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Quality Evaluation of *Ogi* from Acha (*Digitaria exilis*), Soybean (*Glycine max*) and Carrot (*Daucus carota* L.) Composite Flour

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Ogi was produced from composite flour of fermented Acha, roasted Soybean and Carrot. The raw materials were blended in varying proportions. Proximate composition, functional properties and sensory characteristics of the formulated *Ogi* samples were evaluated. The results of the proximate composition showed a significant increase in moisture (5.36% to 9.94%), protein (3.94% to 16.98%), fat (1.89% to 10.23%), crude fiber (1.80% to 3.12%) and ash (0.35% to 0.99%); while a decrease was observed in carbohydrate (86.66% to 58.74%) with increase in supplementation with roasted Soybean flour and constant addition of carrot flour along with the milk flavor. The functional properties showed significant increase in foam capacity (5.99% to 7.97%), Swelling index (2.46 v/v to 3.08 v/v) and Least gelation capacity (8.10% to 14.0%); while a decrease was observed in bulk density (0.84 g/mL to 0.72 g/mL), water absorption capacity (1.40% to 1.10%) and foaming stability (3.39% to 2.79%). Sensory characteristics result revealed that there was no significant difference

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(p<0.05) in aroma and overall acceptability with increasing incorporation of roasted Soybean flour and constant addition of Carrot flour with milk flavor. Aside the control sample (containing 100% fermented Acha flour) there was preference for Sample C (70% fermented Acha flour: 15% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor) and Sample D (60% fermented Acha flour: 25% roasted Soybean flour: 10% `Carrot flour: 5% Milk flavor) in terms of color (6.65 and 6.25), taste (6.95 and 6.35), aroma (6.45 and 6.30), mouth feel (6.10 and 6.35) and overall acceptability (6.50 and 6.50) respectively, among the blend formulations. Supplementation of fermented Acha with roasted Soybean and Carrot flour considerably increased the protein and fat contents of the blend; hence Soybean should be used for supplementation of cereal based product in order to improve their nutritional composition.

Keywords: Carrot flour; fermented Acha flour; functional properties; Ogi; proximate composition; roasted soybean flour; sensory characteristics.

1. INTRODUCTION

Ogi is a smooth, free flowing thin porridge obtained from wet-milled, fermented cereal grain and it serves as a major weaning food for infants, a breakfast meal for both children and adults and sometimes it is chosen as food for the sick [1,2]. It is also known as '*Eko*', '*Agidi*', '*Akamu*', '*Koko*' in Nigeria [3]. *Ogi* can be consumed in itself as a whole or can be consumed along with other food products such as cooked beans, fried bean cake commonly called *Akara*, *Moi-moi*, bread, fried plantain and fried yam. Other enriching ingredients like milk, tea, sugar and honey can be added to *Ogi* to serve as an integral part of the meal in order to enhance its taste and nutrients. The major disadvantage of sole cereal gruel is that the starchy nature of these foods makes them bind so much water, thus yielding a bulky gruel with decreased nutrient content [4]. In addition, the high moisture content of *Ogi* slurry predisposes it to spoilage; however the reduction in moisture content through drying can enhance the shelf life, provide convenience and allow for easy reconstitution of the *Ogi* powder [5]. The amino acid compositions of the proteins in the cereal grains are generally low in the contents of lysine [6]; while the protein in legumes have a well-recognized deficiency of the essential Sulphur-bearing amino acids namely, methionine and cysteine, but are comparatively rich in lysine [7]. Protein malnutrition is rampant in both developing and underdeveloped countries. Since, animal's protein is beyond the reach of this group; their primary protein supply comes from plant based products [8]. Therefore, blending a cereal with a legume will help in improving the nutrient density of *Ogi* and nutrient intake, which may result in the prevention of malnutrition problem especially among infants and children.

Acha (*Digitaria exilis*) also known as *Fonio* or *hungry rice* has a packed reserve of nutrients and it is regarded as one of the oldest African cereal crops, indigenous to West Africa. It is a rich source of vitamins, minerals, fiber, carbohydrate, protein, amino acids containing methionine and cysteine [9]. These two amino acids however are lacking in wheat, rice, maize and other cereal crops [10]. The total Sulphur amino acid content of 7.3% makes Acha an excellent complement to legumes [11]. Acha has more protein and fiber contents than rice; more so, greater carbohydrate content than millet, sorghum and maize. The tiny grains are gluten-free and when cooked is light and easy to digest and can be included in many different cereal based recipes, making it an attractive ingredient for health food products for those with gluten intolerance, poor health or for baby food [12]. Cooking and fermentation increased both proximate and mineral composition in treated samples of Acha, but decreased anti-nutritional factors in most parameters tested. Cooking and fermentation could be used by most rural and poor urban dwellers to increase nutrient content of their diets [13]. Therefore, its nutritional benefits outweigh the nutritional benefits from other similar cereal crops.

