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Production and Evaluation of *Ogi* Produced from Fermented Maize and Tropical Almond Nut flour (Terminalia catappa)

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Introduction

Malnutrition is one of the major concerns to most countries in Africa, particularly in developing countries where there are shortages in nutritious foods for the young ones. The major nutritional deficiency known is as a result of protein malnutrition in humans. Although animal proteins are superior to plant proteins, their ratio in diets, especially in developing countries, is not likely to change in the immediate future due to inadequate supply and high unit cost (Lopez-Bellido and Fuentes, 1986).

Also in children, an adequate nutrition within the first 1000 days has been reported to be essential for their healthy growth and development (Motuma et al. 2016). Illness such as common childhood diarrhea, global malnutrition are consequences of poor nutrition (Onyango et al. 2014). Others include; stunting (a state of an adult being shorter than potential height), and micronutrient deficiencies (Motuma et al. 2016). Therefore, in order to avert the challenges of good nutrition faced by the children of 6–23 months in most developing countries, the introduction of protein and energy-rich complementary foods to the children is very critical at this stage (Udoh and Amodu 2016).

Over a very long period of time in the developing countries, cereal based food often fail to meet the nutritional need of younger children due to poor/low nutrient contents (Ijarotimi and Keshinro 2012a). Such cereals like sorghum, rice and maize constituted about 85% of total global cereals utilized in preparation of local complementary foods (Sofi et al. 2009) but with implications of having low protein contents (Tufa et al. 2016).

The nutritional problems arising from wide utilization of common maize, sorghum and guinea corn with poor/ low protein contents, limiting lysine and tryptophan as well as expensive purchasing cost of high protein sources (Ikujenlola and Ogunba 2018) had paved way for the utilization of almond seeds and Maize. Therefore, there is need to explore the nutritional qualities of these crops in the production of complementary food for children due to their nutrient composition and accessibility to many low-income homes. Hence this study. In this study, almond nut flour was used with maize ogi flour to make blends of infant foods.

Tropical almond *(Terminalia catappa* Linn) is known to be an underutilized crop which is classified into a group of nuts that has a single edible kernel enclosed in a hard shell (Othmer, 1976). The almond tree also called Tropical almond, belongs to the family *combretaceae* distributed in the tropics including Nigeria (Adesina, 2013). In southern Nigeria, the rural dwellers who know the importance of protein in diets use the almond kernel to enrich and fortify their locally made complimentary foods, which may be low in protein. They are tasty and are cholesterol-free and rich in important nutrients including vegetable protein, fibre and unsaturated fatty acids (Rajaram and Sabate, 2006). Almond is a major tree nut which may be consumed raw or cooked, blanched or unblanched, combined and/or mixed with other nuts. It can also be incorporated into other products (Socias i Company *et al.*, 2008). Almond seeds ranked number two after cashew nuts in tree nut (Shakerardekani et al. 2013). Studies had shown that besides high nutritive values, almonds provide varied healthful effects like cardiometabolic, modulation of blood glucose fluctuations, reduction in postprandial plasma lipids and free radicals scavengers (Palacios et al. 2020).

Ogi is a Yoruba name but in most state of Nigeria, it is referred to maize pap. *Ogi* is widely consumed with or without accompaniment, as weaning, breakfast and dinner food. Due to its soft texture, 'ogi' is used to nurture the sick and the convalescent to good health. It is a popular food among thee lderly and a convenient food for categories of people including nursing mothers (Odunfa and Adeyele; 1987; Adeyemi, 1988).

Although, significant information abound globally on the use of composite flour blends from different cereal and legume crops but there exist scanty information on the utilization of almond seed and Maize ogi blends as complementary food for children. Hence, the aim of this study was to formulate and assess the nutritional quality of almond seed, maize ogi flour blends as ingredients for complementary infant food [1-11].

Materials and Methods

Fresh Almond (*Terminalia catappa. L)* fruits were gotten from the almond trees in Obafemi Awolowo University, Nigeria. The maize used for the production of ogi was purchased from the University's Agric farm. The two raw materials used identified at the Botany Department of the same University. The equipment, cabinet dryer and some reagents were obtained from the Department of Food Science and Technology, Obafemi Awolowo University, Ile-Ife.

Preparation of Maize- *Ogi* (fermentation of Maize)

Maize- *Ogi* was prepared using the wet-milling process described by Adeola et al (2012). Two hundred grams of the cleaned maize grains samples were soaked in each plastic bucket containing 300 ml of distilled water and steeped for 72 h at room temperature (28 ± 2 °C). The steep water was discarded by decantation and the steeped grains were wet-milled using a Kenwood chef grinder. The milled slurry was then sieved through a fine mesh sieve.

