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Effect of Crayfish Inclusion on the Chemical and Sensory Properties of *Ogi* Prepared from Maize, Millet and Sorghum

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Abstract: The effect of crayfish inclusion on the chemical and sensory properties of *ogi* prepared from maize, millet and sorghum was investigated. Blends were formulated based on a 13g/day protein RDA for toddlers as established by the Protein Advisory Group and were analysed for chemical and sensory attributes. All data were statistically analysed and significance difference was accepted at 5% probability level. All samples met the recommended dietary allowance (RDA) for Ash (<3g/day), fibre (<5g/day), carbohydrate (64g/day) and protein (13g/day). There was significant difference ($p < 0.05$) among all samples in terms of Vitamin A and D contents with values ranging from 8.39 to 5.34 µg/100g and 0.22 to 0.27mg/100, respectively. There was however no significant difference ($p > 0.05$) in vitamin B contents among the samples. The samples fell short of the RDA in terms of mineral composition. Anti-nutritional factors in the *ogi* samples were low, implying a high bioavailability of minerals with the exception of calcium as evident in the molars ratio calculated. Sensory scores revealed substantial overall acceptability of the samples. The quality of *ogi* samples were greatly affected by crayfish inclusion and hence could provide appreciable nutritional benefits for both infant and adults.

Keywords: *Ogi*, Vitamins, Chemical Properties, Anti-nutrients, Sorghum

1. Introduction

In many parts of the world and especially in Africa, cereals and their products are very well utilized as staple foods. They have been principal components of human diet for thousands of years [1]. They contribute significantly to the overall energy and protein intake in the areas of high consumption. A major fermented cereal product used as food for both infants and adults is *Ogi.*

Ogi is a locally prepared semi-solid food from fermented cereals (maize, millet and sorghum) in many African countries including Nigeria [2]. It is highly energy dense and also a good lactose stimulant for nursing mothers. The traditional preparation of *ogi* involves the processes of steeping maize, millet or sorghum in water (1-2 days), followed by wet-milling, wet-sieving and fermentation for 2-3 days [3-4].

Malnutrition associated with reduced consumption of breast milk and over-consumption of high energy dense complementary foods such as *ogi* is an area requiring continuous intervention through fortification, supplementation, dietary diversification, nutrition education, etc which if not addressed especially during the crucial period of infancy, could lead to permanent negative impact on their health and quality of life. Poor feeding practices and short fall in food intake remain the most direct causes of malnutrition and ill health amongst children.

Crayfish (*Procambarus clarkii*) are fresh water crustaceans which in recent times have been receiving increasing research attention. They are excellent sources of micro nutrients and proteins which can impart nutritive value to foods.

Ogi generally has been implicated as contributing to the prevalence of kwashiorkor among infants [5] owing to its high energy density and reduced proteins. This has informed many research attempts to improve its nutritional value with plant and animal protein sources [6-9] in order to meet the

Dietary Reference Intake (DRI) for infants [10].

The present study was aimed to elucidate the effect of crayfish inclusion on the quality of *ogi* prepared from maize, sorghum and millet.

2. Materials and Methods

2.1. Sample Procurement

Cereals (maize, millet and sorghum) and crayfish (*Procambarus clarkii*) were purchased from Gboko main market, Benue State, Nigeria.

2.2. Sample Preparation.

Ogi samples were prepared traditionally from maize, millet and sorghum following the method described by Odunfa [3]. Cereal grains were cleaned and then steeped in water for 48h. The steeped water was decanted and the grains wet-milled before sieving with muslin cloth. The pomace was then discarded and the suspension was allowed to sediment for 48h during which fermentation occurred. The *ogi* collected was sundried, sieved and stored in airtight containers.

Crayfish was processed into powder as described by Iombor *et al.* [11]. The process involved cleaning, sun drying, milling and sieving to obtain fine powder, after which it was packaged in an air tight container subsequent to further usage.

2.3. Blend Formulation

Crayfish powder was incorporated into the respective cereal-based *ogi* samples through material balancing [12] based on the protein contents of the individual food materials to achieve a targeted 13% protein food as recommended by the Protein Advisory Group [13] for toddlers (Table 1).