Soybean (*Glycine max*) a grain legume, is one of the richest and cheapest sources of plant protein that could be used to improve the diets of millions of people, especially the poor and low income earners in developing countries because of its nutritional quality, attractiveness and functional properties [14]. It is an important source of proteins (40%), lipids (20%), minerals (5%), and B vitamins for human nutrition [15]. Soybeans contain all the essential amino acids (except methionine and cysteine), which must be supplied in the diet because they cannot be synthesized by the human body. There is increasing evidence that the consumption of Soybean products reduces cancer, blood serum cholesterol, osteoporosis, chronic renal disease, heart disease, oxidative stress and others [16-18]. The processing of Soybean will not only help in making nutrients more accessible and enhance palatability; it will also help in removing undesirable constituents. As a result of the health benefits which Soybean products have to offer, it has prompted a rise in the demand for beans. In this respect, the world production of Soybean has significantly increased in the last decade, rising from 200 million metric tons in 2005 to 324 million metric tons in 2016 [19]. Though, the 2015 annual production is very low (less than 3 million metric tons) in Africa; in this area of the world, Soybean plays an important role in infant nutrition [15]. In particular, soy flour is used to fortify traditional cereal-based foods [20,21]. The major challenges in using soybean flour in infant food are the elimination of anti-nutrients, oligosaccharides, beany flavor and the reduction of the viscosity of the resulting porridge [15]. Soaking and roasting have been applied to meet these objectives [22,23]. Roasting at 100ºC for 20 min was reported to inhibit 90% of trypsin inhibitors activity in soybean flour [15].

Carrot (*Daucus carota* L.) is a significant source of vitamins (A, B, C, E), beta carotene, folic acid, pantothenic acid and trace elements such as K, Na, Ca, Mg, P,S, Mn, Fe, Cu and Zn [24]. Consumption of Carrot improves eyesight, lowers cholesterol and improves digestion [25]. Consumption of carrot and its products would be very useful in alleviating vitamin A deficiency particularly, among children below six years and adults [26]. Vitamin A deficiency (VAD) has been reported to be one of the major public health problems in developing countries in which Nigeria is one [26]. There is therefore the need to develop enriched products such as *Ogi* in order to address the nutritional needs and enhance the health of the vulnerable groups. A formulated *Ogi* could well serve as an effective vehicle for incorporating protein and macronutrients which can be accessed conveniently by consumers, especially children who need them the most for their growth and development.

Therefore, the rationale behind this study was to produce a more palatable *Ogi* with an improved nutritional value knowing that Acha is the testiest and most nutritious of all grains; a cereal rich in methionine and cysteine, while soybeans is a legume rich in lysine, an essentially limiting amino acid in most cereals.

2. MATERIALS AND METHODS

2.1 Sources of Materials

Raw materials such as Acha (*Digitaria exilis*), Soybeans (*Glycine max*) and Milk flavor were purchased from Central Market, Kaduna, North West Nigeria; while Carrot (*Daucus carota* L.) was purchased from a local Market in Jos, North Central Nigeria. Equipment and materials used for the study were supplied by laboratories in the Department of Food Science and Technology, University of Agriculture, Makurdi.

2.2 Sample Preparations

2.2.1 Production of fermented Acha flour

Fermented Acha flour was produced according to the methods described by Adegoke [27] and Osungbaro [28]. Briefly, Acha grains were washed with cold clean water repeatedly until it became clear, after which it was de-stoned using water. This action made the heavier sand settle at the bottom of the plastics as vibration was gently applied and it was repeated from one plastic container to another, until grains were free of sand. The grain was steeped and wet milled using attrition mill (model R175A) with warm water into fine slurry. The resulting starch slurry was filtered or sieved using Muslin cloth. In order to obtain a wet fermented Acha starch, it was covered and allowed to stay for 36 h, a process referred to as souring during which further fermentation proceeds. The filtered and sediment starch was decanted, dewatered and dried in a Cabinet dryer at 65ºC for 6 h. The dried starch was then milled in a Hammer mill (500 μm-2.50 mm, EU 5000 D model) and sieved using a Mesh sieve (250 μm mesh screen). The fermented Acha flour produced was finally packaged in sealed polyethylene bags for blending and preparation of *Ogi* formulations.

2.2.2 Production of roasted soybean flour

Roasted Soybean flour was produced using an earlier method of Msheliza et al. [29]. Soybean seeds were carefully cleaned and sorted out to remove defective and small sized seeds, foreign particles such as stones, sticks and leaves. Whole grains of soybean weighing 1 kg was soaked for 2 h in clean water of three times its weight by volume until the seed coat became soaked and wet to facilitate dehulling. Mortar and pestle were used for dehulling. The dehulled soybean was washed to remove the seed coat, drained and then partially sun dried. The soybean was then traditionally roasted using an open thick aluminum pot. A commercial grinding machine was used to mill the dehulled grain into fine flour and let to pass through a sieve of about 1 mm mesh screen. The roasted soybean flour was packaged in a plastic container until when required.

