TOWARD IMPROVING ECONOMIC DEVELOPMENT OF PEARL MILLETS- *OGI*: EFFECTS OF GARLIC AND/OR GINGER ADDITION ON FLOUR'S FUNCTIONAL PROPERTIES AND GRUEL'S PHYSICOSENSORY PROPERTIES

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Abstract
There is increasing awareness on the consumption of ancient or lesser grains, such as pearl millets by consumers in the sub-Saharan Africa regions. Effects of complimenting Ogi prepared from pearl millets with garlic and ginger (at 2% and 4%, singly and when combined) were investigated. Ogi flour was analysed for its functional properties (bulk density, water absorption capacity, and swelling capacity). The cooked Ogi (gruel) was analysed for their physicochemical properties (pH, total titratable acidity, and specific gravity) and sensory quality, using standard procedures. Addition of garlic and ginger into Ogi increased the bulk density significantly, at 2% and 4% (singly and when combined). Conversely, water absorption capacity of the Ogi flour decreased with the addition of garlic or ginger and when combined. However, the swelling capacity of flour increased with the addition of combined garlic and ginger (2%-4%) into Ogi. The physicochemical properties determined which were pH, total titratable acidity and specific gravity, increased significantly. Sensory attributes including aroma, viscosity, mouth feel, aftertaste and residual particles of gruel differed significantly with ginger and garlic addition. Thus, gruel with 4%garlic+4%ginger had the highest overall acceptability score and the consumers showed higher preference to willing-to-buy the product over others. Reduced viscosity observed in the gruel containing garlic or ginger singly suggested that it could be an appropriate meal for the weaning, aged and the sick. Increasing utilization of pearl millet for food products would have enhance more value-added products, promote food security and economic development with more income generation.
***Keywords**: Garlic, ginger, gruel, ogi, pearl millet, sensory quality*

Introduction
There is a greater awareness in the food products from ancient and lesser grains such as pearl millets in the developing nations of Africa and Asia. Pearl millet is a significance cereal crop assumed to originate from West Africa and presently distributed beyond this region into the semi-arid regions of Africa and Asia. Nigeria, Niger and Mali are the major producers in the sub-Saharan Africa, with production volumes between the years 2016 and 2020 ranged from 3038 to 3,886,079 tons/year (FAOSTAT, 2022). The crop is rich in essential minerals like copper, iron, magnesium, phosphorus, selenium and zinc (Banwo, Oyeyipo, Mishra, Sarkar, & Shelty, 2022). Millet drink, *fura*, o*gi*, *Ben-kida*, *Ajon*, *Bushera*, and *Uji* are common staple foods in the sub-Saharan Africa (Bamidele, Adebowale and Xi, 2022). Pearl millet (14.5%) is comparable to wheat (14.4%) in terms of proteins and is associated with a more complete essential amino acids (Bombom, Kawesi, Walugembe, Bhebhe & Maphosa, 2023). Millets generally is a climate-resilient crop that has the potential to fight hunger and malnutrition, contribute to contribute to healthy diets and nutritious foods. Furthermore, millets are capable of improving livelihoods of people through new market opportunities (Taylor et al., 2022). The above-stated qualities exhibited by millets in-general, may be the reason why the Food and Agriculture Organization (FAO) of the United Nations named year 2023 as the International Year of Millets. Greater consumption of pearl millet diets can promote human's health and can also offer opportunities to farmers to improve food and nutritional security in sub-Saharan Africa. In view of the above consideration, could millet complemented with garlic and ginger powder separately or when combined be acceptable to the consumer?

Ogi is a fermented cereal slurry that is consumed after cooking the slurry on open fire, basically from wood. This cooking operations involves diluting the semi-solid starch sediment obtained after the wet-sieving of fermented cereal grains, is reconstituted to desired consistency with cool water and cooked in boiling water (Adebowale & Adeyanju, 2022). Literature has it that, sweetened the gruel is at consumers discretion with sucrose or honey but for satisfaction, most consumers enjoyed to compliment *Ogi* with various legume pudding and snacks like robo (fried-melon meal cake), and occasionally with spiced green-leafy vegetable (Adebowale & Adeyanju, 2022). The consumption of the gruel has becomes a tradition in Nigeria and the neighboring Francophone in the West Africa sub-regions, especially during fasting and weaning periods, and by the sick, aged or old. Comprehensive processing operations of *Ogi* have been reported (Ladunni, Aworh, Oyeyinka, Oyeyinka, & Adebo, 2020).