2.4. Determination of Proximate Composition

Moisture, fat, protein (% N x 6.25), ash and crude fibre contents were determined according to standard methods of AOAC [14]. Carbohydrate content was calculated by difference as described by Ihekoronye and Ngoddy [15].

2.5. Determination of Anti-nutritional Factors

Phytate, oxalate, saponins, tannins and trypsin inhibitor contents in the crayfish-blended *ogi* samples were determined using a spectrophotometer (Spectro Sc 20, Labomed, Inc. USA) [16]

2.6. Determination of Mineral Contents

Mineral determination was carried out by acid digestion according to AOAC [14]. The ash obtained after incineration at 500°C was dissolved in aquaregia (10mL nitric acid +30mL HCl) solution and boiled for 30min. The mixture was transferred into a 250mL volumetric flask and boiled again for 30min. The mixture was filtered into 100mL volumetric flask and made up to the mark with distilled water. The mineral concentration was determined using the Atomic Absorption Spectrophotometer (Model: 6405 UV/VIS, Jenway, UK).

2.7. Determination of Vitamins

Vitamin A, B_1, B_{12} and D were evaluated using HPLC (Model: BLC-10/11, BUCK Scientific, USA) techniques as described by AOAC [14]. For each sample, 3.0g was mixed with 5mL of n-hexane and 20mL of HPLC grade water. The mixture was homogenized at 12000 rpm and centrifuged (3500 x g) for 30 min. followed by sequential filtration through whatman No 1 filter paper and 0.45µm membrane. Then 15µL of the supernatant was injected into the HPLC equipped with a UV detector set at 254nm. The peaks of the vitamins in the samples were calculated in relation to the peaks of standard vitamins.

2.8. Determination of Molar Ratio of Anti-nutrients to Minerals

The molar ratio of anti-nutrients to minerals was obtained by dividing the mole of anti-nutrient with the mole of minerals [16]

2.9. Sensory Evaluation

Crayfish blended *Ogi* samples were processed into semi-solids ready for consumption and served to a 15-member panel comprising staff and students of the Department of Food Science and Technology, University of Agriculture, Makurdi, Benue State, Nigeria to evaluate attributes such as appearance, aroma, taste, mouth feel, and overall acceptability using a 9-point hedonic scale [17]

Table 1. *Blend ratio for crayfish incorporated Ogi (% dry weight).*

Sample	A	B	C
Maize *ogi*	87.89	-	-
Millet *ogi*	-	87.67	-
Sorghum *ogi*	-	-	89.23
Crayfish	12.11	12.33	10.77

2.10. Statistical Analysis

Data obtained was analysed using a one way of variance. Means were separated using Duncan's multiple range test and significance difference was accepted at 5% probability ($p < 0.05$).

3. Results and Discussion

3.1. Effect of Crayfish Inclusion on the Proximate Composition of Ogi

Results for effect of crayfish inclusion on the proximate composition of *Ogi* from maize, millet and sorghum are presented in Table 2. Significant differences ($p < 0.05$) were observed between all samples for moisture, crude fat, ash, protein and carbohydrate contents. The moisture content of the formulated *ogi* samples ranged from 10.84-12.05% and was highest with sorghum-based *ogi*. The moisture content of food gives an indication of its safety and microbial stability

[18]. Crude fibre, ash, carbohydrate and protein contents of the *ogi* blends compared favourably with the FAO/WHO [19] recommended values of <5% fibre, <3% ash, 64% carbohydrate and 13% protein. The low fibre content of the samples would permit substantial consumption during complementary feeding, thereby providing a greater opportunity to meet the daily energy and other vital nutrient requirements for children. The fat contents of the blends were lower than the FAO/WHO [19] recommended value (10-24%). This may be attributed to the effect of fermentation on the cereals. The results obtained in this study are comparable with findings of Ijarotimi and Keshinro [20].

