ISSN: 2347-467X, Vol. 5, No. (3) 2017, Pg. 206-213

Current Research in Nutrition and Food Science

Journal Website:www.foodandnutritionjournal.org

Improving Nutritive Value of Maize-*Ogi* as Weaning Food Using Wheat Offal Addition

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Abstract

The deficiency in affordable nourishing foods for neonates after weaning has been major concern in developing countries and this has contributed to increased malnutrition rate, illnesses and even children's mortality rate. The addition of wheat offal to traditionally affordable '*Ogi*' as an alternative approach for combating the threats of protein malnutrition in neonates was explored in this work. Wheat offal was added at increasing levels of 0, 20, 40, 60, 80 and 100 w/w% as fortifying feed with prepared maize-*Ogi* as meal. Proximate analysis, pasting characteristics, sensory evaluation, nutritive and functional properties of the resulting blends was evaluated using standard methods. Results of proximate analysis showed an increased protein (2.787 – 34.064%), fat (2.282 – 9.015%) and ash (8.913 – 17.171%) contents with increased level of wheat offal from 20 to 100 w/w addition, while decreased carbohydrate content was observed with increased addition of wheat offal. The water absorption capacity increased also with level of wheat offal addition. The pasting characteristics result indicated up to 40% fortification of maize-*Ogi* with wheat offal as stable blend against retrogradation in terms of setback value and viscosity. The 40% level of fortification was preferred in terms of quality index of taste, texture, color, sourness and appearance. In conclusion, the nutritional indices investigated indicated addition level of wheat offal to 40% limit to solve protein-energy malnutrition and food security issues in neonates.

Article History

Received: 20 June 2017
Accepted:15 September 2017

Keywords

proximate composition, malnutrition, organoleptic assessment, neonates, functional properties, maize ogi, wheat offal.

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To link to this article: http://dx.doi.org/10.12944/CRNFSJ.5.3.04

Introduction

Inadequacy of calories and protein in diets, which are responsible for growth and maintenance of the body, causes malnutrition in both adults and children. This constitutes a great risk in terms of illness and subsequently results majorly to deaths in children worldwide[1]. In Nigeria, which is just 1% of world's population has 10% of the world's maternal and mortality rates of children within age of five which is attributed to high level of malnutrition[2]. Infants under six months of age suffered most from severe acute malnutrition and this is often associated with higher mortality in infants than older adults.

Breast feeding new born for minimum of six months before introduction of supplementary foods to bridge vitamins, iron, protein and energy deficiency is essential; knowing the fact that breast milk offers systemic immunity and antigen handling for neonates[3,4]. As babies grow older, the demand for additional nutrients increases and breast milk alone becomes insufficient. An investigation of protein and energy intake level of children of low-income group was reported which specified that one-third to one-half of the infants suffered varying degrees of malnutrition[3]. The lack of appropriate nutrients in infants predisposes them to several infections after weaning periods[5-8]. In Nigeria, the first weaning food introduced to children of low-income group is '*Ogi*' also known as pap or akamu which is derived from the fermentation of maize, sorghum or millet. In Nigeria, maize-*Ogi* is seen as one of the cheapest and popular food for weaning neonates and also serves as common breakfast food for adults when taken hot with bean balls (Akara). However, *Ogi* contains only 1.8% protein, less than 1% fat and 310 kcal/100g as compared to about 9% of protein and 4% fat in maize. The loss in nutrient is due to the fermentation and seiving processes during the processing technique from maize to *Ogi*.

Wheat offal is a by product obtained from wheat after flour processing. It consist of both coarse and fine middling, wheat germ and wheat bran. Wheat offal has been observed to be a good source of crude protein (14.80% – 17.60%), crude fat and crude fibre (10%)[9-10]. The use of wheat flour fortification with sorghum flour in the production of biscuits has indicated the possible use of cereals such as wheat offal in food materials[11]. Studies have shown that cereals are generally low in protein[11-13] and are also restrictive in some essential nutrients, hence there is need to supplement cereals with protein sources in order to enrich the nutritive values. Furthermore, in a state where animal protein becomes unaffordable for low-income group, the use of wheat offal as source of protein fortification of maize-*Ogi* as weaning food has not been explored and hence, the nutritive composition and organoleptic profile of wheat offal as protein augmentation in maize-Ogi was investigated in this study.

Materials

Maize grain (white variety) was purchased at Bodija market, Oyo State, Nigeria and certified at the International Institute of Tropical Agriculture, Samonda, Ibadan, Nigeria. Wheat offal was obtained directly from Flour Mills Plc, Apapa, Lagos, Nigeria.