The effects of complementing cereal-based gruels with different amount spices such as garlic and ginger (Adebowale & Adeyanju, 2022). Garlic and ginger in particular are noted for their refreshing, pleasant and aroma nature, these unique properties perhaps make these spices essentially indispensable ingredients in most traditional diets. These spices are reportedly embedded with constituents that are capable to scavenge free radicals, and thus have the ability to confer health benefits to human. Adebowale and Adeyanju (2022) evaluated the physico-sensory properties of *Ogi* from sorghum that was complemented with garlic and ginger. The authors found that, at 2% garlic + 4% ginger addition in *Ogi* led to a steady decrease in bulk density and viscosity of the cooked gruel. This investigation further strengthened and affirm the previous study reported by Olaniran, Abiose, Adeniran, Gbadamosi and Iranloye (2020). Both authors concluded that, *Ogi* prepared from maize and sorghum could be ideal breakfast meal suitable for aged, sick and weanling. The literal and scientific explanations for its suitability for the vulnerable group could be that, *Ogi* can be drink or swallowed with ease due to the low viscosity. An improvement in flour functionality and physicosensory properties of *Ogi* from pearl millets to promote food and nutritional security as well economic development is worthy studying.

While a lot has been studied on *Ogi*, information is not adequate on the effects of compliment *Ogi* prepared from pearl millet with garlic and ginger, separately or when combined. Therefore, this study investigated the effects of complimenting *Ogi* from pearl millet with garlic and ginger on flour properties and the physicosensory properties (pH, Total titratable acidity, specific gravity and sensory quality) with the aims of improving economic development of pearl millet

Materials and Methods

Sources of materials

Pearl millet grains, garlic bulbs and ginger rhizomes used for the study were purchased from a retail market at Abeokuta, Ogun state in Nigeria. Processing operations of all the materials were conducted the Food Processing and Engineering Workshop and analysis on flours and products were carried out in the Food Chemistry Laboratory, The Federal polytechnic Ilaro.

Processing of Pearl millet grains with added garlic and ginger into gruel

Unprocessed pearl millet grains and the spices (garlic and ginger) were sorted to remove dirt, stones and empty kernels. Exactly 5 kg were soaked in 10 L of portable water and fermented for a period of 72 h at 27±2 °C. Using a laboratory-based hammer mill, the fermented mass was milled with garlic and ginger, based on the formulations. The milled mass was wet-sieved using the muslin clothe and sufficient quantity of water, separating the filtrate (starch suspension) and the residue. The starch suspension was settled for about 24 h and the supernatant was removed. The starch left was de-watered using a mechanical press to achieve the cake. The cake was pulverized to reduce the particle size and facilitate drying. The cake was dried in a cabinet dryer at 60 °C for 5 hours, and milled to flour of 500 µm particle size, then packaged and kept at -20 °C till for further use and analyses.

Formulation of samples

Ogi samples were formulated with addition of the spices (garlic and ginger), separately and when the spices are mixed at 2% and 4% levels. Ogi without any of the spices is used as the control sample. The formulated samples are shown below:

Table 1: Formulation of Dried Ogi with spices in Different Proportions

Sample	Spices (%)	
	Garlic	Ginger
Ogi (gruel) only-the control	0	0
Ogi+2%garlic	2	0
Ogi+4%garlic	4	0
Ogi+2%ginger	2	0
Ogi+4%ginger	4	0
Ogi+2%garlic+2%ginger	2	2
Ogi+2%garlic +4%ginger	2	4
Ogi+4%garlic +2%ginger	4	2
Ogi+4%garlic+4%ginger	4	4

Analyses

Determination of flours' Functional Properties

The functional properties were carried out of the dried Ogi samples as described previously (Bamidele, Fasogbon, Oladiran & Akande, 2015). Water absorption capacity (WAC): With 2 g sample inside a centrifuge tube, 30 mL of hot water (70 ±2°C) was added and vortexed for 10 min on two occasions at intervals. The vortexed suspension was then centrifuged instantly at 4100 xg for a period of 15 min at 22-25 °C. After the centrifugation process, the supernatant was removed and solid left was weighed, and WAC was calculated. The swelling capacity was determined with nearly 2.5 g of dried *Ogi* into a centrifuge tube with 40 ml of water were added, and heated to 80 °C for 10 min. The heated sample was cold-centrifuged at 4100 xg for 15 min. The dried portion was weighed and the swelling capacity was calculated. The bulk density was estimated with 10 g of dried *Ogi* sample was weighed into a-25 ml capacity cylinder, by tapping gently the cylinder on the edge of the lab bench allowing the volume of the content remained unchanged. Change in volume of the sample was recorded as the bulk density (g/ml).

