Nutritional characteristics and sensory properties of maize-based *ogi*supplemented with mushroom (*Pleurotusostreatus)* flour

ABSTRACT

The study evaluates the effect of supplementation of maize-based *ogi* with mushroom (*Pleurotusostreatus)* flour on nutritional characteristics and sensory properties. Standard processing and analytical methods were used in raw material preparation and analyses.*Ogi* and mushroom flour were blended in ratio of 100:0, 90:10, 80:20, 70:30 and labeled A, B, C and D respectively. A commercial maize based complementary food was used as control. There was significant difference ($p < 0.05$) among all samples for all the Vitamin assayed with values ranging from 4.86 to 9.06 (µg/100g), 0.32 to 1.09 mg/100 g, 0.22 to 0.69 mg/100 g, 3.82 to 13.03 mg/100 g and 0.13 to 1.12 mg/100 g for vitamin A, B_1, B_2, B_3 and C. The vitamin values compare favourably with that of control sample. Significant ($P<0.05$) difference exists across the samples for Zn, Mg, Fe, K and Ca with values ranging from 1.12 to 1.71 mg/100 g, 37.7 to 102 mg/100 g, 4.72 to 13.23 mg/100 g, 23.05 to 125.3 mg/100 g and 125.5 to 160.25 mg/100 g respectively with corresponding higher values for control sample. Result showed negligible amounts of anti-nutritional factors ranging from 0.29 to 0.36 mg/100 g, 0.02 to 0.03 mg/100 g, 0.03 to 0.06 mg/100 g and 0.56 to 0.83 mg/100 g for phytate, oxalate, trypsin inhibitor and tannin respectively. The functional properties of the flour blends values ranged from 0.58 to 0.72 g/mL, 0.99 to 2.2 g/g, 5.21 to 8.94 g/g, 1.75 to 3.72 mL/g and 5.5 to 9.0% for bulk density, water absorption capacity, water retention capacity, swelling capacity and least gelation concentration respectively. Sensory scores revealed substantial overall acceptability of the samples. The quality of *ogi*samples were greatly improved by mushroom supplementation and could be nutritional beneficial to children and adults.

Key words:Maize,mushroom, nutritional, *Ogi*, supplementation

1.0 INTRODUCTION

"In developing countries, malnutrition is still a serious health problem affecting infants and young children"[1, 2]."It is globally reported as of 2012 that malnutrition resulted to 165 million stunted, 99 million underweight, and 51 million wasted children with 53% estimated childhood deaths" [3]."Though causes of malnutrition are diverse and interrelated, inadequate dietary intake during the complementary feeding period is considered to be major contributing factor (UNICEF, 2013)"[4]. In most cases, cereal and its products are utilized as staple food during complementary feeding. However due to poor nutritional profile of cereals and their product, it might be difficult to attain the nutritional adequacy of infants and children during complementary feeding. In Nigeria, the common cereal based food used during the complementary feeding period is *ogi.*

"Ogi is a fermented gruel and is popular weaning and breakfast cereal in sub-Saharan Africa traditionally made from maize, sorghum or millet" [2, 5]. "It is a highly energy-dense product used as a weaning food. Traditionally *ogi*is prepared by steeping maize, millet or sorghum in water (1-2 days), followed by wet-milling, wet-sieving and fermentation for 2- 3 days" [3-4, 6, 7]. "The nutritional composition of *ogi* is mainly starch and it is low in protein, vitamins and minerals. Efforts to improve the nutritional status of *ogi* have therefore been based on fortification with legumes to provide the deficient amino acids without much attention to other protein and micronutrient source as mushroom". [8]

Oyster mushrooms otherwise known as *Pleurotus* species are fungi with distinct fleshy fruiting bodies. They are reported to be excellent sources of protein and micronutrients which can impact the nutritive value of food through supplementation. Despite its abundant availability and nutritive value, oyster mushroom has been grossly underutilized in Nigeria.

"Ogi has been implicated in the prevalence of Protein Energy Malnutrition and micronutrients malnutrition due to its high energy density, reduced protein and micronutrients. This has called for several research attempts based on legumes and some animal protein sources with little research on high quality sources

like mushroom". [9] The study was aimed to evaluate the effect of mushroom inclusion on the quality of maize based *ogi.*

2.0 MATERIALS AND METHODS.

2.1 Raw Material Procurement

Maize (*Zea mays*) was obtained from Wadata market, Makurdi and oyster mushroom was obtained from Oracle Farms Makurdi, Benue State, Nigeria(N 7° 21' 2.9736", E 8° 50' 10.5936").

