PRODUCTION AND QUALITY EVALUATION OF MAIZE-GROUNDNUT-CRAYFISH-ACHA COMPLEMENTARY FOOD: A PRODUCT DEVELOPMENT APPROACH

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ABSTRACT

Complementary food was produced from acha, yellow maize, groundnut and crayfish. Blends of yellow maize and acha were prepared by substituting 0 to 50% yellow maize with 50 to100% acha, respectively. The most acceptable blend was selected for further study. Groundnut (0-25%) was incorporated into 100-75% of maize/acha mixture respectively. The most acceptable mixture of maize/acha/groundnut was blended with ground crayfish at varying proportions of 90 to 100% and 0 to 10% respectively. Results of the preliminary study showed that blend of yellow maize and acha at 40% and 60% respectively, and the incorporation of 5% groundnut flour to 95% acha/maize mixture were most acceptable. The addition of crayfish increased the protein (6.10 – 12.61%), fat (18 – 24.33%), ash (0.8-1.60%), however, decreased the moisture (4.23-6.72%) and carbohydrate (57-68.3%) contents of the prepared acha-maize-g/nut-crayfish composite gruels. The study showed that porridges prepared from blends of acha, yellow maize, groundnut and crayfish could be said to be nutritionally adequate to support growth and well being of children and the aged.

Keywords: Complementary food, quality evaluation, maize, acha, groundnut, crayfish

INTRODCTION

The ability of breast milk to meet requirements for macronutrients and micronutrients becomes limited with increasing age of the infant (Goulet *et al.*, 2008). Therefore, the timely introduction of complementary foods during infancy is necessary for both nutritional and developmental reasons, and to enable the transition from milk feeding to family foods (Ugwuona *et al.*, 2012). Complementary foods are defined as any solid or liquid foods with nutritional value other than breast milk, offered to breast-fed infants (Guigluani and Cesar, 2000). According to WHO (2004), the period of complementary feeding is a critical phase of the infant's developmental system with respect to nutrition and digestion, therefore, complementary foods should be of low bulk density, high nutrient content, microbiologically safe, of suitable consistency and affordable to the market (FAO/WHO, 1985). Guigluani and Cesar (2000) reviewed the nutrient density requirements, amount and frequency, hygiene, interfering factors and method of feeding of complementary foods.

In most developing countries, particularly in Africa and Asia, complementary foods are prepared locally from cereal grains which form part of the staple foods of the people (Ugwuona *et al.*, 2012). Maize, sorghum, millet, rice and acha which are commonly used in Nigeria (Ugwuona *et al.*, 2012) are of low nutrient density and this has attracted much attention of nutrition workers in several countries and international organizations (Mahgoub, 1999). Protein-energy malnutrition among children is the major health challenges in the developing countries (FAO, 2001; Ijarotimi and Keshinro, 2012) and this is as a result of inappropriate complementary feeding practices, low nutritional quality of traditional foods, high cost of quality protein-based foods (Ijarotimi and Keshinro, 2012), low income, poor sentimental conditions and lack of education (Cameron and Hofvender, 1983). In addition, few low-income countries have failed to adopt comprehensive complementary food policies and programmes which have been developed (Mahgoub, 1999). These programmes are based on local foods that are culturally acceptable, easily prepared and affordable by the majority (Mahgoub, 1999). Several works have been done to enhance the nutritional status of cereal grains using legumes which are known to be richer in protein, certain minerals and vitamins (Deshpande, 1992; Ijarotimi *et al*., 2012; Brou *et al*., 2013; Agu *et al*., 2012; Ayo *et al*., 2011; Ayo *et al*., 2010; Ayo *et al*., 2009, Ayo *et al*., 2008, Ayo and Olawale 2003). The use of cereal-legume based food has long been advocated as alternative protein and energy source for infant and young children (Mensah and Tomkins, 2003). It is evident that when cereals and legumes are judiciously selected and combined, a desirable pattern of essential amino acids of high biological value is obtained (Nnam, 2001). Cereals are rich in sulphur containing amino acids such as methionine and cystine while legumes are rich in essential amino acids such as lysine (Ijarotimi *et al*., 2012). However, proteins of highest biological values and best digestibility are found in foods of animal origin such as fish, meat etc. (Guigluani and Cesar, 2000). According to Ajanaku *et al*. (2013), crayfish meat is more easily digested than other types of meat due to its short muscle fibers. Crayfish included in the diet may offer some of the health benefits ascribed to seafood in general, including protection against cancer, asthma and heart diseases (Heli and Bradly, 2013). This present work is aimed at producing a nutrient dense complementary food from acha, yellow maize, groundnut and crayfish.

