PRODUCTION AND EVALUATION OF BREAKFAST CEREALS FROM BLENDS OF ACHA AND FERMENTED SOYBEAN PASTE (OKARA) TO FOSTER FOOD SECURITY AND BIODIVERSITY

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Introduction

Breakfast cereal is defined as dry cereal eaten at breakfast (Thorndike and Bamhart, 1977) which has been processed into different forms by soaking, swelling, roasting, grinding, rolling or flaking, shredding or puffing of any cereal and is eaten as breakfast. Breakfast cereal products were originally sold as milled grains of wheat and oats that required further cooking in the home prior to consumption. In this century, due to efforts to reduce the amount of in-home preparation time, breakfast cereal technology has evolved from the simple procedure of milling grains for cereal products that require cooking to the manufacturing of highly sophisticated ready-to-eat products that are convenient and quickly prepared (Tribelhorn, 1991).

Acha (*Digitaria exilis*), is a cereal with very tiny seeds which poses difficulty in processing but is absolutely rich in amino acids (Vodouhè *et al*., 2012) and needs to be supplemented with a legume for higher nutrient-dense product. Acha (*Digitaria exilis*), a traditional cereal crop from West Africa, is popular because it is well adapted to local conditions and has good nutritional and culinary properties (Cruz, 2012). Acha, one of the oldest and richest cereals of West Africa, is unknown to many people and neglected by research and extension services. It has potential to improve nutrition, boost food security, foster rural development and support sustainable use of the land (Anon, 2012). The grains are used in porridge and couscous, for bread, and for beer. For a long time, research activities in the region have been oriented towards major cereals such as maize, rice and sorghum. The interest in fonio is relatively recent (Vodouhe e*t al*., 2012). Fonio is also regarded as a grain with medicinal and healing properties. It is recommended for lactating women and diabetic people and is often used in diets of sick people (Vodouhe e*t al*., 2012).

"Okara" is the residue obtained from ground soybean (*Glycine max*) after removing the water-extractable fraction used to produce tofu or soymilk. After soymilk extraction, much of that fat, fibre and protein remains in okara (O'Toole, 1999; Riaz, 2006). It contains most of the carbohydrates, some of the protein and a small portion of the oil from soybeans. It also contains minerals like calcium, iron, copper and zinc. Generally, okara contains about 50% dietary fibre, 25% protein, 10% lipid, 4% low molecular weight carbohydrates and 4% ash (Li *et al*., 2008). Okara has the potential to be used as a fermentation substrate for ethanol and methane production. It can be utilized for animal feed, fertilizer and pet food among others. Okara can also be used for food products either wet, dried or as a paste in food products ranging from meat to baked products. Overall, the use of okara in foods is not prevalent anywhere in the world. Little okara is being used in the food industry today, either as baked soy products (in Ontario), fresh or freeze-dried for shipping to a production facility. Given the cost and technology required to process okara and the relatively low value of the product, no large scale primary processing of okara is occurring commercially in Canada (Anon, 2005). Certain barriers exist in the use of okara in food- rapid degradation; high costs of drying; feasibility of freezing; alternative protein sources among others. Also, possible barriers to the use okara in food include process or use of okara as soon as it is produced, drying, develop entirely new market channels for premium priced products that add enough value to make okara economically food feasible and lastly, develop strategic alliances among companies (soy beverage producers, food processors, farmers) to reduce costs, hare expenditure and maximize value (Anon., 2005). Fermentation of okara could be sterilized and dried (Rashad *et al*., 2011) or lyophilized (Aoki *et al*., 2003).

Therefore, the major thrust of the study is to develop and evaluate nutritionally, microbiologically and organoleptically the nutrient-dense breakfast cereal produced by blending acha and fermented okara.

MATERIALS AND METHODS

The raw materials, acha grains, soybean seeds, sugar, and salt were procured. Acha grains were purchased from Nyanya market, Abuja whereas other ingredients were purchased from Ogige main market, Nsukka, Enugu state, Nigeria. Okara (fermented soybean residue) was produced from the processing of soybean into residue and acha flour was produced from acha grains. Functional and sensory (Ihekoronye and Ngoddy, 1985) properties, proximate (AOAC, 2010) and micronutrient composition (Kirk and Sawyer, 1998) as well as microbiological count (Harrigan and McCance, 1981) were determined using standard methods.

Processing of Acha Grains to Flour
The processing of Acha grains to flour is illustrated with the flowchart below (Figure 1).