3.2. Effect of Crayfish Inclusion on Vitamins Content of Ogi

Vitamin A content in all samples differed significantly ($p < 0.05$) with crayfish-blended maize *ogi* having the highest value of 8.39µg/100g and millet based *ogi* having the least value of 5.34µg/100g (Table 3). The vitamin A content of all samples fell short of the recommended dietary allowance (RDA) for children between the ages of 1 – 3 (210µg/day). This may be due to dilution effect from the cereal materials which are known to be deficient in vitamin A. Vitamin A is essential for improvement of vision and maintaining body tissues among many other functions [21]. There was no significant difference ($p > 0.05$) between all samples in vitamin B_1 content. The vitamin B_1 content of all samples met the recommended dietary allowance for toddlers (0.4mg/day). Vitamin B_1 (thiamin) is useful in the generation of energy from carbohydrates [22]. Vitamin B_{12} values of the *ogi* samples ranged from 0.50-0.54 mg/100g. Vitamin B_{12} is required for cellular metabolism of macro nutrients. It is also fundamental in the synthesis of blood cells in bone marrow [23]. The vitamin B_{12} content of all samples fell below the [RDA] of 0.7mg/day for toddlers as recommended by FAO/WHO [19].

Crayfish-blended sorghum *ogi* was highest in vitamin D content (0.27mg/100g) (Table 3). Vitamin D content of all samples met the RDAof 0.01mg/day for toddlers. Vitamin D aids in the absorption of calcium and its deficiency results in bone diseases such as rickets. The values obtained are consistent with those obtained by Solomon [24] on Nutritive value of three potential cereals-legume based complementary foods.

Table 2. *Effect of Crayfish Inclusion on the Proximate Composition of Ogi (% dry basis).*

Samples	**Moisture**	**Crude Fat**	**Ash**	**Crude Fibre**	**CHO**	**Protein**
A	11.16^b±0.02	4.10^b±0.05	2.80^a±0.10	2.79^b±0.01	78.18^c±0.01	12.13^b±0.02
B	10.84^c±0.10	3.00^c±0.20	2.62^b±0.03	2.87^a±0.20	78.64^b±0.10	12.87^a±0.01
C	12.05^a±0.03	4.36^a±0.01	2.44^c±0.07	2.80^b±0.05	79.34^a±0.01	11.06^c±0.01
LSD	0.01	0.01	0.01	0.01	0.02	0.01
FAO/WHO	<5	10-25	<3	<5	64	13

Values are means ± standard deviation of duplicate determinations.
Values in the column followed by the same superscript are not significantly different (p>0.05)
LSD: Least Significant Difference

Table 3. *Effect of Crayfish Inclusion on the Vitamin Content of Ogi.*

Samples	**Vitamin A (µg)**	**Vitamin B_1 (mg/100g)**	**Vitamin B_{12} (mg/100g)**	**Vitamin D (mg/100g)**
A	8.39^a±0.01	0.57^a±0.10	0.54^a±0.04	0.22^c±0.01
B	5.34^b±0.20	0.58^a±0.02	0.50^b±0.10	0.24^b±0.10
C	6.32^c±0.01	0.58^a±0.08	0.53^a±0.30	0.27^a±0.02
LSD	0.01	0.01	0.01	0.01

Values are means ± standard deviation of duplicate determination.
Values in the column followed by the same superscript are not significantly different (p >0.05)

3.3. Effect of Crayfish Inclusion on the Mineral Content of Ogi

Table 4 showed the effect of crayfish inclusion on the mineral composition of *Ogi* from maize, millet and sorghum. There was no significant difference ($p > 0.05$) in calcium content of the crayfish incorporated *ogi* samples from maize and sorghum as well as with millet and sorghum. Difference, however, existed between crayfish-blended maize and millet *ogi* samples. Calcium forms a major component of bones and assists in teeth development. It also plays a role in blood coagulation [25]. Iodine content in all samples ranged from 0.27 to 0.28mg/100g with no significant difference, although crayfish-blended maize ogi was highest. Iodine is required as a mandatory structural and functional element of thyroid hormones [26]. Its deficiency results in goitre. Iron content was significantly different in all the samples and was lowest with crayfish-blended millet ogi. Iron is essential for normal functioning of central nervous system and in the oxidation of carbohydrates, protein and fats [27]. Iron is also necessary for the formation of haemoglobin and also plays an important role in oxygen transfer in human body [28].

Although magnesium content was lowest with crayfish-blended millet, values were not significantly different. Magnesium is required for normal functioning of the muscle and nervous systems, helps in supporting a healthy immune system, keeps bone strong and helps in regulating blood sugar levels, thereby promoting normal blood pressure [29].