Determination of the pH, total titratable acidity and specific gravity of gruel

The pH of each sample was measured with an automatic pH meter. Total titratable acidity was determined with 10% suspension of the sample and titrated against 0.1 M $NaOH_{(aq)}$ with phenolphthalein indicator. A pink colour appearance marked the end of titration. Each ml of 0.1 N NaOH used was equivalent to 90.08 mg of lactic acid. The specific gravity of the sample was estimated by using the density bottle technique. The weight of the dry and empty density bottle was determined. The density bottle was filled with gruel avoiding bubbles. In a thermo-regulated water bath, the temperature of the bottle and contents was adjusted to 20 °C (Jude-Ojei, Ajayi, & Ilemobayo, 2017).

Preparation of pearl millet gruel

The gruel was prepared by cooking the suspension of (80 g dried Ogi flour into 200 ml cold water) in a stainless-steel pot containing 600 ml of boiling over a hot plate. The mixture is continuously stirred with a silicone paddle to prevent lumping (Adebowale, Taylor and de Kock, 2020).

Sensory evaluation of pearl millet gruels

A panel member of 45 volunteers, comprising of 22 males and 23 females; aged between 17 and 53 years from the polytechnic staff and students were selected. The panels most of whom are regular consumers of gruels, were screened. Gruels were kept 50 °C in an electrically-operated water bath. About 40 g of sample was measured into a glass ramekin and blind-coded. The glass was covered with aluminum foil. A ample at a time was presented for evaluation for two sessions. Filtered water was given to the panels to cleanse the palate during and in-between evaluation. Sample viscosity is evaluated by taken a teaspoon full and chew in the mouth. A-2 session evaluation was conducted at 30 min/session, for sensory attributes including colour, taste, aroma, viscosity, mouth feel, aftertaste and residual particles. A scale of 9- point hedonic scores ranging from minimum value of 1= dislike extremely to maximum value of 9 = extremely, was used for the evaluation (Adebowale et al., 2020).

Statistical analysis

Unprocessed experimental data obtained from the flours' functional and gruel's physico-sensory properties were subjected to one-way analysis of variance (ANOVA). The results were presented as mean and standard deviations of replicate determinations. Means obtained were classified by Tukey's HSD Test at $p < 0.05$ significance level with XLSTAT software for windows version 2018.

Results

Functional properties of dried pearl millet-*Ogi*

Table 2 shows the effects of garlic and ginger addition into pearl millet-*Ogi*, on the functional properties of dried *Ogi*. The functional properties were determined in terms the bulk density, water absorption capacity and swelling capacity. Flours' bulk density, water absorption capacity and swelling capacity were significantly (p<0.05) different. The values of bulk density and swelling capacity increased in samples containing garlic or ginger, singly and when combined, whereas the water absorption capacity decreased steadily from the control to those containing garlic or ginger.

Table 2: Effect of Garlic and Ginger addition into Pearl millet-*Ogi* on the Functional Properties of Flour

Samples	Functional properties		
	Bulk Density (g/ml)	Water	Swelling Capacity

		Absorption Capacity (%)	
Ogi (gruel) only	0.67±0.02[cd]	184.4±2.8[b]	3.76.5±0.01[g]
Ogi+2%garlic	0.68±0.01[cd]	180.3±2.1[d]	4.78±0.03[e]
Ogi+4%garlic	0.71±0.04[bcd]	175.7±2.1[f]	4.17±0.01[c]
Ogi + 2%ginger	0.68±0.02[cd]	181.5±2.1[c]	3.94±0.04[f]
Ogi +4%ginger	0.72±0.03[bc]	171.3±6.4[g]	4.23±0.02[b]
Ogi +2 garlic+2%ginger	0.87±0.02[a]	166.5±3.5[h]	4.24±0.03[b]
Ogi +2%garlic+4%ginger	0.71±0.07[bcd]	186.7±1.4[a]	4.38±0.05[a]
Ogi + 4 garlic+2%ginger	0.74±0.06[b]	177.3±5.6[e]	3.64±0.01[h]
Ogi +4%garlic+4%ginger	0.89±0.03[a]	156±2.8[i]	4.08±0.08[d]
p-value	<0.0001	<0.0001	<0.0001

Values are means and standard deviation (n=3). Means with same letter(s) within the column are not significantly ($p<0.05$) different.