MATERIAL AND METHODS

Materials: Acha (*Digiteria excil*), yellow maize (*Zea mays*), groundnut (*Arachis hypogea*), crayfish (*Paranephrops planifrons*) used for the research was purchased from Bauchi Metroplis Market. The maize and acha were processed into flour after cleaning, sorting, washing, drying ($50^{o}C$, APV Cabinet dryer), cooling (29 – $32^{o}C$), milling and sieving (0.04 mm aperture), while the groundnut was cleaned, toasted and milled (attrition mill) into paste.

Preliminary Investigation**:** Yellow maize flour was substituted (0 - 50%) for acha flour to produce maize - acha composite flour used to prepare gruel and the most acceptable sample was determined sensorilly. The groundnut paste was complemented (0 - 25%) with the most acceptable maize - acha composite flour for maize-groundnut-acha blend which was also subjected to sensory evaluation to determine the most acceptable and used to develop the final product.

Sample Preparation**:** Ground crayfish was added (0 - 10%) into the maize-groundnut-acha composite flour to produce maize-groundnut-crayfish-acha composite flour which was used to prepare the gruel. Table 1 show the recipe used to develop the complementary food. There are three formulations I, II and III in sequence comprising of acha and maize; acha, maize and groundnut; and acha, maize, groundnut and crayfish, respectively (Figure 1).

Sample analyses: Proximate (protein, fat, ash, carbohydrate and moisture) and sensory (flavor, texture, color, taste and general acceptability) analyses were determined using the methods described by AOAC (2000) and nine point Hedonic scale described by Ihekoronye and Ngoddy (1985), respectively.

Statistical Analysis**:** Statistical analyses were carried out using the SPSS version 16.0. The means of the samples were determined. The analysis of variance (ANOVA) was performed to determine significant differences at $P<0.05$ between means of the samples while the means were separated using the Duncan multiple range test.

Table 1: Recipe Preparation

S/No.		Recipe I		Recipe II	Recipe III	
		Acha	Maize	Acha/Maize/G/nut	Acha/Maize/G.nut/C. fish	
1	100	0	100	0	100	0
2		90	10	95	5	98
	2					