The over tails were further washed off with 700 ml of distilled water. The slurry were allowed to stand and further fermented for 48 h by allowing to stand and sediment at room temperature (Akinrele, 1970). The souring water was decanted from the sediments and the Ogi slurry obtained was collected into a muslin cloth and hand squeezed to remove excess water leaving behind the semi-wet ogi samples which were dried at 60°C for 12 h to obtain dry *ogi* powder samples as shown in Figure 1. The dry form of maize *ogi* was further dry milled into a fine powdery form due to lump formation that occurred during the drying of the slurry.

Preparation of Almond Flour

Figure 2 describes the preparation of Almond flour from tropical almond seed. 50g of nuts was weighed and soaked in tap water (1:6 w/v) at room temperature (25 ± 2 °C) for 12 hrs as described by Kaur and Kapoor (1990) though with slight modification. The soaked nuts was washed twice with ordinary water followed by rinsing with distilled water and then dried in an oven at drying temperatures of 70 °C to a constant weight. The dried sample was milled and stored in an airtight glass container for further analysis.

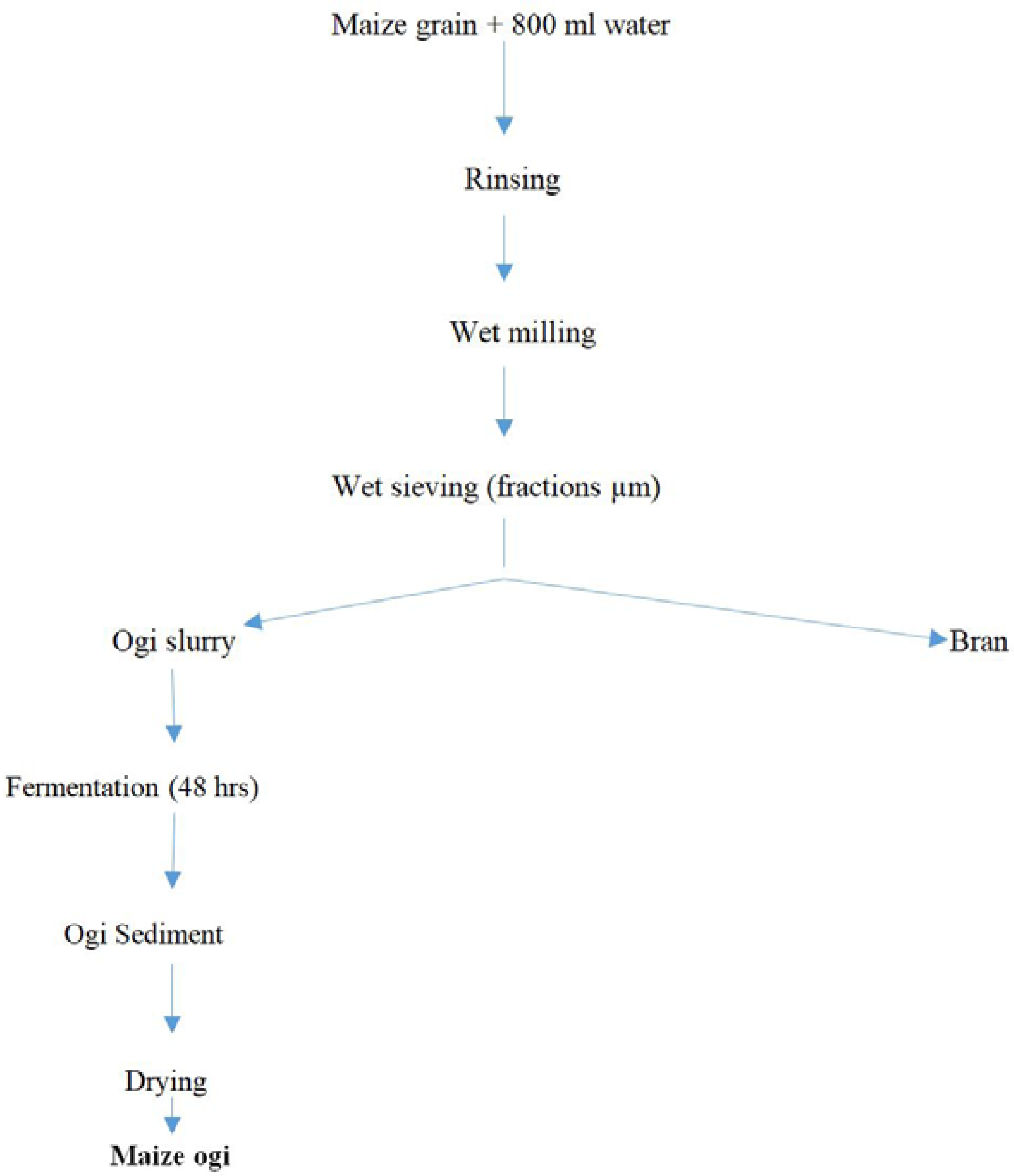

Figure 1: Flow chart for the laboratory preparation of maize ogi
Source: Adeola et.al.,, 2012

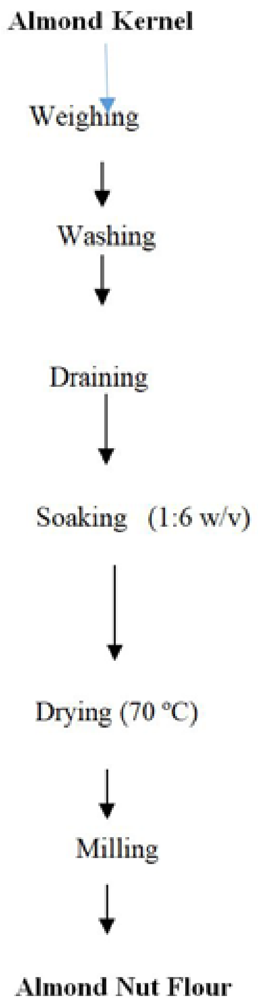

Figure 2: Flow chart for the production of Almond Flour

Makinde and Oladunni (2016) with slight modifications

Supplementation of maize-ogi with carrot pulp

The maize ogi flour and almond flour were mixed together in the ratio 95:5; 90:10; 85:15.

Sample	maize ogi flour	almond flour
100%	100%	0
95%:	95%	5
90%:	90	10
85%:	85	15

Table 1: Blends of maize flour and almond flour

Proximate composition analysis

The proximate analysis (moisture, protein, fat, ash and crude fiber) of the diets was determined according to the methods of Association of Official Analytical Chemists (AOAC 2005) while the carbohydrate content was calculated by difference. The crude protein and fat contents were obtained by micro-Kjedahl (N × 6.25) and soxhlet procedures, respectively.

Determination of Functional Properties of the Flour Blends