Values for manganese ranged from 0.15-0.19 mg/100g with crayfish-blended maize *ogi* significantly ($p<0.05$) different from those of millet and sorghum *ogi*. This variation may be due to the respective composition in parent cereal material. Manganese helps in developing healthy bone structure and creation of essential enzymes for building bones. It also acts as a co-enzyme to assist metabolic activity in the human body. Other benefits include the formation of connective tissues, absorption of calcium, proper functioning of the thyroid gland, regulation of blood sugar level and metabolism of fats and carbohydrates [27].

Phosphorous and Zinc contents ranged from 0.86 to 0.89mg/100g and 1.28 to 1.34mg/100g respectively. In a similar manner, phosphorus and zinc contents of crayfish-blended millet *ogi* were significantly different from those from maize and sorghum based *ogi*. Zinc is an essential trace element and plays an important role in various cell processes including normal growth, brain development, behavioural response, bone formation and wound healing [30].

Mineral composition values fell below the FAO/WHO [19] recommended values for toddlers. This could be attributed in part to the low amount of crayfish added in the blend and also to the low mineral contents of the cereals.

Table 4. *Effect of Crayfish Inclusion on the Mineral Content of Ogi (mg/100g).*

Samples	Calcium	Iodine	Iron	Magnesium	Manganese	Phosphorus	Zinc
A	$0.14^{a}\pm0.11$	$0.28^{a}\pm0.03$	$1.43^{a}\pm0.01$	$0.13^{a}\pm0.07$	$0.15^{b}\pm0.01$	$0.89^{a}\pm0.01$	$1.34^{a}\pm0.02$
B	$0.12^{b}\pm0.05$	$0.27^{a}\pm0.10$	$1.33^{c}\pm0.11$	$0.12^{a}\pm0.03$	$0.19^{a}\pm0.20$	$0.86^{b}\pm0.02$	$1.28^{b}\pm0.10$
C	$0.13^{ab}\pm0.10$	$0.27^{a}\pm0.02$	$1.41^{b}\pm0.01$	$0.13^{a}\pm0.05$	$0.18^{a}\pm0.13$	$0.89^{a}\pm0.01$	$1.33^{a}\pm0.04$
LSD	0.01	0.01	0.01	0.01	0.01	0.03	0.01
FAO/WHO	500	65	16	76	32	456	3.2

Values are means ± standard deviation of duplicate determinations.
Values in the column followed by the same superscript are not significantly different (p>0.05)
LSD: Least Significant Difference

3.4. Effect of Crayfish Inclusion on Anti-nutritional Factors in Ogi

Significant differences ($p <0.05$) in oxalate concentration between crayfish-blended *ogi* samples were recorded (Table 5). Maize based *ogi* was highest (1.24mg/100g) in oxalate concentration probably due to concentration in parent cereal. Similar results were recorded by Ijarotimi *et al*. [20]. Oxalates bind calcium present in food, thus rendering it unavailable for body utilization. They also precipitate protein around body tissues [31]. There was no significant difference ($p >0.05$) in the phytate content between all the samples with values ranging between 1.37 to 1.39mg/100g. Phytates have been reported to form indigestible complexes with minerals, thereby decreasing the bioavailability of these minerals [32]. Saponin and tannin concentrations of the samples varied significantly ($p <0.05$) with values ranging from 0.70mg/100g to 0.79mg/100g and 116.8mg/100g to 121.0mg/100g respectively. Growth stagnation has been associated with high levels of tannins in foods [33]. No significant difference was observed for trypsin inhibitor contents between the crayfish incorporated *ogi* samples from maize and millet. Values were higher than those reported by Folake *et al.* [34] using rice-based *masa*, soybean and crayfish.

3.5. Molar Ratios of Anti-nutrients to Minerals in Crayfish-Blended Ogi

The molar ratios of calcium, zinc, iron, oxalate, and phytate were calculated as an index of bioavailability of dietary minerals (Table 6).

3.5.1. Phytate/ Calcium

The Phytate: Calcium molar ratio has been proposed as an indicator of Ca bioavailability [35]. Phytic acid has been identified as a major contributor to decreasing calcium bioavailability. Ratios obtained in this study were higher in all samples than the critical toxicity value (< 0.24), indicating inhibitory action of phytates on calcium.