2.2 Sample Preparation

Ogi and mushroom flour were prepared as described by Akingbala*et al.,*[10] with slight modification. The maize grains were sorted cleaned and steeped in warm water for 72h. The steeped grains were thoroughly washed and wet-milled into paste using local disc attrition mill before sieving using muslin cloth. The suspension was allowed to settle for 48h during which fermentation occur. The supernatant was decanted and the *ogi* was collected, oven dried, blended using FoshanGeuwa KD-313B blender and stored in air-tight container for further usage.
Fresh and clean oyster mushroom was weighed and dice into small pieces with stainless steel knife. The diced mushroom was blanched, oven dried and blended using FoshanGeuwa KD-313B blender and stored in air-tight container for further usage.

2.3 Blend formulation

The *ogi*flour was measured into different weights: 100g, 90g, 80g and 70g. The mushroom flours were measured into weights: 10g, 20g, and 30g respectively. The samples were mixed into proportions of 100:0, 90:10, 80:20, and 70:30 for *ogi*-mushroom, respectively. Each combination represents samples A, B, C and D respectively(Table 1)

2.4 Methods

2.4.1 Determination of mineral content

Mineral determination was carried out by acid digestion according to AOAC [11]. "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)". [11]

2.4.2 Determination of vitamin content

Vitamin A, B1, B2, B3 and C were evaluated using HPLC (Model: BLC-10/11, BUCK Scientific, USA) techniques as described by AOAC [11]. 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.

2.4.3 Determination of Anti-nutrients

"Phytate, oxalate, saponins, tannins and trypsin inhibitor contents in the crayfish-blended ogi samples were determined using a spectrophotometer (SpectroSc 20, Labomed, Inc. USA)"[12]

2.4.4 Determination of functional properties

Determination of bulk density

This was determined using the method described by [11]. About 2.5 g of sample was filled in a 10 ml graduated cylinder and its bottom tapped on the laboratory bench until there was no decrease in volume of the sample. The volume was recorded.

$$\text{Bulk density} = \frac{weight\ of\ sample\ (g)}{volume\ of\ sample\ (ml)} \quad (1)$$

2.4.4.1 Determination of swelling capacity

Swelling capacity was determined according to the method of Onwuka,[13]. About 100 mg of the sample was mixed with 10 ml of distilled water in a calibrated cylinder at room temperature. After equilibration for 18hr, the bulk volume was recorded and swelling capacity expressed as volume occupied by sample per gram of original sample dry weight**.**

$$\text{Swelling capacity (\%)} = \frac{change\ in\ volume\ of\ sample}{original\ weight\ of\ sample} \quad (2)$$

2.4.4.2 Water absorption capacity

WAC was determined following the methodology ofRobertson et al. [14] 0.5g of sample was weighed in a test tube and an excess of water (10mL) was added. The mixture was agitated and left to hydrate for 30min. After centrifugation at 1650 r/min for 10 minutes the mixture was left to settle and to separate the supernatant. Finally, the sediment was weighed. The WAC was calculated as follows**:**

$$\text{WAC} = \frac{sediment\ \ weight\ (g) - weight\ (g)}{sample\ \ weight} \quad (3)$$

2.4.4.3 Gelation Concentration

Flour samples suspensions of 2-20% was prepared in distilled water and vortexed for 5minutes. 10ml of prepared dispersions was transferred into a test tube. The tubes were heated at 90°C for 30 minutes in water bath and then placed in a cold room at 4°C for 30minutes. The gelation concentration was determined as the lowest concentration at which the sample does not fall down or slip from an inverted test tube [14].

2.4.4.4 Water retention capacity

Water retention capacity was determined using the method ofKaur and Singh [15]. “1 g of the sample was weighed and 30 ml of distilled water was added. The mixture was shaken and left to hydrate for 24h. Subsequently, the mixture was centrifuged at 2000 r/min for 30 min. The supernatant was then separated and the hydrated sediment was weighed. Afterwards, the sediment was transferred to moisture dish and dried at 105°C for 6h, and then the dry sediment will be weighed”. [15] The WRC was calculated as follows:

$$\text{WRC} = \frac{Hydrated\ \ sediment\ \ weight\ (g) - Dry\ \ sediment\ \ weight}{Dry\ \ sediment\ \ weight\ (g)} \quad (4)$$

2.5 Sensory quality attributes evaluation

“Mushroom blended *Ogi* samples were processed into semisolids ready for consumption and served to a 20-member panel comprising of nursing mothers, 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, sourness, and overall acceptability using a 9-point hedonic scale" [16]