Methods

Preparation of Maize-*Ogi* Sample

2 kg of maize grain was cleaned and steeped into 5 litres of tap water for 2 days at room temperature. The steeping water was drained to recover the steeped grains and subsequently wet milled on a grain hammer mill. Excess water was added and the slurry was properly stirred and allowed to pass through a vibrating shaker of 500 nm sieve. The obtained slurry was allowed to settle for a minimum of 12 hours and in succession, the supernatant was decanted to obtain the fresh maize-*Ogi* slurry. The slurry was then dried at 45 - 50 ^{o}C for 24 hours using a cabinet dryer, cooled, milled and packaged in labelled polythene bag.

Preparation of Maize-*Ogi* Wheat Offal Meal

100 g of *Ogi* was fortified with 20, 40, 60, 80 and 100 g of wheat offal on dry basis in accordance to batch composition shown in Table 1. The purpose of the batching process is for fortification with wheat offal and not to substitute the content of the maize-*Ogi* powder. The food blends were mixed using Eurosonic 5-speed hand mixer with rotating bowl and samples properly labelled and kept in air tight plastic container for further chemical analysis.

Table 1: Batch composition of Maize-*Ogi* Wheat offal fortification

Sample	A	B	C	D	E	F
Wheat offal (g)	0	20	40	60	80	100
Maize *Ogi* (g)	100	100	100	100	100	100

Chemical Analysis of Maize-*Ogi* Wheat Offal Meal

The AOAC method of analysis[14] was employed for the determination of moisture content, ash content, crude fat and total nitrogen (Kjeldahl method) of the maize-*Ogi* wheat offal meal. The total nitrogen was converted to crude protein by multiplying with a factor of 5.72. The crude fibre content of the blends was determined using the filter bag technique in accordance to method 962.09 of the Official Methods of AOAC (2000) International[14]. The available carbohydrate content was determined by difference of amount of moisture, protein, fat, ash and crude fibre, which is subtracted from 100. Water absorption capacity was determined using the method of Adeyeye *et al.*[15]. Ascorbic acid content was analysed using oxidation-reduction method based on the reduction of indophenol dye by an acid extract of the ascorbic acid. The method of Bolaji *et al.,*[16] was used for the titratable acidity. The pH of sample blends was measured using a Unican model pH meter which had been previously standardized with buffer solutions of pH 4 and pH 9. Pasting properties were determined using a Rapid Visco Analyser by method of Osungbaro *et al.,*[17]. Sensory evaluation was determined by expert who were trained in the assignment from Flour Mills Plc, Apapa, Lagos using a 6-point Hedonic index of taste, appearance, texture, color, sourness and acceptability. All reagents were of analytical grade and were used as received without further purification. All data obtained were subjected to analysis of variance.

Results and Discussion

Effects of Wheat Offal Addition on Proximate Composition of Maize-*Ogi* Food

The result of the proximate analysis of the maize-*Ogi* wheat offal blends is presented in Table 2. The analysis of moisture content especially in food samples is very important this is because it affects packaging, mixing and blending of food samples. The moisture content of all fortified samples was in range of 0.864 - 1.43% which indicates an improved shelf-life if properly packaged and stored. Highest moisture content of the maize-*Ogi* wheat offal blends was observed in the 60% blend while the 40% blend had the lowest moisture content. It was observed that all the samples were within the normal moisture range of dried foods which is in accordance to judgement by Ogunlakin[18] with a moisture content of 10% taken as the standard value for flour and starch related materials. Furthermore, the moisture content of the fortified maize-*Ogi* was found to be lower than the control which is an indication of good shelf life.

Table 2: Proximate Analysis of Maize-*Ogi* Wheat offal fortification

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude Fibre (%)	Carbohydrate (%)
A	1.43 ± 0.04	0.214 ± 0.016	1.294 ± 0.11	1.645 ± 0.160	4.03 ± 0.02	91.387 ± 1.52
B	0.864 ± 0.002	7.214 ± 0.012	2.282 ± 0.31	2.787 ± 0.145	10.63 ± 0.45	76.223 ± 1.29
C	0.185 ± 0.0001	6.546 ± 0.623	2.878 ± 0.19	10.801 ± 0.962	16.48 ± 0.69	63.110 ± 1.40
D	1.357 ± 0.21	7.713 ± 0.841	6.431 ± 0.45	19.157 ± 0.725	17.41 ± 1.22	47.932 ± 1.51
E	0.838 ± 0.062	8.129 ± 0.671	6.539 ± 0.32	28.414 ± 0.998	22.34 ± 1.34	33.740 ± 1.99
F	0.946 ± 0.007	8.941 ± 0.896	9.015 ± 0.26	34.064 ± 1.025	24.62 ± 1.55	22.414 ± 1.73