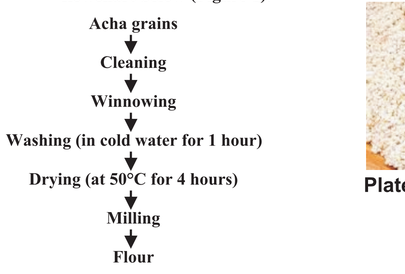

Plate 1: Diagram of Acha grains

Figure 1: Modified flowchart for processing of acha grains to flour.
Source: Ibrahim (2001)

Plate 2: Diagram of Soybean seeds

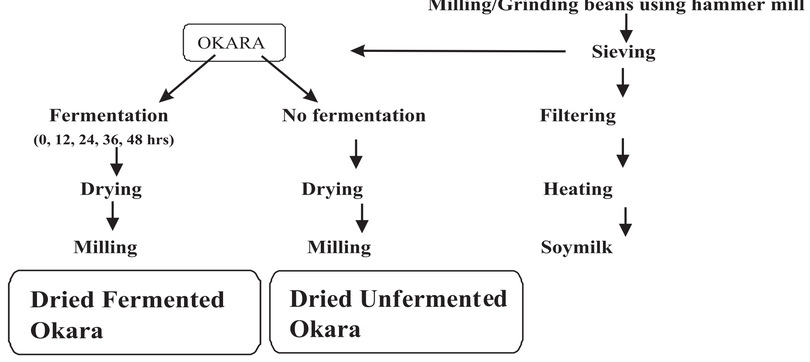

Figure 2: Flowchart for the production of okara

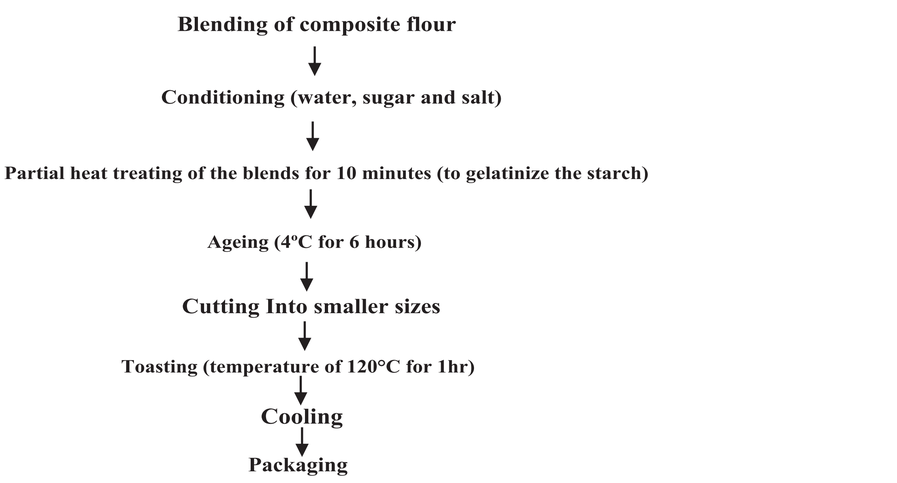

Figure3: Flow diagram for production of Breakfast Cereal.

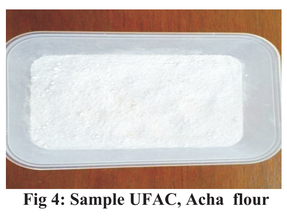

Fig 4: Sample UFAC, Acha flour

Fig 5: Sample UFOK, Unfermented okara flour

Fig 6: Sample FEOK, Fermented okara

Data Analysis

Mean values were subjected to analysis of variance (ANOVA) using Duncan's Multiple Range test (DMRT) and SPSS (Statistical Package for Social Science) version 20 computer was used. Significance was accepted at $p<0.05$ according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

Fermentation of okara increased the nutritional composition of the products. The mineral contents (calcium, iron, phosphorus and zinc) increased significantly ($p<0.05$) as a result of the increase in the ash content which is a measure of mineral levels in the products. Thus, it can be inferred that fermentation contributed to the higher levels of the mineral obtained. Fermentation increased the functional properties, proximate composition and particle size distribution of the products. The high nutrient density and low bulk of the flours could serve as good base ingredients to be used especially in complementary foods, for young children feeding breakfast cereals to enhance dietary diversification. Similar reports were observed by Mbaeyi-Nwaoha and Onweluzo (2013). The study showed that fermentation increased moisture (4.71 to 6.11%), crude fibre (36.62 to 46.18%), and carbohydrate (2.50 to 2.71%) contents of the flour samples, whereas there was a decrease in the fat (16.29 to 13.27%), ash (6.36 to 1.41%) and crude protein (33.53 to 30.32%) contents. The proximate composition of the selected products revealed that protein (17.86 to 21.30%), fat (0.83 to 2.21%), ash (2.02 to 2.21%) and crude fibre (4.16 to 4.24%) contents increased, whereas the moisture (11.99 to 7.62%) and carbohydrate (63.16 to 62.44%) content decreased. There were few microbial counts in the flour samples owing to the processing which was carried out in a clean environment, the oven drying and packaging. Fermentation also influenced the vitamin content. Vitamin A and Bcontent of the products decreased while the vitamin B and B contents increased. At the end of the research, the consumer's preferred sample 70:30 UFAC:UFOK TBFC and 70:30 UFAC:FEOK 4C TBFC in respect to colour, flavour, mouthfeel, texture and overall acceptability. This agreed to the findings of Chukwu and Abdul-kadir (2008) which showed that acha has good texture.