2.2.3 Production of carrot flour

The method described by Marvin [30] with slight modification was used in the preparation of Carrot powder. The carrots were washed in portable water, sorted, unwanted particles removed and shredded into flat shapes. The sliced carrots were blanched for 3 min in hot water to preserve color and nutrients. The carrots were immediately cooled under running water and dried in an oven (PRO-125 model, Genlab, UK) at 50ºC for 12 h. The dried carrot was ground to a fine powder using a Hammer mill (500 µm-2.50 mm, EU 5000 D model) and sieved with a 250 µm aperture sieves. The flour was packed in a seal lock cellophane bag until ready for used.

2.2.4 Preparation of *Ogi* formulations

Ogi was prepared according to the method described by Ihekoronye [31]. Fermented Acha flour was blended with roasted Soybean flour, Carrot flour and Milk flavor as shown in Table 1. Each blend was mixed thoroughly in a Kenwood mixer (Model A 220) for 10 min to produce *Ogi* formulations. The formulations developed were individually packaged in sealed polyethylene bags until used for analysis. In addition, 100% fermented Acha flour formulation was similarly prepared as a reference.

2.3 Determination of Proximate Composition

The moisture, protein, crude fat, crude fibre and ash contents of the formulated *Ogi* samples were determined according to the standard methods of AOAC [32]. Carbohydrate was calculated by difference [7]: % Carbohydrate = 100%– (% moisture + % protein + % fat + % crude fiber+ % ash).

2.4 Determination of Functional Properties

The Bulk density was determined by using an earlier method described by Ahemen et al. [33]. Water absorption capacity and foaming capacity were determined by the methods described by Ohizua et al. [34]. Foam stability, swelling index and least gelation capacity of the *Ogi* samples were determined by the methods of Ojo and Enujiugha [35].

2.5 Sensory Evaluation

The organoleptic characteristics of the *Ogi* from fermented Acha, roasted Soybean and Carrot composite flour samples were evaluated by a 20 member trained panelists drawn from Department of Food Science and Technology, University of Agriculture, Makurdi, comprising both staff and students who were already familiar with the consumption of *Ogi*. The *Ogi* was made into slurry by adding water till it formed a paste and boiled water was added to it and stirred continuously till it became viscous and formed a gruel as described by Ojo and Enujiugha [35]. The panelists were provided with a questionnaire. The samples were evaluated

Table 1. Blend formulations of *Ogi* from Acha, soybean and carrot flour

Formulations	Fermented Acha flour (%)	Roasted soybean flour (%)	Carrot flour (%)	Milk flavor (%)
A	100	-	-	-
B	80	5	10	5
C	70	15	10	5
D	60	25	10	5
E	50	35	10	5

A = 100% fermented Acha flour: 0% roasted Soybean flour: 0% Carrot flour: 0% Milk flavor (Reference sample); B = 80% fermented Acha flour: 5% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor; C= 70% fermented Acha flour: 15% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor; D= 60% fermented Acha flour: 25% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor and E= 50% fermented Acha flour: 35% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor for color, taste, aroma, mouth feel and overall acceptability using a 9-point hedonic scale in which 9 = like extremely and 1 = dislike extremely as previously used by Meilgaard et al. [36]. The order of presentation of samples to the panel was randomized. Tap water was provided for each panelist to rinse their mouth in-between evaluations.

2.6 Statistical Analysis

All analyses were conducted in duplicate determinations. Means and standard deviation were calculated. The data obtained were subjected to Analysis of Variance (ANOVA). Least Significance Difference (LSD) test was used to separate means where significant difference existed at (P<0.05).

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of *Ogi* Made from Fermented Acha, Roasted Soybean and Carrot Composite Flour