Bulk Density: The bulk density of the flour samples were determined by weighing 50g of the sample into 100ml graduated cylinder, then, gently tapping the bottom several times on a laboratory bench, until no further diminution of the sample level. After this, the final volume is expressed as g/ml (Nwosu, 2011).

$$Bulk\ density = \frac{weight\ of\ sample\ (g)}{volume\ of\ sample\ after\ tapping\ (ml)}$$

Water / Oil Absorption Capacity: The AOAC, 2006 method was used, from each sample, one gram was weighed into a conical graduated flask and 10ml of water or oil was added to the weighed sample. A warring whirl was used to mix the sample for 30 seconds. The sample was allowed to stand at room temperature for 30 minutes and then transferred to a graduated centrifuged tube and centrifuged at 5000rpm for 30 minutes. After wards, the mixed sample was transferred from the graduated tube into a 10ml measuring cylinder to know the volume of the free water or oil. The absorption capacity was expressed as grams of oil or water absorbed per gram of sample.

$$Water\ absorption\ capacity\ (\%) = \left(\frac{W_3 - W_2}{W_1}\right) \times 100$$

$W_3 = weight\ of\ test\ tube\ + sample\ after\ centrifuging\ and\ decanting$

$W_2 = weight\ of\ test\ tube + sample\ before\ water\ addition\ and\ centrifugin$

$W_1 = weight\ of\ sample$

$$Oil\ absorption\ capacity\ (\%) = \left(\frac{W_3 - W_2}{W_1}\right) \times 100$$

$W_3 = weight\ of\ test\ tube\ + sample\ after\ centrifuging\ and\ decanting$

$W_2 = weight\ of\ test\ tube + sample\ before\ water\ addition\ and\ centrifuging$

$W_1 = weight\ of\ sample$

Swelling capacity and solubility index

The method of Sathe and Salunkhe (1981) with slight modification was used to determine the swelling power and solubility index of all samples at temperatures of 70 °C, 80 °C and 90 °C. A previously tarred 50 ml centrifuge tube containing 40 ml of 1 % flour suspension (w/v) was shaken slowly and the three temperatures, 70 °C, 80 °C and 90 °C was maintained in a boiling water bath. The suspension was centrifuged at 3500 x g for 20 mins and the swollen granules was weighed after the supernatant was decanted.