3	4	80	20	90	10	96
4	6	70	30	85	15	94
5	8	60	40	80	20	92
6	50	50	75	25	90	10

G.nut = Groundnut, C. fish=Crayfish

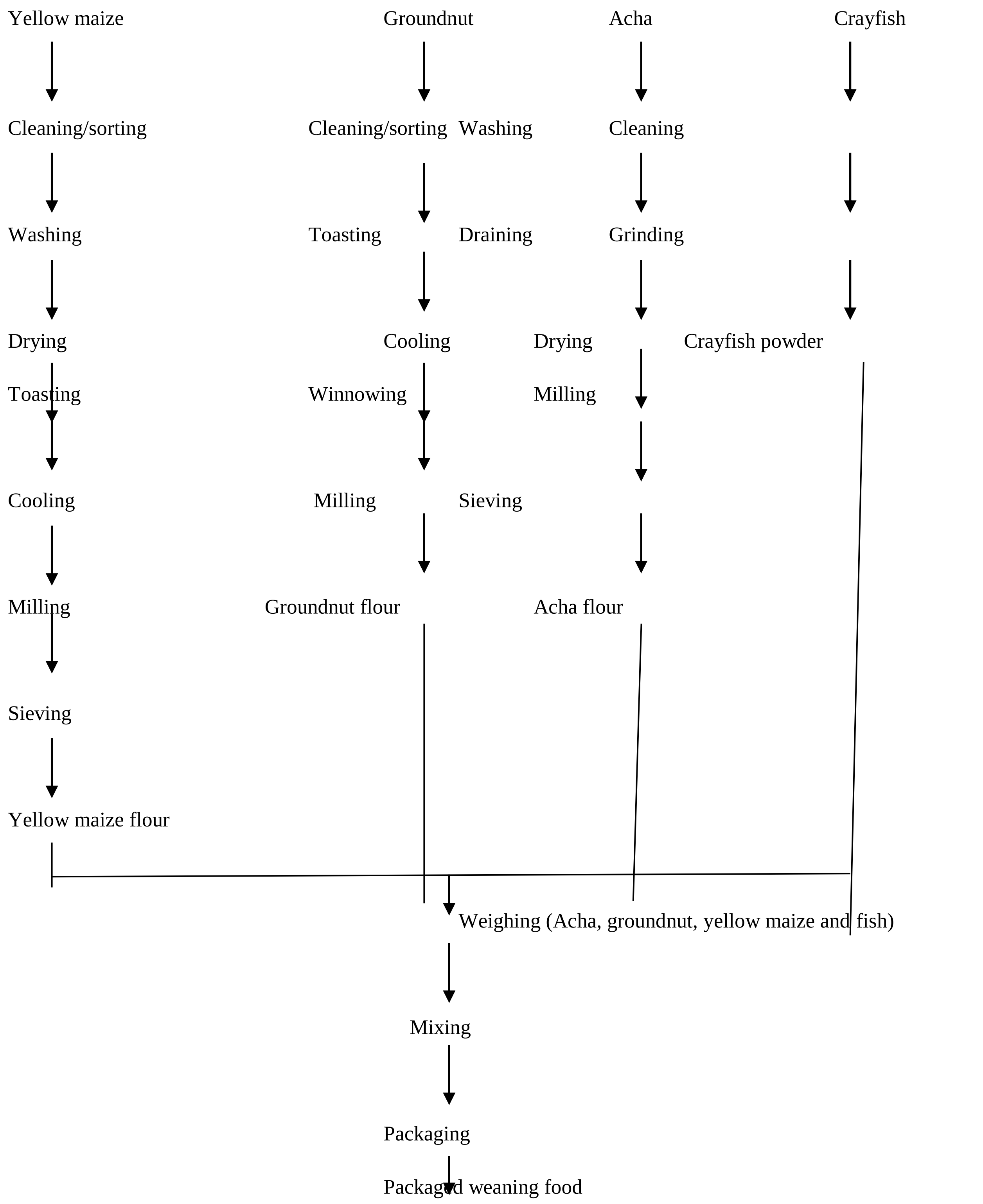

Figure 1: Flow chart for complementary food production

***Preliminary Observation*:** The addition of maize for acha in acha-based complementary food was most acceptable at 40% of maize (Table 2), while the added groundnut paste was most acceptable at 5% of added groundnut to acha-maize composite flour (Table 3).

RESULTS AND DISCUSSION

Table 2: Sensory Score for Acha-Maize Blend

Sample Code	Acha (G)	Maize (G)	Texture	Flavour	Taste	Colour	General Acceptability
BC	100	0	3.4^{f}	3.1^{f}	3.2^{f}	2.4^{f}	3.2^{e}
AB	90	10	3.8^{e}	4.3^{e}	4.4^{e}	2.9^{e}	4.1^{c}
AC	80	20	4.6^{d}	5.1^{d}	4.8^{d}	3.2^{d}	4.4^{c}
BA	70	30	5.0^{c}	5.4^{c}	5.2^{c}	4.6^{c}	5.2^{b}
BB	60	40	6.3^{a}	7.8^{a}	7.2^{a}	6.9^{a}	6.6^{a}
AA	50	50	5.9^{b}	7.2^{b}	6.6^{b}	5.8^{b}	6.5^{a}

*Values are means of twenty scores. Values followed by different superscript in column are significantly different ($p \leq 0.05$) from one another.

Table 3: Sensory Score for Acha-Maize-Groundnut Blend

Samples	Acha maize	Groundnut	Texture	Taste	Colour	Flavour	General Acceptability
BC	100	0	8.24^{a}	7.89^{a}	8.01^{a}	8.51^{a}	7.80^{a}
AB	95	5	8.31^{a}	7.68^{a}	8.21^{a}	8.56^{a}	7.85^{a}
AC	90	10	6.44^{b}	6.24^{b}	5.75^{b}	6.36^{bc}	6.65^{b}
BA	85	15	6.21^{b}	4.66^{c}	4.10^{d}	6.11^{c}	4.75^{c}
BB	80	20	5.72^{cd}	3.72^{d}	4.95^{c}	5.72^{d}	4.65^{c}
AA	75	25	5.33^{d}	3.79^{d}	4.20^{d}	5.33^{e}	3.70^{d}

*Values are means of twenty scores. Values followed by different superscript in column are significantly different ($p \leq 0.05$) from one another.

Effect of added Crayfish on the Sensory Quality

The means scores for flavour, taste and general acceptability increased respectively from 7.05 to 7.65, 7.15 to 7.90 and 6.85 to 8.40 with increasing addition of crayfish (0-4%) and then decreased from 6.75 to 6.35, 6.55 to 6.00 and 6.75 to 5.95 with increasing addition (6-10%), respectively. The increase could be due to the inherent flavour which at higher concentration is not acceptable. Means scores for texture, and colour decreased from 7.40 to 5.80 and 7.6 to 6.80, respectively with increase in percentage of added crayfish (0-10%). The decrease could be due to the increase in the particle size and colour impacted by the added crayfish. The sample with added 4% cray fish was most preferred and acceptable.