The result of proximate composition (moisture, protein, crude fat, crude fiber, ash and carbohydrate) of the formulated *Ogi* is shown in Table 2. The moisture content ranged from 5.36% to 9.94%, with 100% fermented Acha flour (Sample A) having the lowest value of 5.36%; while the sample with 35% roasted soybean flour supplementation (Sample E) had the highest value of 9.94%. Increasing levels of roasted Soybean flour led to an increase in the moisture and carbohydrate contents of the samples. Moisture plays a very important role in the keeping quality of foods and high moisture can have an adverse effect on their storage stability [37]. The Moisture contents of the samples were within the recommended value (5-10%) [38]. Flour products with moisture content less than 13% are more stable from moisture dependent deterioration [34]. The protein content of the formulated *Ogi* samples ranged from 3.94% to 16.98%, there was significant (p<0.05) difference among the samples, with 100% fermented Acha flour (Sample A) having the lowest protein of 3.94%; while the Sample with 35% roasted Soybean flour supplementation have the highest value of 16.98%. The increase in protein content due to supplementation with roasted Soybean flour is in agreement with Temple and Bassa [39] who reported that addition of legumes to cereals improves the protein content of the cereals. The low level of protein in Sample A to Sample C (3.94% to 5.60%) may be due to the method of processing. The crude fat content ranged from 1.89% (Sample A) to 10.23% (Sample E) with significant variations observed in all the samples. The increase in the amount of crude fat could be attributed to the inclusion of oil-dense soybeans in the *Ogi* based diet. This attribute tends to agree with the recommendations by FAO/WHO [40] that vegetable oils be included in foods meant for infants and children, which will not only increase the energy density, but also be a transport vehicle for fat soluble vitamins [38]. Crude fibre measures the cellulose, hemicelluloses and lignin content of food [41]. The crude fibre content ranged from 1.8% – 3.12%. There was significant difference among all the samples, with 100% fermented Acha flour having the lowest value of 1.80%, while the Sample with 35% roasted Soybean supplementation have the highest value of 3.12%. The fiber content increased as the percentage inclusion of Soybean supplementation increased. This shows that the composite blends are good repository of fiber and can be used in the formulation of functional food products. Similar results were also obtained by Ohizua et al. [34] for composite flour blends obtained from unripe cooking banana, pigeon pea and sweet potato. All the formulated *Ogi* samples had fibre content that were within the recommended range for diets of not more than 5 g dietary fibre per 100 g dry matter [42]. Consumption of high fiber food products has been linked to reduction in hermorrhoids, diabetes, high blood pressure, and obesity [43, 44]. Fibre has useful role in providing roughage that aids digestion, soften stools and lowers plasma cholesterol level in the body [41]. The ash content ranged from 0.35% to 0.99%, with 100% fermented Acha flour having the lowest value of 0.35%. With increase in supplementation, the value increased (p<0.05) significantly to 0.99% (Sample E). Ash content represents the presence of mineral matter in a food. The carbohydrate content ranged from 58.74% to 86.66%. There was significant (p<0.05) difference between all the samples, with 100% fermented Acha flour having the highest value. With increase in supplementation of roasted Soybean flour and constant addition of Carrot flour with milk flavor, there was significant (p<0.05) decrease in carbohydrate content to 58.74%. The decrease could be due to the low content of carbohydrate in the added roasted Soybean flour which agreed with the findings of Iwe [14] that Soybeans are poor source of carbo hydrate.

Table 2. Proximate composition of *Ogi* made from fermented Acha, roasted Soybean and carrot composite flour

Formulations	Parameters (%)					
	Moisture content	Crude protein	Crude fat	Crude fiber	Total ash	Carbohydrate content
A	$5.36^{d}\pm0.03$	$3.94^{e}\pm0.04$	$1.89^{e}\pm0.04$	$1.80^{e}\pm0.01$	$0.35^{c}\pm0.04$	$86.66^{a}\pm0.67$
B	$5.63^{c}\pm0.02$	$4.29^{d}\pm0.04$	$3.91^{d}\pm0.49$	$1.96^{d}\pm0.03$	$0.66^{b}\pm0.03$	$83.55^{b}\pm0.45$
C	$5.65^{c}\pm0.06$	$5.60^{c}\pm0.02$	$5.42^{c}\pm0.05$	$2.40^{c}\pm0.06$	$0.69^{b}\pm0.06$	$80.24^{c}\pm0.07$
D	$9.24^{b}\pm0.06$	$11.46^{b}\pm0.03$	$7.67^{b}\pm0.03$	$2.60^{b}\pm0.02$	$0.73^{b}\pm0.05$	$68.30^{d}\pm0.15$
E	$9.94^{a}\pm0.03$	$16.98^{a}\pm0.08$	$10.23^{a}\pm0.01$	$3.12^{a}\pm0.05$	$0.99^{a}\pm0.05$	$58.74^{e}\pm0.04$
LSD	0.10	0.09	0.09	0.12	0.20	1.14

Values are means ± standard deviations of duplicate determinations. Means with different superscripts in the same column are significantly (p<0.05) different

A= 100% fermented Acha flour: 0% roasted Soybean flour: 0% Carrot flour: 0% Milk flavor (Reference sample); B= 80% fermented Acha flour: 5% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor; C= 70% fermented Acha flour: 15% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor; D= 60% fermented Acha flour: 25% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor; E= 50% fermented Acha flour: 35% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor and LSD: Least Significance Difference