Results and Discussion

Proximate composition of formulated flour blends

The proximate composition is the basis for establishing the nutritional value and consumers' overall acceptance of the product and also important in determining the quality of food raw materials and often (Mashood and Rizwana 2010).

Therefore, the proximate compositions of maize-ogi and almond flours blends are presented in Table 1. The blends were all dried to a minimum level (8–10%) which werefound in the range of the FAO recommended level (< 15%) for most dried food samples (National Research Council, NRC 2009). The other proximate compositions were calculated based on the dry weights of the blends.

It is shown from the result obtained that there is an increase in the parameter of the blends as the level of the almond nnut flour increased, while the carbohydrate content decreased with an increase in the level of substitution of the product. In terms of protein content of the sample, (85:15) had a significantly ($p<0.05$) high protein content of 22.07% while the same 100% maize ogi sample had the lowest protein content of 2.18%. The significant improvement of the protein content of the sample is highly expected since almond flour is rich source of protein. The total carbohydrate was significantly higher ($p<0.05$) as sample 100% maize ogi (84.33%) compared to other samples, this may be due to the fact that it's 100% maize ogi.

The ash content ranged from 1.19% to 1.24%. These values are higher than the values reported from the production of legumes fortified weaning food (Egounlety, 2002) but similar to that reported results of Kanu *et al.* (2009) from production and evaluation of breakfast cereal-based porridge mixed with sesame and pigeon peas for adults. The ash contents were significantly present ($p<0.05$) in all the samples. Sample 85:15 had the highest content of 1.24%, followed by 90:10 with a value of 1.22% while 100% maize ogi sample had 0.45% and 95:5 sample had the ash content value of 1.19%. This may be due to high organic content of the almond nut flour, since ash content represent the total mineral content in food and thus serve as variable tools for nutritional evaluation. The moisture content of the sample ranges from 9.28 to 12.37% which is not above acceptable value for flour and this came about as a result of dehydration processes involved and this would enhance the shelf stability of the product.

Both (95:5) and (85:15) were significantly present in varying amount of lipids of 4.34 and 4.77%, respectively. These findings were in agreement with the work of (Kolapo and Sanni, 2005). The carbohydrate content decreased with increase proportion of the almond nut flour supporting the claims of (Jimoh and Olatidoye, 2009; Akpapunam, *et al.*, 1997). There was an increase in the values of crude fibre as the inclusion of almond nut flour to maize ogi increased. Crude fibre of the blends ranged between 7.48 % and 10.68%.

Table 2: Proximate composition of flour produced from blend of maize ogi and almond nut flour

Samples	Carbohydrate	Moisture	Protein (%)	Lipids (%)	Ash (%)	fibre (%)
100:0	84.33±0.11a	9.28 ±0.08b	2.18±0.06c	0.98±0.07c	0.95±0.01c	2.28c
95:5	56.55±0.22d	10.10±0.05c	20.34±0.05b	4.34±0.02b	1.19±0.02c	7.48b
90:10	53.33±0.27c	10.50±0.03ab	21.76±0.04a	4.50±0.02a	1.22±0.01b	8.69b
85:15	48.84±0.32b	12.37±0.10a	22.07±0.01a	4.77±0.01b	1.27±0.01a	10.68a

Mean values with different letter within the same column are significantly different ($p>0.05$) *100% maize ogi; 85:15- 85 % ogi + 15% almond nut flour; 90:10- 90% ogi + 10% almond nut flour; 95:5- 95% ogi + 5 % almond nut flour*

Functional properties: The bulk density of the sample was notice to have almost the same value of 0.63% except sample 85:15 that had (0.67%). Bulk density gives an indication of the relative volume of packaging material required. Generally, higher bulk density is desirable for the greater ease of dispersibility and reduction of paste thickness which is an important factor in convalescent child feeding (Padmashree *et al*., 1987). The bulk density is related to particle size reduction which is evidence on the milling of the product.

Also bulk density is an indication of porosity of a product which influence packaging design and could be used to determine the type of packaging material required (Iwe and Onadipe, 2001). There was an increase in the level of water absorption capacity. Sample 85:15 had high water absorption of capacity (7.39%), 95:5 (7.10%), 90:10 (7.28%). As the inclusion of the almond nut increased, the water absorption capacity of the blends increased. The increase in water absorption capacity implies high digestibility of the starch. Its characteristics represent the ability of the product to associate with water under condition where it is limiting in order to improve handling (Giami, 1993). Water binding capacity is a useful indication of whether flour or isolates can be incorporated into aqueous food formulations especially those involving dough handling (Okerie and Bello, 1988; Giami, 1993).

