean: 5% palm weevil., CF2: 70% Sweet potato: 20% Africa yam bean: 10% palm weevil., CF3: 60% sweet potato: 25% Africa yam bean:15% palm weevil.

Table 2: Function properties of complementary food produced from sweet potato, African yam bean and palm weevil blends

Sample %SP:%AYB%PW	WAC (g/ml)	OAC (g/ml)	Swelling capacity (g/ml)	Bulk density (g/ml)
Control (100:0)	4.13± 0.31^{bc}	0.50± 0.10^{c}	5.03± 0.15^{d}	0.86± 0.05^{c}
CF1	5.20± 0.20^{ab}	1.23± 0.15^{ab}	5.90± 0.10^{b}	0.94± 0.05^{ab}
CF2	4.53± 0.30^{b}	1.40± 0.20^{a}	6.03± 0.15^{b}	0.99± 0.05^{a}
CF3	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)

Control= 100% Sweet Potato; CF1= 80% sweet potato: 15% Africa yam bean: 5% palm weevil., CF2: 70% Sweet potato:20% Africa yam bean: 10% palm weevil., CF3: 60% sweet potato: 25% Africa yam bean:15% palm weevil

Table 3: Sensory evaluation of complementary food produced from sweet potato African yam bean and palm weevil 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}
CF1	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}
CF2	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± 1.32b
CF3	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± 1.69c

Means with the same superscript within the same column are not significantly different (p>0.05)

Control= 100% Sweet Potato; CF1= 80% sweet potato: 15% Africa yam bean: 5% palm weevil., CF2: 70% Sweet potato: 20% Africa yam bean:10% palm weevil., CF3: 60% sweet potato: 25% Africa yam bean:15% palm weevil.

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 and palm weevil. 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) [5].

Protein values obtained ranged from 4.25 to 8.83% (Table I). Protein contents of samples increased with increase in levels of AYB substitution and palm weevil. This agreed with the report of Yusufu *et al.* (2013) [36] who reported significant increase in the protein level of complementary food prepared from sorghum, AYB and Mango mesocarp flour blends. Akinwande *et al.* (2014) [5] also observed increase in the protein content of ready-to-eat breakfast cereals from blends of whole maize and African Yam Bean and crayfish. The protein contents of AYB and palm weevil fortified samples increased significantly (p<0.05) when compared with sweet potato sample with no inclusion. 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) [35] 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 20% AYB inclusion followed by sample with 25% 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 20, and 35% AYB and 10% and 15% pal weevil 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) [29]. Higher values obtained in sample with 25% of AYB could be due to bioavailabilty of the mineral in the mixes. The carbohydrate contents on the other hand ranged from 74.99-78.80% and sample with 15% AYB and 5% pal weevil inclusion had the highest while sample with 25% AYB and 15% pal weevil inclusion had the least. The results obtained differed significantly from one another. Akinwande *et al.* (2014) [5] 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) [1]. The fat contents ranged from 0.45-0.84% and it significantly increased with increase in AYB and pal weevil inclusion. The highest value was obtained from the sample with 25% AYB and 15% pal weevil 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) [16] 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 and palm weevil increased. Control sample is significantly different from samples with all levels of AYB and palm weevil inclusion. Ukegbu *et al*. (2015) [35] also reported decrease in fibre content of pap made from cereal as concentration of AYB and Cray fish increased. Igbabul *et al*. (2014) [16] 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.

Table II provides the functional properties of sweet potato and AYB and palm weevil 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 25% AYB inclusion (1.00g/ml) and the least was obtained from the control sample (0.86g/ml). Udensi and Eke (2000) [34] reported that higher bulk density is desirable due to greater ease of dispensability 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) [21].

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 25% AYB and 15% palm weevil while the lowest value was recorded in 100% sweet potato product. This agreed with the report of Igbabul *et al*. (2014) [16] 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) [19] indicated higher WAC and can increase volume of gruels during cooking. Swelling can change hydrodynamic attributes of food by influencing 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 3.80-5.20g/ml. The sample with 20% 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) [23] and Ajanaku *et al*. (2012) [4] reported that high water binding capacity improves the reconstitution ability. Mbofung *et al*. (2006) [26] also reported that the water absorption capacity of any flour depends on its starch content. The report of Menon *et al*. (2015) [27] showed that fortification of refined flour with legume based flour increased water absorption capacity. However, the lowest value obtained in sample with 25% AYB and 15% palm weevil inclusion could be due to interaction in starches of sweet potato and AYB which affected the water absorption capacity. Hoover and Sosulski (1986) [14] 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 0.50-1.40g/ml. The oil absorption capacity is important as it improves the mouth feel and retains the flavor (Igbabul *et al*., 2014) [16].

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 and 5% palm weevil. This indicates production of breakfast cereal with up to 15% AYB and 5% palm weevil is acceptable. The sample with 20% AYB inclusion received the least acceptance rating from the panel lists due to the colour and taste which could be as a result of its beany flavour.

Taste is an important parameter when evaluating sensory attribute of food. The product might be appealing and having high energy density but without good taste, such a product is likely to be unacceptable. Appearance is important attribute in food choice and acceptance. Aroma is an integral part of taste and general acceptance of the food before it is put in the mouth. It is therefore an important parameter when testing acceptability of formulated foods (Ibironke *et al*., 2012) [15]. According to Ibironke *et al*. (2012) [15]. In addition to a sufficient energy density, sensory qualities of complementary food formulations correspond to food preferences for infants and young children are of the highest importance. Sensory evaluation is easy in its principle but its implementation in the field is often complicated because of low literacy among the rural mothers' and the difficulty for them to understand some sensory testing methods. Roasting of the oilseed had an important improvement on the aroma of the formulations.

Conclusion

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

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