3.2 Some Functional Properties of *Ogi* Made from Fermented Acha, Roasted Soybean and Carrot Composite Flour

Results of the functional properties of *Ogi* made from fermented Acha, roasted Soybean and Carrot composite flour are presented in Table 3. The bulk density significantly ($p<0.05$) decreased from 0.84 g/mL (Sample A) to 0.72 g/mL (Sample E) with increasing supplementation with roasted Soybean flour, and constant addition of carrot flour alongside milk flavor. This is in agreement with Onuh and Abdulsalam [45] who reported that the result fell within the reported value for starch foodstuff. Ohizua et al. [34] reported bulk density values of 0.48 g/mL to 0.92 g/mL for composite flour blends obtained from unripe cooking banana, pigeon pea, and sweet potato; which were comparable to the results obtained in this research. The result of bulk density (BD) is used to evaluate the flour heaviness, handling requirement and the type of packaging materials suitable for storage and transportation of food materials [34]. In terms of packaging, higher bulk density is desirable, as more food will occupy less space (volume) [46]. However, from nutritional point of view, the decreasing bulk density implies that, infants can eat more of the food thus making more nutrients available to them. The lower the bulk density value, the higher the amount of flour particles that can stay together and thus increasing energy content that could be desirable from such diet [47]. Water absorption capacity (WAC) illustrates the amount of water available for gelatinization [48]. Water absorption capacity decreased ($p<0.05$) significantly from 1.4% to 1.1% with Sample A having the highest value and Sample E having the lowest WAC. Variation in WAC of composite flours may be due to difference in concentration of protein, their degree of interaction with water and possibly their conformational characteristics [49]. As the supplementation of roasted Soybean flour increases with the constant addition of carrot flour with milk flavor, WAC decreases. Lower water absorption capacity is desirable for making thinner gruels with high caloric density per unit volume [50]. Form capacity (FC) is used to determine the ability of the flour to foam which is dependent on the presence of the flexible protein molecules which decrease the surface tension of water [34]. The FC increased from 5.99% in Sample A to 7.97% in Sample E as the percentage inclusion of roasted soybean flour into the blend formulation for *Ogi* increased. This is expected as the soybean is a better repository of protein than acha and carrot. Similar result (1.38% to 10.00%) was reported by Ojo and Enujiugha [35] as supplementation of melon and conophor nut increased in fermented maize flour. It was also in agreement with the findings of Ohizua et al. [34] who revealed FC values of 2.01% to 12.88% with increasing addition of pigeon pea to the Unripe cooking banana/Sweetpotato flour blends. Foam stability decreased ($p<0.05$) significantly from 3.39% (Sample A) to 2.79% (Sample E) as roasted Soybean flour supplementation increased with constant addition of carrot flour and milk flavor. The changes observed in flour can be caused by physiological differences in the composition of protein and the presence of other compounds such as lipids and carbohydrate in different proportions [51]. Swellling index ranged from 2.46 v/v to 3.08 v/v with Sample E having the highest value, while sample A had the least value. With increase in supplementation of roasted soybean flour, there was an increase in swelling index. These values were comparable to those obtained by Ali et al. [52] on the effect of different supplementation of Soybean flour on Pearl millet property. Swelling index of the sample illustrates the ability of the sample to absorb a particular amount of water and retain some within the duration of study. Moorthy and Ramanujan [53] reported that swelling of flour granule is an indication of the extent of associative forces within the granules. The variations in the swelling index indicate the degree of exposure of the internal structure of the starch present in the flour to the action of water [54]. Least gelation capacity (LGC) measures the minimum amount of flour needed to form a gel in a measured volume of water [34]. The LGC increased significantly (p<0.05) from 8% to 14%. Sample A with 100% fermented Acha flour formed a strong gel at 8%. As roasted Soybean flour supplementation increases with addition of constant amount of Carrot flour and milk flavor, a strong gel is formed at 12%, while for Sample E, strong gelation occurred at 14%. No gel was formed at 2%, 4% and 6% concentrations. It was also observed that treatment with increasing supplementation of roasted Soybean flour formed a weak gel. Similar findings were reported by Ali et al. [52] for Pearl

Table 3. Some functional properties of *ogi* made from fermented acha, roasted soybean and carrot composite flour

Formulations	Parameters					
	BD (g/mL)	WAC (%)	FC (%)	FS (%)	SI(v/v)	LGC (%)
A	0.84^{a}±0.05	1.40^{a}±0.38	5.99^{c}±0.42	3.39^{a}±0.06	2.46^{e}±0.04	8.00^{a}±0.20
B	0.80^{a}±0.05	1.30^{a}±0.20	6.10^{c}±0.43	3.16^{b}±0.17	2.67^{d}±0.02	12.00^{b}±0.80
C	0.74^{a}±0.03	1.25^{a}±0.20	6.57^{b}±0.46	2.97^{b}±0.14	2.90^{c}±0.02	12.00^{b}±0.50
D	0.73^{a}±0.06	1.20^{ab}±0.26	7.94^{a}±0.33	2.82^{bc}±0.14	2.91^{b}±0.01	12.00^{b}±0.70
E	0.72^{a}±0.04	1.10^{b}±0.10	7.97^{a}±0.72	2.79^{bc}±0.06	3.08^{a}±0.02	14.00^{c}±0.50
LSD	0.12	0.13	0.33	0.19	0.03	1.07

Values are means ± standard deviations of duplicate determinations. Means with different superscripts in the same column are significantly (p<0.05) different

A= 100% fermented Acha flour: 0% roasted Soybean flour: 0% Carrot flour: 0% Milk flavor (Reference sample); B= 80% fermented Acha flour: 5% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor; C= 70% fermented Acha flour: 15% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor; D= 60% fermented Acha flour: 25% roasted Soybean flour: 10% `Carrot flour: 5% Milk flavor; E= 50% fermented Acha flour: 35% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor; BD: Bulk Density; WAC: Water Absorption Capacity; FC: Foaming Capacity; FS: Foaming Stability; SI: Swelling Index; LGC: Least Gelation Capacity and LSD: Least Significance Difference