Samples were significant different ($p<0.05$) in swelling capacity sample. 85:15 had the high value of swelling capacity. These properties agreed with the report that proteinous seeds such as horse eye bean flour is a good thickener that has been earlier reported by Adebowale *et al*. (2005). Hence, almond nut flour is a good thickener.

The swelling power (SP) capacity is an important factor used to determine the amount of water that food samples would absorb as well as the degree of swelling within a given time (Ijarotimi and Keshinro 2012a). The SP ranged from 7.23 to 7.93 at 70 °C, 8.28 to 8.45 at 80 °C and 8.44 to 8.54 at 90 °C with no significant difference ($p > 0.05$) between the control and maize ogi- almond flour blends, whereas, 85:15 and 95:5 blends have the highest and least SP, respectively. This implied that the 85:15 with the highest SP when compared to the other complementary diets would produce a thick viscous gruel [8-13].

Table 3: Functional properties of blends of fermented maize ogi and almond nut flour

Parameters	WAC	Bulk density	S.C 70 °C	S.C 80 °C	S.C 90 °C
100%	2.08±0.02	0.54±0.01	4.08±0.01	4.78±0.01	4.92±0.01
85: 15	7.39±0.01	0.67±0.01	7.93±0.01	8.45±0.01	8.54±0.01
90:10	7.28±0.01	0.63±0.01	7.71±0.01	8.34±0.01	8.49±0.01
95: 5	7.10±0.02	0.61±0.01	7.23±0.01	8.28±0.01	8.44±0.01

100% maize ogi; 85:15- 85 % ogi + 15% almond nut flour; 90:10- 90% ogi + 10% almond nut flour; 95:5- 95% ogi + 5 % almond nut flour.

WAC: Water absorption capacity; S.C- Swelling capacity

Table 4: Mean sensory scores of Ogi from maize-ogi and almond nut flour blends

Parameter	Colour	Mouthfeel	Aroma	Taste	Acceptability
100%	2.7a	2.9a	2.8a	2.9a	3.3a
95: 5	2.4b	2.7a	2.5b	2.6b	2.8b
90:10	2.2c	2.3b	2.3b	2.4c	2.5c
85:15	2.0d	2.2c	2.1c	2.3d	2.3d

Mean with different letters are statistically different ($p = 0.05$) according to Duncan's multiple range test

100% maize ogi; 85:15- 85 % ogi + 15% almond nut flour; 90:10- 90% ogi + 10% almond nut flour; 95:5- 95% ogi + 5 % almond nut flour

Sensory evaluation: Table 4 presents the sensory scores associated with porridges made from the blends and the control. The mean sensory scores of the control porridge and those of the blends differed significantly (<0.05) in colour, taste, aroma, mouthfeel and general acceptability. The appearance of the porridges from sample blends was moderately liked by mothers. However, the control was liked moderately. Colour is an important sensory attribute of any food because of its influence on acceptability. It also shows the suitable raw material used for the preparation, provides information about the formation and quality of the product. The taste, flavour, texture and general acceptability all ranged between like slightly and dislike moderately. However, the porridges from all the blends differed significantly (<0.05) with the control. Sample blend (95:5) was most generally accepted among the samples. The variation in the proportion of the almond nut flour resulted in the difference (>0.05) in the sensory attributes measured. The control had more acceptability in all the sensory attributes studied. This could be because the familiarity in taste, flavour and colour. This food formulation will provide the required protein and energy level that will provide basic nutrients for the day's work and eventually reduce the problem of protein malnutrition in rural areas (Bilsnorough, 2016). In conclusion, it was observed that supplementation beyond 10 % almond nut affected the product palability.

Conclusion

The study revealed that the complementary food formulated from almond seed, maize compared favorably with weaning food (*ogi*) to meet the nutritional needs of children above six months of age. Thus, it could be inferred that the functional properties of these diets would lead to production of appropriate co qualities of the maize ogi-almond nut blends therefore, encouraged its utilization in the global preparation of future compleimentary foods for young children. Also. Its proximate composition inferred that the blends are rich in minerals (from the value obtained from ash content), protein which also prevents protein energy malnutrition. Hence, the inclusion of almond nut flour can be up to 10%.

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