Control (100% acha TBFC) | 70:30 acha:0hr fermented okara | 60:40 acha:12hr fermented okara TBFC

Figure 7: Toasted breakfast cereals based on the acceptable ratios and fermentation

70:30 acha:24hr fermented okara TBFC | 50:50 acha:36hr fermented okara TBFC | 70:30 acha:48hr fermented okara TBFC

Figure 8: Toasted breakfast cereals based on the acceptable ratios and fermentation time

Key: TBFC- Toasted breakfast cereals

CONCLUSION AND RECOMMENDATION

Thus, breakfast cereal formulated from unfermented and fermented okara (0 to 48hrs fermentation) would serve as a good dietary nutrient-dense breakfast cereals for both children and adults. It is recommended that further study should be carried out on the health benefits of consuming acha and okara. It is also recommended that consumers should be introduced to acl and okara as they are both not popularly known, especially in the eastern part of Nigeria where this work was carried out. It is recommended that further study be carried out on the followi Nutritional composition of other fermented products; Shelf-stability studies on acha and okara (fermented and unfermented); Isolation and characterization of the fermenting microflora in the products; Feeding trials using bioassay among others.

Table 1: Micronutrient (vitamin And Mineral) Compositions of Toasted Breakfast Cereals Formulated From Blends of Acha and Fermented Okara

Products	Vitamin A	Vitamin B_1	Vitamin B_2	Vitamin B_3	Iron	Calcium	Phosphorus	Zinc
UFAC	$83.05^{a} \pm 0.04$	$10.04^{a} \pm 0.05$	$0.04^{b} \pm 0.00$	$0.53^{c} \pm 0.03$	$0.45^{c} \pm 0.06$	$1.97^{b} \pm 0.01$	$88.30^{c} \pm 0.42$	$0.07^{b} \pm .042$
UFAC:FEOK 1C	$34.55^{b} \pm 0.06$	$8.03^{b} \pm 0.18$	$0.40^{b} \pm 0.00$	$1.72^{b} \pm 0.03$	$0.65^{b} \pm 0.03$	$1.99^{b} \pm 0.01$	$192.80^{b} \pm 0.28$	$0.14^{b} \pm .021$
UFAC:FEOK 4C	$11.13^{c} \pm 0.04$	$8.00^{b} \pm 0.00$	$0.55^{a} \pm 0.00$	$2.85^{a} \pm 0.01$	$1.10^{a} \pm 0.00$	$3.23^{a} \pm 0.02$	$289.75^{a} \pm 1.06$	$0.29^{a} \pm .014$

Values are means ± standard deviation of duplicate determination. Values bearing the same superscripts within the same column are not significantly ($p<0.05$) different from each other.

Key: UFAC→100% acha (control); UFAC:FEOK 1C→70:30 acha:unfermented okara breakfast cereals; UFAC:FEOK 4C→70:30 acha:fermented okara breakfast cereals.

Table 2: Proximate composition of toasted breakfast cereals formulated from blends of acha, acha:unfermented and acha:fermented okara (48 hours)

Products (%)	Crude Protein (%)	Fat (%)	Ash (%)	Crude Fibre (%)	Moisture (%)	Carbohydrate
UFAC	$17.16^{c} \pm 0.07$	$0.70^{c} \pm 0.03$	$1.86^{a} \pm 0.04$	$3.55^{b} \pm 0.01$	$0.25^{b} \pm 0.03$	$66.48^{c} \pm 0.04$
UFAC:FEOK 1C	$17.86^{b} \pm 0.01$	$0.83^{b} \pm 0.04$	$2.02^{ab} \pm 0.11$	$4.16^{a} \pm 0.06$	$11.99^{a} \pm 0.05$	$63.16^{b} \pm 0.16$
UFAC:FEOK 4C	$21.30^{a} \pm 0.09$	$2.21^{a} \pm 0.02$	$2.21^{a} \pm 0.01$	$4.24^{a} \pm 0.03$	$7.62^{c} \pm 0.06$	$62.44^{a} \pm 0.22$

Values are mean ± standard deviation of duplicate readings. Values with the same superscripts within the same column are not significantly
$p>0.05$) different from each other.

Key: UFAC→100% acha (control); UFAC:FEOK 1C→ 70:30 acha-unfermented okara breakfast cereal; UFAC:FEOK 4C→70:30 acha-fermented okara breakfast cereal

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