Table 4. Sensory characteristics of *Ogi* made from fermented Acha, roasted soybean and carrot composite flour

Formulations	Attributes				
	Color	Taste	Aroma	Mouth feel	Overall acceptability
A	7.75^{a}±0.83	7.25^{a}±1.64	6.60^{a}±1.32	7.35^{a}±1.01	7.10^{a}±1.61
B	5.95^{b}±0.92	6.00^{b}±1.14	6.40^{a}±1.32	5.80^{b}±0.81	6.20^{a}±0.81
C	6.65^{ab}±0.73	6.95^{ab}±1.24	6.45^{a}±1.16	6.10^{b}±1.14	6.50^{a}±1.24
D	6.25^{b}±1.64	6.35^{ab}±1.77	6.30^{a}±1.27	6.35^{b}±1.19	6.50^{a}±1.16
E	5.90^{b}±1.10	6.70^{ab}±1.27	6.45^{a}±1.40	5.85^{b}±1.39	6.30^{a}±1.38
LSD	0.86	1.13	0.96	1.36	1.15

Values are means ± standard deviations of duplicate determinations. Means with different superscripts in the same column are significantly (p<0.05) different

A= 100% fermented Acha flour: 0% roasted Soybean flour: 0% Carrot flour: 0% Milk flavor (Reference sample); B= 80% fermented Acha flour: 5% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor; C= 70% fermented Acha flour: 15% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor; D= 60% fermented Acha flour: 25% roasted Soybean flour: 10% `Carrot flour: 5% Milk flavor; E= 50% fermented Acha flour: 35% roasted Soybean flour: 10% Carrot flour: 5% Milk flavor and LSD: Least Significance Difference millet supplemented with Soybean flour. The gelation properties variation can be attributed to the sizes of the various constituents such as proteins, carbohydrates, and lipids suggesting that the interaction between these components may also play an important role in the functional properties [55]. Protein gelation is very important in the development and acceptability of many foods, including vegetables and other products [56]. The gelation mechanism and gel appearance are mainly controlled by the balance between attractive hydrophobic interactions and repulsive electrostatic interactions [56].

3.3 Sensory Characteristics of *Ogi* Made from Fermented Acha, Roasted Soybean and Carrot Composite Flour

Table 4 shows the result of the sensory attributes of the formulated *Ogi* produced from fermented Acha, roasted Soybean and Carrot composite flour. The result indicated that aside the control sample (containing 100% fermented Acha flour) there was preference for Samples, C and D in terms of color (6.65 and 6.25), taste (6.95 and 6.35), aroma (6.45 and 6.30), mouth feel (6.10 and 6.35) and overall acceptability (6.50 and 6.50) respectively, among the blend formulations. The result also revealed that the sensory attributes of aroma and overall acceptability do not differ significantly ($p>0.05$) in all the samples as shown in Table 4.

4. CONCLUSION

Supplementation of fermented Acha with roasted Soybean and Carrot flour alongside milk flavor resulted in considerable improvement in the protein content of the flour. The functional properties of *Ogi* such as bulk density, water absorption capacity, foam stability decreased significantly ($p<0.05$) with increasing incorporation of roasted Soybean flour; while the foam capacity, swelling index and gelation capacity increased significantly ($p<0.05$) with increase in supplementation with roasted Soybean flour. The sensory data revealed that Sample C and Sample D were preferred with higher overall acceptability. Further research in the future should be focused on the shelf life study of the *Ogi* flour samples in order to determine how long the product can stay on the shelf without getting spoilt.

COMPETING INTEREST

Authors have declared that no competing interests exist.

REFERENCES

1. Nnanyelugo DO, Onofiok NO. Weaning Foods in West Africa: Nutritional problems and possible solutions. Occasional Paper Department of Home Science and Nutrition, University of Nigeria, Nsukka; 2004.
2. Abioye VF, Aka MO. Proximate composition and sensory properties of moringa fortified maize-ogi. Journal of Nutrition and Food Sciences. 2015; 12:1-4.
3. Afolayan MO, Afolayan M, Abuah JN. An investigation into sorghum based ogi (Ogi-Baba) storage characteristics. Advance Journal of Food Science and Technology. 2010;2(1):72-8.
4. Mbaeyi-Nwaoha IE, Obetta FC. Production and evaluation of nutrient-dense complementary food from millet (*Pennisetum glaucum*), pigeon pea (*Cajanus cajan*) and seedless breadfruit (*Artocarpus altillis*) leaf powder blends. African Journal of Food Science. 2016;10 (9):143-56.
5. Esther L, Charles AO, Adeoye OS, Toyin OA. Effects of drying method on selected properties of *ogi* (Gruel) prepared from sorghum (*Sorghum vulgare*), Millet (*Pennisetum glaucum*) and Maize (*Zea mays*). Food Process Technol. 2013;4 (7):1000248.
6. Manay N, Shakaksharaswany M. Food Facts and Principles. 2nd edition. India: New Age International Ltd; 2006.
7. Ihekoronye AI, Ngoddy PO. Integrated food science and technology for the tropics: Macmillan; 1985.
8. Enwere NJ. Foods of plant origin. Nsukka, Nigeria: Afro-Orbis Pub, Ltd; 1998.
9. Istifanus MF, Agbo EB. Nutritional and Health Benefits of Acha (*Digitaria exilis*) in the Human Diet–A Review. Nigerian Food Journal. 2016;34(2):72-8.
10. Barikmo I, Ouattara F, Oshaug A. Protein, carbohydrate and fibre in cereals from Mali—how to fit the results in a food Compositiontable and database. Journal of Food Composition and Analysis. 2004;17 (3-4):291-300.
11. National Research Council. Lost crops of Africa: volume I: grains: National Academies Press; 1996.