Note: ± is standard deviation from the mean value

Fat content of the blends increased with increase level of wheat offal addition which is obviously linked with wheat offal fat content. Fats help in the development of baby's brain, 60% of the brain and sheath surrounding the nerves are composed of fat. According to the Official Journal of the American Academy of Pediatrics[19], there is no restriction to the recommendation of fat and cholesterol for infants below two years of age, where rapid growth and development require high energy intake. It has been observed that this is much different from the nutritional requirements for adults. The ash content of the food blend increased with the increased addition of wheat offal which is a function of amount of minerals available to enhance the diet. The 100% wheat offal addition had the highest ash content. The low ash content in the control blend was attributed to the sieving process during fermentation in which most of the beneficial minerals were sieved away[20] and was enriched by increasing addition of wheat offal in other blends.

Ogi is generally known to have low protein content, which is required as one of the building blocks of life and essential for growth and development, hence the need to enrich *Ogi* with protein sourced food to make it nutritive to extent that is much acceptable as weaning meal. An increased value from 1.645% for control to 34.064% at 100% wheat offal addition was observed in the protein content of the fortified blends. This is in accordance with previous works by other researchers[20,21] on fortification of *Ogi* using groundnut seeds and crayfish. Furthermore, Modu *et al.,*[22] also reported increased protein content in the production and evaluation of weaning meal from fermented red maize fortified with cowpea. The protein content of maize-*Ogi* wheat offal fortified food increased with increased proportions of wheat offal compared with the control. An indirect relationship between the protein content and the CHO content of the maize-*Ogi* wheat offal blends was also observed in the research work. The CHO content decreased with increased protein content; this had similar scenario with other research works[20,23,24,25] that made use of fortification process with groundnut, soybeans and yam flour.

Functional Properties of The Food Blends

The result obtained for the determination of the functional properties of the fortified food is shown in Table 3. There was no apparent effect on wheat offal addition on the pH of the blends. The water absorption capacity increased with the increased level of addition of wheat offal. Water absorption capacity is used to confirm whether flour or isolates can be incorporated into aqueous food formulations especially those used for making dough[26,27]. The observed increased value in water absorption implies that the starch will easily be digested. Low water absorption capacity is due to less availability of polar amino acids.

Table 3: The pH, water absorption capacity, titratable acidity and ascorbic acid of Maize-*Ogi* wheat offal fortification

Sample	pH	Water absorption capacity (g/g)	Titratable acidity (% lactic acid)	Ascorbic acid (mg/100 g)
A	3.44 ± 0.01	1.4 ± 0.02	0.09 ± 0.003	25.64 ± 1.25
B	3.35 ± 0.01	2.3 ± 0.66	0.09 ± 0.007	46.15 ± 1.53
C	3.36 ± 0.03	2.8 ± 0.01	0.08 ± 0.005	30.77 ± 2.21
D	3.39 ± 0.02	2.2 ± 0.03	0.05 ± 0.005	41.03 ± 2.12
E	5.88 ± 0.01	2.2 ± 0.74	0.04 ± 0.001	30.77 ± 2.40
F	5.01 ± 0.02	2.4 ± 0.02	0.08 ± 0.003	30.77 ± 1.06

This study revealed that 40% wheat offal addition had the highest water absorption capacity (2.8 ± 0.01 g/g) which signifies good thickening effect that is needed in baking process. There was no apparent effect of wheat offal addition on the titratable acidity, however a decreased value was observed with the 80% addition of wheat offal.

Taste Panel Assessment of Maize *Ogi*-Wheat Offal Blends

Table 4 illustrated the sensory scores associated with the porridges made from maize-*Ogi* wheat offal blends in comparison with normal *Ogi* preparations. The preparations were appraised and judged by a ten-man trained taste panel. There was a significant difference in the mean sensory scores of the blends and the control in the following hedonic parameters: taste, color, appearance, texture, sourness and general acceptability. The control had the highest acceptability value in the entire sensory quality studied. There was no difference in the appearance for all the food blends. It was observed that the fortified blends beyond 40% wheat offal addition exhibited lowest acceptability.