2.6 Statistical analysis

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

3.0 RESULTS AND DISCUSSION

3.1 Effect of mushroom inclusion on the mineral content of maize-based *ogi*

The result indicates an increasing trend with increasing level of mushroom inclusion confirming superior mineral content of mushroom flour. The zinc content significantly ($P<0.05$) differs across the samples for flour blends and control sample. The result showed that the control is a better source of zinc as compared to the formulated food products. The zinc content of the samples with 10%, 20% and 30% mushroom inclusion agrees with the report ofAbraham*et al.,*[17] in their work on *ogi* supplemented with cray fish. The magnesium content ranged from 37.7 to 102.0 mg/100 g with the formulation with 30% recording the highest magnesium content. The iron content ranged from 4.72 to 13.23 mg/100 g for flour blends. The sample with 30% flour had the highest iron content though was significantly ($P<0.05$) lower than the iron content of the control sample, however both meet the RDA of 10mg/100g for infants (IOM) [18]. The potassium content of flour blends indicates an increasing trend with increasing level of mushroom flour inclusion in the blends. This is probably due to the high potassium content of mushroom flour. Values ranged from 23.05 to 125.3 mg/100 g. The potassium content reported in this study is below the RDA of 700 mg/day for infants (IOM) [18]. The result for calcium content ranged from 125.15 to 160.25 mg/100 g for flour blends. The formulation with 30% inclusion recorded the highest value but lower than the calcium content (177 mg/100 g) of the control sample. The values reported by this study are below the RDA of not be less than 435.51 mg/100 g of the dry weaning food[19].

3.2 Effect of mushroom inclusion on the vitamin content of maize-based *ogi*

The vitamin A content differed significantly ($P<0.05$) across the samples. The sample with 30% mushroom inclusion had the highest vitamin A content (9.06 µg/100 g) as compared to the control and the four blends (Table 3). The result obtained by this study showed similarity tothe report ofAbraham*et al.,*[17] in his work on cray fish inclusion in maize-based complementary food. The values obtained fell short of the adequate intake of 300µg/day (IOM) [18]. Cereals are known to be deficient in vitamin A, leaching of vitamins during processing could account for the low vitamin content.Vitamin A is essential for improvement of vision and maintaining body tissues among many other functions [20]. There was significant difference across all the samples in vitamin B_1 content. A general increase with increasing level of mushroom inclusion was observed. This could be due to high vitamin B_1 content of mushroom flour. The sample with 30% mushroom inclusion had the higher vitamin B_1 content as compared to the flour blends and control sample. The result show similarity to the report ofAbraham*et al.*,[17]. The vitamin B_1 content of the samples with mushroom inclusion and the control sample met the RDA of 0.2 - 0.9 mg/day for infants and children [21].Vitamin B_1 (thiamin) is useful in the generation of energy from carbohydrates [22]. The vitamin B_2 content of varies significantly ($P<0.05$) across all the samples and increased with increasing level of mushroom inclusion probably due to high vitamin B_3 content of the mushroom flour. The formulation with 30% mushroom inclusion had the highest vitamin B_2 content as compared to control sample and flour blends. The vitamin B_2 content reported bythis study is within the 0.13 to 4.22 mg/100 g reported by Miriam [23] in her work on complementary food from acha-based complementary food. The flour blend and control values in this study met the RDA of 0.3 – 0.9 mg for infants and children [24]. The result of Niacin showed increasing trend with increasing level of mushroom flour inclusion in the blends. This is probably due to high niacin content of mushroom. The values ranged from 3.82 to 13.01 mg/100 g for flour blends with the formulation with 30% mushroom inclusion comparing well with the control sample. The values obtained are within the recommended daily intake of 2 – 12 mg/day for infants and children. The vitamin C content ranged from 0.13 to 1.12 mg/100 g for flour blends and increased with increasing

level of mushroom inclusion. The sample with 305% mushroom inclusionhad higher vitamin C content as compared the flour blends.The result is in line with that of Mariam [23] whose values ranged from 0.21 to 0.62 mg/100 g.

3.3 Effect of mushroom inclusion on anti-nutritional factors in maize-based *ogi*

The phytate content decreased with increasing level of mushroom inclusion. The decrease could be due to low anti-nutritional content of mushroom flour. Low phytate level was detected in flour blends while phytate was not detected in control. The low phytate content in flour blends may be due to processing method. The result is in agreement with the report ofAdeoti and Osundahunsi [25] whose values ranged from 0.06 mg/100 g to 0.24 mg/100 g for commercial product to fermented product respectively. Phytates have been reported to form indigestible complexes with minerals, thereby decreasing the bioavailability of these minerals [30]. There was no significant ($P<0.05$) difference in oxalate content in the flour blends. Oxalate was not detected in the control sample. The oxalate content of the sample without mushroom inclusion was slightly higher than the flour blends. All the oxalate values reported in this study are below the critical limit of of 0.25 mg/g reported by Adeoti and Osundahunsi [25].