12. Chinwe OU, Ojukwu EO, Jackson BA. ACHA: A potential grain as a food fortifier. Asian Journal of Agriculture and Food Sciences. 2015;3(05).
[ISSN: 2321–1571].
13. Echendu CA, Obizoba IC, Anyika JU, Ojimelukwe PC. Changes in chemical composition of treated and untreated Hungry Rice "Acha" (*Digitaria exilis*). Pakistan Journal of Nutrition. 2009;8(11): 1779-85.
14. Iwe MO. The science and technology of soybeans. Enugu, Nigeria: 20 communication service Ltd.; 2003.
15. Agume A, Njintang N, Mbofung C. Effect of soaking and roasting on the physicochemical and pasting properties of soybean flour. Foods. 2017;6(2):12.
16. Lee G, Wu X, Shannon G, Sleper A, Nguyen T. Soybean, chapter 1 in genome mapping and molecular breeding in plants; Oilseeds Kole C., Ed. Springer: Berlin/Heidelberg, Germany. 2007;1-53.
17. Knight DC, Eden JA. A review of the clinical effects of phytoestrogens. Obstetrics & Gynecology. 1996;87(5):897-904.
18. Ekor M, Emerole GO, Farombi EO. Phenolic extract of soybean (*Glycine max*) attenuates cisplatin-induced nephrotoxicity in rats. Food and Chemical Toxicology. 2010;48(4):1005-12.
19. USDA. World Agricultural Production; Foreign Agricultural Service Circular Series. Washington, DC, USA. 2016; 6-16.
20. Plahar WA, Nti CA, Annan NT. Effect of soy-fortification method on the fermentation characteristics and nutritional quality of fermented maize meal. Plant Foods for Human Nutrition. 1997;51(4): 365-80.
21. Tchango JT. The nutritive quality of maize-soybean (70: 30) tempe flour. Plant Foods for Human Nutrition. 1995;47(4):319-26.
22. Yadav S, Khetarpaul N. Indigenous legume fermentation: Effect on some antinutrients and in-vitro digestibility of starch and protein. Food Chemistry. 1994; 50(4):403-6.
23. Baik BK, Han IH. Cooking, roasting, and fermentation of chickpeas, lentils, peas, and soybeans for fortification of leavened bread. Cereal Chemistry. 2012;89(6):269-75.
24. Sharma KD, Karki S, Thakur NS, Attri S. Chemical composition, functional properties and processing of carrot—a review. Journal of Food Science and Technology. 2012;49(1):22-32.
25. Bystrická J, Kavalcová P, Musilová J, Vollmannová A, Tomáš T, Lenková M. Carrot (*Daucus carota* L. ssp. sativus (Hoffm.) Arcang.) as source of antioxidants. Acta Agriculturae Slovenica. 2015;105(2):303-11.
26. Phebean IO, Akinyele O, Toyin A, Folasade O, Olabisi A, Nnenna E. Development and quality evaluation of carrot powder and cowpea flour enriched biscuits. International Journal of Food Science and Biotechnology. 2017;2(2):67-72.
27. Adegoke GO. Understanding food Microbiology. 2nd Edition. Nigeria: Alleluia Venture Ltd; 2004.
28. Osungbaro TO. Physical and nutritive properties of fermented cereal foods. African Journal of Food Science. 2009; 3(2):023-7.
29. Msheliza EA, Hussein JB, Ilesanmi JO, Nkama I. Effect of fermentation and roasting on the physicochemical properties of weaning food produced from blends of sorghum and soybean. J Nutr Food Sci. 2018;8(681):2.
30. Marvin S. Processing of dried carrots and carrot powder. Food Recipe; 2009.
31. Ihekoronye AI. Manual of Small-Scale Food Processing. London: Macmillan Publishers Ltd; 1999.
32. AOAC. Official Methods of Analysis. 18th Edition. Washington D.C. USA: Association of Official Analytical Chemist; 2010.
33. Ahemen SA, Shima AN, Acham IO. Evaluation of the Physical, Functional and Microbiological Properties of Composite Bread from Wheat, Tigernut and Defatted Sesame Flour Blends. Asian Food Science Journal. 2018;4(2):1-10.
34. Ohizua ER, Adeola AA, Idowu MA, Sobukola OP, Afolabi TA, Ishola RO, Ayansina SO, Oyekale TO, Falomo A. Nutrient composition, functional and pasting properties of unripe cooking banana, pigeon pea, and sweetpotato flour

blends. Food Science & Nutrition. 2017; 5(3):750-62.