3.5.2. Phytate/ Iron

Phytate: Iron molar ratios greater than 0.15 are indicative of poor iron bioavailability [36]. Results from this study in terms of phytate: iron molar ratios of all the samples were less than the critical value, implying a likelihood of good iron absorption when ingested.

3.5.3. Phytate/ Zinc

The importance of foodstuffs as a source of dietary zinc depends on both the total zinc content and the level of other constituents in the diet that affect zinc bioavailability. Values for phytate: zinc molar ratio were lower than the critical molar ratios of Phy:Zn, indicating good availability of zinc. Phytate: zinc molar ratio is considered a better indicator of zinc bioavailability than total dietary phytate levels alone [37].

3.5.4. Oxalate/ Calcium

The importance of oxalate contents of an individual plant product in limiting total dietary calcium availability is of significance only when the ratio of Oxalate: calcium is greater than 1 [38]. Bioavailability of calcium from the study was acceptable. Values were lower scores than the critical value of 1. Oxalic acid and its salts can have deleterious effects on human nutrition and health, particularly by decreasing calcium absorption and aiding the formation of kidney stones [39].

3.5.5. (Phytate) (Calcium)/ (Zinc) Molar Ratios

The potential effect of calcium on zinc absorption in the presence of high phytate intakes has led to the suggestion that the (Phy) (Ca)/ (Zn) millimolar ratio may be a better index of zinc bioavailability than the [Phy]/ [Zn] molar ratio alone. In this study, the values of (Ca) (Phy)/ (Zn) millimolar ratios of all the samples were lower than the critical level (0.50).

Table 5. *Effect of Crayfish Inclusion on the Anti-nutritional Composition of Ogi (100g/mg).*

Samples	Oxalate	Phytate	Saponins	Tannins	Trypsin Inhibitor
A	1.24^{a}±0.120	1.39^{a}±0.01	0.79^{a}±0.02	120.40^{b}±0.03	0.81^{a}±0.06
B	1.07^{c}±0.08	1.37^{a}±0.10	0.76^{b}±0.10	116.80^{c}±0.01	0.72^{b}±0.01
C	1.13^{b}±0.20	1.33^{a}±0.06	0.70^{c}±0.03	121.00^{a}±0.01	0.73^{b}±0.03
LSD	0.01	0.07	0.01	0.01	0.01

Values are means ± standard deviation of duplicate determinations.
Values in the column followed by the same superscript are not significantly different (p>0.05)
LSD: Least Significant Difference

Table 6. *Molar Ratios (mol/kg) Anti nutrients to Minerals in Ogi.*

Samples	Phytate: Ca	Phytate: Fe	Phytate: Zn	Oxalate: Ca	(phytate x Ca): Zn
A	0.602	0.102	0.082	4.025	0.004
B	0.692	0.105	0.087	4.052	0.003
C	0.620	0.098	0.080	3.950	0.003
Critical value	0.24	0.15	10.00	1.00	0.50

3.6. Effect of Crayfish Inclusion on the Sensory Characteristics of Ogi

While significant differences (p <0.05) were observed between samples for appearance and mouth feel, there was no difference in terms of aroma, taste and general acceptability (Table 7). The similarities in aroma, taste and general acceptability could be attributed to the contribution of crayfish. Crayfish has a characteristic aroma and taste which it impacts on foods. Differences in appearance and mouth feel could be due to the characteristic parent cereal material.

Table 7. *Effect of Crayfish Inclusion on the Sensory attributes of Ogi.*

Samples	Appearance	Aroma	Taste	Mouth feel	General Acceptability
A	7.75^{a}	7.50^{a}	7.05^{a}	7.05^{a}	7.50^{a}
B	6.65^{b}	7.10^{a}	6.85^{a}	6.60^{b}	6.85^{a}
C	6.70^{b}	7.10^{a}	7.75^{a}	7.75^{ab}	6.80^{a}
LSD	0.77	0.89	0.89	0.77	0.84

Values in the column followed by the same superscript are not significantly different (p>0.05)

4. Conclusion

Crayfish inclusion imparted positively on the nutritional value of *ogi*, making it a good source of nutrients for both weaning infant and adults. The anti-nutritional factors in the formulated *Ogi* samples were low, implying a high bioavailability of its mineral with the exception of calcium. The sensory data also revealed that all the formulated food samples were generally accepted.

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