Physicochemical properties of gruel made from dried pearl millet-*Ogi*

Table 3 shows of effects of ginger and garlic addition into pearl millet-*Ogi* on the physicochemical properties measured as pH, titratable acidity and specific gravity of gruel. The parameters of the physicochemical properties were all significantly ($p<0.05$) different. The all the parameters measured were significantly different. However, the order of significance is TTA<<<pH<<SG i.e. the specific gravity is highly significant parameter than the pH and TTA. The pH, TTA and specific gravity ranged from 6.22-6.37, 0.35-0.80 and 76.5-76.9 respectively.

Table 3: Effect of Ginger and Garlic addition into Pearl millet-*Ogi* on the Physicochemical Properties of gruel

Samples	Physicochemical properties		
	pH	**Total Titratable Acidity**	**Specific Gravity**
Ogi (gruel) only	6.29±0.06[abc]	0.30±0.14[bc]	76.5±0.1[d]
Ogi+2%garlic	6.20±0.01[d]	0.35±0.07[bc]	76.8±0.3[ab]
Ogi+4%garlic	6.32±0.05[ab]	0.60±0.05[ab]	76.8±0.1[ab]
Ogi + 2%ginger	6.37±0.02[a]	0.50±0.28[abc]	76.7±0.4[c]
Ogi +4%ginger	6.31±0.06[ab]	0.50±0.14[abc]	76.5±0.2[d]
Ogi +2 garlic+2%ginger	6.32±0.00[ab]	0.20±0.02[c]	76.9±0.3[ab]
Ogi +2%garlic+4%ginger	6.22±0.01[cd]	0.20±0.03[c]	76.8±0.5[ab]
Ogi + 4 garlic+2%ginger	6.25±0.04[bcd]	0.85±0.21[a]	76.9±0.1[a]
Ogi +4%garlic+4%ginger	6.22±0.03[cd]	0.80±0.28[a]	76.7±0.08[c]
p-value	0.019	0.024	0.0001

Values are means and standard deviation of three determinations. Means with same letter(s) within the column are not significantly ($p<0.05$) different.

Sensory evaluation of pearl millet gruel prepared from dried pearl millet-*Ogi*

Table 4 shows the sensory attributes of the gruel prepared from pearl millet-*Ogi*, with garlic and ginger. The gruel samples containing the spices (alone and when they are combined) were significantly ($p<.05$) different and have better scores than that without garlic or ginger. The overall acceptability of the gruel with spices was higher when compared with the control (without garlic or ginger).

Table 4: Effects of garlic and ginger addition into pearl millet-*Ogi* on the sensory attributes of gruel.

Samples	Sensory attributes								Willingness-to-buy
	Colour	Taste	Aroma	Viscosity	Mouthfeel	After taste	Residual Particle	Overall acceptability	
Ogi (gruel) only	7.2±0.6[ab]	7.0±1.13	6.8±0.7[bc]	7.0±1.1[bc]	7.2±1.1[abc]	7.2±1.2[a]	6.9±1.0[b]	7.2±1.0[abc]	6.8±0.9[c]