35. Ojo DO, Enujiugha VN. Chemical Composition, Physico-Chemical Properties and Acceptability of Instant '*Ogi*' from Blends of Fermented Maize, Conophor Nut and Melon Seeds. J Food Process Technol. 2016;7(630):2.
36. Meilgaard MC, Civille GV, Carr BT. Sensory Evaluation Techniques. 4th edition: CRC Press, Boca Raton; 2007.
37. Akume JN, Ariahu CC, Acham IO. Quality Evaluation of ready-to-eat *Garri* made from Cassava mash and mango fruit mesocarp blends. Asian Food Science Journal. 2019; 8(3):1-9.
38. Achidi AU, Tiencheu B, Tenyang N, Womeni HM, Moyeh MN, Ebini LT, Tatsinkou F. Quality evaluation of nine instant weaning foods formulated from cereal, legume, tuber, vegetable and crayfish. International Journal of Food Science and Nutrition Engineering. 2016; 6(2):21-31.
39. Temple VJ, Bassa JD. Proximate chemical composition of Acha (*Digitaria exilis*) grain. Journal of the Science of Food and Agriculture. 1991;56(4): 561-3.
40. FAO/WHO. Preparation and use of food-based dietary guidelines: Report of joint FAO/WHO consultation technical report series 880. Geneva. FAO/WHO/UNICEF Protein Advisory Group; 1998.
41. Ajala AS, Ogunsola AD, Odudele FB. Evaluation of drying temperature on proximate, thermal and physical properties of cocoyam flour. Global Institute for Research and Education Global Journal of Engineering, Design and Technology. 2014;3(4):13-8.
42. Shima AN, Ahemen SA, Acham IO. Effect of addition of Tigernut and defatted Sesame flours on the nutritional composition and sensory quality of the Wheat based Bread. Annals Food Science and Technology. 2019;20(1):15-23.
43. Chukwu BN, Ezebuiro VO, Samuel E, Nwachukwu KC. Gender differential in the incidence of *Diabetes mellitus* among the patients in Udi Local Government Area of Enugu state, Nigeria. International Letters of Natural Sciences. 2013;4.
44. Jaja T, Yarhere IE. Risk factors for type 2 *Diabetes mellitus* in adolescents secondary school students in Port Harcourt, Nigeria. Nigerian Journal of Paediatrics. 2015;42(2):137-41.
45. Onuh JO, Abdulsalam KO. Production and evaluation of the physico-chemical properties of maize-bambara groundnut "*apula*". Nigerian Food Journal. 2009;27 (1):83-92.
46. Plaami SP. Content of dietary fiber in foods and its physiological effects. Food Reviews International. 1997;13(1):29-76.
47. Fasuan TO, Fawale SO, Enwerem DE, Uche N, Ayodele EA. Physicochemical, functional and economic analysis of complementary food from cereal, oilseed and animal polypeptide. International Food Research Journal. 2017;24(1).
48. Marta H, Tensiska T. Functional and amylographic properties of physically-modified sweet potato starch. KnE Life Sciences. 2017;2(6):689-700.
49. Menon L, Majumdar SD, Ravi U. Development and analysis of composite flour bread. Journal of Food Science and Technology. 2015;52(7):4156-65.
50. Ige MM. Physicochemical, pasting and sensory characteristics of complementary foods formulated from plantain, pigeon pea and maize flours. Donnish Journal of Food Science and Technology. 2017;3(2):007-15.
51. Akintayo ET, Oshodi AA, Esuoso KO. Effects of NaCl, ionic strength and pH on the foaming and gelation of pigeon pea (*Cajanus cajan*) protein concentrates. Food Chemistry. 1999;66(1):51-6.
52. Ali MA, El Tinay AH, Elkhalifa AEO, Mallasy LO, Babiker EE. Effect of different supplementation levels of soybean flour on pearl millet functional properties. Food and Nutrition Sciences. 2012;3(1):1.
53. Moorthy SN, Ramanujam T. Variation in properties of starch in cassava varieties in relation to age of the crop. Starch-Stärke. 1986;38(2):58-61.
54. Ruales J, Valencia S, Nair B. Effect of processing on the physico-chemical

characteristics of quinoa flour (*Chenopodium quinoa*, Willd). Starch-Stärke. 1993;45(1):13-9.

55. Maninder K, Sandhu KS, Singh N. Comparative study of the functional, thermal and pasting properties of flours from different field pea (*Pisum sativum* L.) and pigeon pea (*Cajanus cajan* L.) cultivars. Food Chemistry. 2007;104 (1):259-67.
56. Chaparro Acuña SP, Gil González JH, Aristizábal Torres ID. Physicochemical characteristics and functional properties of vitabosa (*Mucuna deeringiana*) and soybean (*Glycine max*). Food Science and Technology. 2012;32(1):98-105.

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