Table 4: Sensory scores of (cooked) Maize *Ogi* and wheat offal blends

Sample	Taste	Appearance	Texture	Colour	Sourness	Acceptability
A	2.2^{c}	2.4^{d}	3.2a	5.0a	5.0a	4.6a
B	1.4^{a}	4.0^{a}	4.7a	4.0a	4.2a	3.7a
C	1.2^{a}	4.0^{b}	3.7b	4.0b	4.3b	3.0a
D	1.4^{b}	4.0^{a}	2.2bc	3.3a	4.2ab	2.8b
E	1.2^{a}	4.0^{b}	1.1d	3.1b	4.6b	2.1a
F	1.4^{c}	4.0^{b}	1.2e	3.1a	4.1a	1.7b
LSD	1.68	1.4^{6}	1.56	1.33	0.86	0.62
'F' Value	3.32	1.62	1.87	6.22	5.22	2.20

Note: Means with no subscript in common are significantly different from each other ($P<0.05$).

Pasting Properties of Maize-*Ogi* Wheat Offal Blends

The result of the pasting properties of fortified maize-*Ogi* wheat offal is indicated in Table 5. Pasting properties is highly essential because it helps to determine the behaviour of the starch porridge before and after cooking[27]. The highest value was documented for control sample, 3635 RVU, while the lowest value was recorded for 100% substituted wheat offal, 1752 RVU. The maximum viscosity attained during or after heating the food blend is known as peak viscosity and this typically an indication of the starch constituent of food. It was observed that the addition of wheat offal to maize-*Ogi* reduced the peak viscosity in all the blends which is an indication that the control had highest starch content and as wheat offal fortification level increased, the starch content in the food blend decreased, which is in line with the outcome of Adegunwa *et al.,*[28] of high peak viscosity value implies a high starch content.

Table 5: Pasting characteristics of the maize-*Ogi* wheat offal fortification

Sample	Vp (RVU)	Tv(RVU)	Vp-Tv (RVU)	Fv(RVU)	Sv(RVU)	Pt(mins)	Tp (°C)
A	3635	2502	1133	4267	1765	5.20	66.00
B	3095	2214	881	3801	1587	5.13	76.60
C	2979	2099	880	3994	1895	5.40	76.65
D	2555	1776	779	3325	1549	5.40	50.55
E	1783	1393	390	2383	990	5.13	76.65
F	1752	1520	232	2597	1077	5.40	77.50

* Vp = Peak viscosity; Tv = Trough viscosity; Vp-Tv= Breakdown value; Fv = Final viscosity; Sv = Setback value; Pt= Peak time; Tp = Pasting temperature; RVU = Relative Value Unit.

The trough value obtained had a range value between 2502 - 1520 RVU and the breakdown value, which is the subtraction of trough value from peak viscosity, and is a measure of good palatability[29] between 1133 - 232 RVU. At a constant temperature phase of the RVU profile, the minimum viscosity value is known as the trough which measures the ability of the paste made from the food blend to withstand breakdown during cooling[27]. In like manner, the scrumptiousness of the blends decreased with addition of wheat offal.

Final viscosity helps to measure the ability of a material to form viscous gel/paste after cooking and cooling and also, the rate at which the material reacts to shear force during stirring[30]. The highest final viscosity value for the control (4267 RVU) indicated the highest ability to form firm gel after cooking and cooling and this is caused by the re-binding of the starch molecules[31]. The 40% wheat offal addition had the highest final viscosity in the fortified samples (3994 RVU) which implied good gel forming ability when wheat offal is used as fortifying food. This was in agreement with the findings of other researchers as well[23,27].

The setback value describes the breakdown of the starch molecules, particularly the amylase component. A high setback value indicates high amylose content and hence high leaching. 40% wheat offal addition had the highest setback value which indicates high amylose level. Gelatinization and pasting occurs when starch based foods are heated in aqueous environment, these two properties helps to determine the texture, quality and digestibility and also, the end use of starchy foods[32]. The amylose to amylopectin ratio of the starch determines the pasting characteristics of the dough[33]. There was no distinct difference in the peak time as observed in Table 5 but there was direct association between pasting temperature and water absorption capacity as also reported by Kulkarni *et al.,*[34]. There was a variation with an increase-decrease approach with maximum reached at 40% inclusion of wheat offal for pasting temperature and decreased value observed at 60% inclusion. This was also the same with the corresponding values obtained for water absorption capacity with 2.8 ± 0.01 g/g at 40% inclusion and decreased to 2.2 ± 0.03 g/g at 60% inclusion which was the lowest.

Conclusion

Wheat offal is a by-product from the production of wheat flour and has widely been used as a complementary food in monogastric animal foods. This work revealed the use of wheat offal as protein source in traditional weaning foods for babies. A good indication from this study revealed wheat offal as nourishment that is beneficial, available and affordable blend in maize-*Ogi* weaning diet for neonates.

Acknowledgement

The authors are grateful to the Management of Covenant University, Ota, Ogun State for providing all chemical reagents and state-of-art laboratory facilities for the execution of the research work.

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