Ogi+2%garlic	6.6±0.8^{b}	6.9±0.96	6.3±0.9^{c}	6.6±0.8^{c}	6.4±0.9^{d}	6.4±0.9^{b}	6.1±0.6^{c}	6.5±0.7^{d}	6.8±1.0^{c}
Ogi+4%garlic	6.8±0.7^{b}	7.2±0.94	6.7±0.7^{bc}	6.7±0.7^{c}	7.0±1.1^{bcd}	6.9±0.8^{ab}	6.7±0.9^{bc}	7.4±0.9^{abc}	7.2±0.5^{abc}
Ogi + 2%ginger	6.8±1.3^{b}	7.1±1.25	6.8±1.1^{bc}	6.8±0.8^{bc}	6.8±1.1^{bcd}	6.8±1.0^{ab}	6.8±1.0^{bc}	6.8±0.9^{cd}	6.8±1.1^{c}
Ogi +4%ginger	7.0±1.2^{ab}	7.0±1.16	6.8±0.9^{bc}	6.8±1.2^{bc}	7.0±1.0^{bcd}	6.8±1.3^{ab}	6.8±0.9^{b}	7.0±0.8^{bcd}	7.0±0.8^{bc}
Ogi +2 garlic+2%ginger	6.7±1.2^{b}	7.0±1.13	6.3±0.9^{c}	6.8±0.8^{bc}	6.6±1.3^{bcd}	6.7±1.2^{ab}	7.0±1.0^{ab}	7.0±1.4^{bcd}	6.9±1.2^{bc}
Ogi +2%garlic+4%ginger	7.2±0.9^{ab}	7.2±1.10	6.7±0.8^{bc}	7.0±0.9^{bc}	6.5±0.8^{cd}	6.9±1.2^{ab}	6.8±1.1^{b}	6.8±1.0^{cd}	7.0±1.0^{abc}
Ogi + 4 garlic+2%ginger	7.2±0.8^{ab}	6.9±0.88	7.1±1.0^{ab}	7.4±0.8^{ab}	7.3±1.1^{ab}	7.0±1.1^{ab}	7.1±1.0^{ab}	7.5±1.1^{ab}	7.6±0.9^{ab}
Ogi +4%garlic+4%ginger	7.7±0.46^{a}	7.4±0.91	7.6±0.9^{a}	7.8±0.8^{a}	7.9±0.4^{a}	7.4±0.5^{a}	7.6±0.8^{a}	7.9±0.7^{a}	7.7±0.7^{a}
p-value	0.052	0.947	0.011	0.010	0.003	0.327	0.014	0.007	0.055

Discussion

The lower pH values (Table 3) of gruel may suggested the presence of acid-production by microorganisms that are present in the fermenting mass of pearl millet. This result agreed with the findings of Adebowale and Adeyanju (2022) on low pH in gruel, which could be associated to the lactic acids that are produced during fermentation by microorganisms, mostly the lactic acid-producing bacteria (Adeyanju, Krugar, Taylor, & Duodu, 2019). The increase in total titratable acidity with gruel samples containing garlic and/or ginger suggests that the potency antimicrobial activities of both spices. This could cause a reduction in the population of microorganisms that might exist in the samples. Another probable explanation for an increase in the total titratable acidity could be due to slight fermentation that takes place during the preparation of the gruel (Adeyanju et al., 2019). This finding agreed with the earlier reports documented (Olaniran et al., 2019; Adebowale & Adeyanju, 2022). Decreasing specific gravity of gruel samples could be because of reduced grain matter for certain volume despite increase with moisture content.

The sensory evaluation results indicated that, the sample with 4% garlic + 4% ginger combination has the highest preference by the rating from the panels. So, the addition of ginger and garlic was able to mask and improve the sensory attributes of fermented pearl millet gruel. The masking of the original aroma of pearl millet could be as a result of the release of some volatile compounds (Li et al., 2016). To the panels, sample containing 4% garlic only has a stronger flavour of garlic, which the panels did not like, and hence the consumer preference is least. The strong flavour associated with garlic could be allergy or objectionable to some consumers. Consequently, addition of garlic into foods at a higher concentration may not be acceptable to all the consumers, especially those that are allergic to it. This could eventually lead to product rejection by the consumers or product failure, despite its health-promoting potential cited in literature. Garlic and ginger are reportedly as good sources of antioxidants and mineral elements (Ryu & Kang, 2017), that could be incorporated into diets because of their ability to promote human health. Therefore, the addition of garlic and ginger to gruel have the potential to improve the sensory quality of gruel or porridge, at an acceptable level. This assertion agrees with the reports of Olaniran et al., 2019 and, Adebowale and Adeyanju, 2022.

Conclusion

Complimenting garlic and ginger to fermented pearl millet grains at a combination of 4% garlic+ 4% ginger, and wet-milled led to a decrease in flour bulk density and improvement in the sensory quality of gruel. Reduction in flour bulkiness and improve mouth feel of gruel with a combination of 4% garlic+ 4% ginger, suggests that the sample will produce less viscous gruel. There is an improvement in sensory attributes and the overall acceptability of the gruel with 4% garlic+ 4% ginger. Thus, gruel with 4%garlic+4%ginger had the highest overall acceptability score and the consumers showed higher preference to willing-to-buy the product over others. Reduction in viscosity of the gruel containing garlic or ginger singly, suggests that it could be an appropriate meal for the weaning, aged and the sick. Increasing utilization of pearl millet for food product can enhance more value-added products, promote food security and economic development with more income generation for the farmers and the Nation at large.

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