Table 4: Sensory Score of Weaning Food

Code	Material AMG	Fish	Flavour	Texture	Colour	Taste	General Acceptability
BC	100	0	7.03^a	7.40^a	7.60^a	7.15^a	6.85^a
AB	98	2	7.15^a	7.25^a	7.55^a	7.65^b	7.75^b
AC	96	4	7.65^b	6.95^b	7.10^b	7.90^b	8.45^c
BA	94	6	6.75^b	6.75^b	6.95^b	6.55^c	6.75^c
BB	92	8	6.45^b	6.25^c	6.80^b	6.30^c	6.45^d
AA	90	10	6.35^b	5.80^d	6.80^b	6.00^c	5.95^e

Values are means of twenty scores. Values followed by different superscript in column are significantly different ($p \leq 0.05$).

**AMG- Acha-maize-groundnut composite flour

Effect of Added Crayfish on the Proximate Composition of Acha-Maize-Groundnut-Crayfish Blend

The proximate composition of the prepared complementary food is shown in Table 5. There was significant difference ($p \leq 0.05$) among the samples in protein content. The protein content increased with an increasing level of crayfish in the formulations, with samples containing 0% and 10% fish concentration having least and highest values respectively. This could be due to increasing levels of amino acids of higher biological value present in crayfish. Guigluani and Cesar (2000) reported that proteins of highest biological values and best digestibility are found in foods of animal origin. The samples also showed significant difference ($p \leq 0.05$) in fat (18 -24.35%) and ash (0.8 - 1.63%) contents. An increase in crayfish in the formulations increased the fat and ash contents significantly ($p \leq 0.05$) and this corroborates earlier work of Ajanaku *et al.* (2013). Several workers reported that crayfish is robust for consumption by virtue of the nourishment it offers in terms of total fat, cholesterol, sodium as well as protein (McDonald *et al*., 2000; Ojewola and Annah, 2006; Ravichandra *et al*., 2009). Ajanaku *et al.* (2013) further reported that crayfish offers a healthy supply of vitamin D and A, calcium, potassium, copper and zinc. The moisture content of the samples ranged from 4.23 to 6.72%. These values were low enough to minimize the activities of microorganisms and reduce biochemical reactions within the formulated samples. The low moisture content of the samples could be due to the drying (50^0C) that the formulations were subjected to. Iombor *et al*. (2009) reported same for complementary formulations prepared from millet, soybeans and crayfish. This characteristic indicates that the resulted flours could be stored safely for long time without the risk of microbial growth (Brou *et al*., 2013). The carbohydrate contents of the samples varied significantly ($p \leq 0.05$). The carbohydrate content decreased significantly ($p \leq 0.05$) with increasing crayfish concentration with 100:0% MGA:crayfish sample having the highest value, which could probably be due to high concentration of carbohydrate in yellow maize and acha (Ugwuona *et al*., 2012).

Table 5: Proximate Composition of the Maize-Groundnut-Crayfish-Acha Composite Complementary Food

Sample M-G-A	C/Fish	Protein	Fat	Ash	Moisture	Carbohydrate
100	0	6.10 ±0.42^{d}	18.00 ±0.96^{c}	0.80 ±0.00^{b}	6.72± 0.03^{a}	68.30 ±0.28^{a}
98	2	7.81 ±0.28^{cd}	18.50 ±0.76^{a}	1.34 ±0.03^{b}	6.44 ±0.03^{b}	65.90 ±0.28^{a}
96	4	9.10 ±0.28^{bcd}	18.90 ±0.79^{a}	2.04 ±0.06^{b}	5.37 ±0.07^{c}	64.64 ±0.28^{ab}
94	6	9.74 ±0.74^{abc}	19.30 ±0.16^{a}	2.20 ±0.00^{b}	5.06 ±0.03^{d}	64.04 ±0.28^{ab}
92	8	11.20 ±2.46^{ab}	19.0 ±0.03^{a}	2.76 ±0.28^{ab}	4.76 ±0.03^{e}	61.94 ±0.03^{b}
90	10	12.61 ±1.82^{a}	19.95 ±0.03^{d}	2.98 ±0.32^{a}	4.23 ±0.03^{f}	60.03 ±0.28^{b}

Values are means and standard deviation of triplicate scores. Values followed by different superscript in column are significantly different ($p \leq 0.05$) from one another.

** M-G-A: Maize-Groundnut-Acha Composite flour*

CONCLUSION

This study showed that acha, yellow maize, groundnut and crayfish could be used to produce excellent complementary food. The most preferred sample composed of 51.84, 34.56, 9.6 and 4% of acha, yellow maize, groundnut and crayfish respectively. This sample had protein, fat, ash, carbohydrate and moisture contents of 9.10, 18.9, 2.04, 64.64 and 5.37%, respectively. Use of locally available materials could be exploited in the development of complementary foods in order to improve the nutrition security of the population.

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