A Significant ($P<0.05$) difference exist across the trypsin inhibitor content of the flour. Trypsin inhibitor was not detected in the control sample. The values obtained for trypsin inhibitor across the sample were far below the critical value of 0.25 mg/100 g reported by Adeoti and Osundahunsi [25] suggesting that the formulated product pose no danger to health and nutrients bioavailability. Trypsin inhibitorwas not detected in the control sample. The values obtained for trypsin inhibitor across the sample were far below the critical value of 0.25 mg/100 g reported by Adeoti and Osundahunsi [25] suggesting that the formulated product pose no danger to health and nutrients bioavailability. The tannin content obtained in this study for flour blends was very low compared to its critical toxicity effect and further reduced during traditional processing. Therefore, the antinutritional effect of tannin is insignificant to availability and utilization of nutrients by infants. Adeoti and Osundahunsi [25] reported critical values of 3 mg/g.

3.4 Effect of mushroom inclusion on the functional properties of maize-based *Ogi*

The bulk density of the flour blends significantly ($P<0.05$) differed across the flour blends and control sample with a decreasing trend with increasing level of mushroom inclusion (Table 5). Values ranged from 0.72 to 0.55 g/mL for flour blends. The formulation with 30% mushroom was lowest in bulk density though slightly higher than the control sample value. The result is in agreement with the report ofOchem*et al.*[26], whose values ranged from 0.70 to 0.67g/mL in proximate composition, functional, and pasting properties of wheat and groundnut protein concentrate flour blends. Bulk density is a measure of flour heaviness and an important parameter that determines the suitability of flour for the ease particulate food packaging and transportation [27]. High bulk density is a disadvantage in case of ready-to-use complementary food (RUCF) because it can limit the nutrient intake per feed [28].The low bulk density observed with increasing level of mushroom inclusion is advantageous for ready-to-use complementary food (RUCF).

Table 1: *Ogi*-ushroom blend formulation

	Flour (g)	
Sample	Ogi	Mushroom
A	100	0
B	90	10
C	80	20
D	70	30

The water absorption capacity (WAC) ranged from 0.99 to 2.20 g/g and increased with increasing level of mushroom inclusion. The formulation with 30% mushroom inclusion hadhigher value (2.20 g/g) among the flour blends but lower than the control sample (2.30 g/g). Protein concentration is reported to have

effect on WAC of flours [29].The observed variation in water absorption capacity among the flours samples could be due to different protein concentration, their degree of interaction with water and their conformational characteristics. The water retention capacity (WRC) of flours ranged from 5.21 to 8.94 (g/g) and increased with increasing level of mushroom substitution. Values of flours significantly (P<0.05) differed across the flour blends and the control samples. All the flour blends samples recorded high value as compared to control sample. The result obtained by this study is in agreement with the report of Ochem*eet al.,* [26] who reported range of 85.05% to 89.19% for water retention capacity.Water retention capacity is important parameters which ultimately determine the sample consistency (that is solid, semi-solid, or liquid). Flours with high water retention capacity values hold large amounts of water during their preparation into gruels and thus become voluminous with a low energy and nutrient density [30]. Thus, food sample with low water retention capacity will potentially provide more energy than food flours with high water retention capacity. The swelling capacity significantly (P<0.05) differed across the samples. Values ranged from 3.72 to 1.75 (mL/g) in decreasing with increasing level of mushroom substitution.This result show similarity with that of Ochem*eet al.,*[26] who reported values range of 12.71% to 9.91% with increasing level of groundnut protein concentrate in complementary food. The least gelation concentration (LGC) of flour blends ranged from 5.5 to 9.00 (%) in increasing trend with increasing level of mushroom substitution. Higher value of LGC was recorded in control sample as compared to flour blends. The result contradicts the report of Ajani *et al.,*[31] and Jackson *et al.,*[32] who work on Functional Properties of Composite Flour made from Wheat and Breadfruit and nutritional properties of mushroom respectively. The difference could be due to food material used in the composition of the complementary food and their relative ratio of different constituents such as protein, carbohydrates and lipids which probably hadeffect on functional properties as suggested by [33].The least gelation concentration is the ability of flour to form gel which provide structural matrix for holding water and other water-soluble materials like sugars and flavors [34].

Table 2: Effect of mushroom inclusion on vitamin content of maize-based *Ogi*

		µ /g			
Sample	A(µ/100 g)	B_1	B_2	B_3	C
A	4.86^{d} ± 0.64	0.32^{e} ± 0.01	0.22^{e} ± 0.01	3.82^{e} ± 0.01	0.13^{e} ± 0.01
B	5.56^{c} ± 0.01	0.44^{d} ± 0.01	0.33^{d} ± 0.01	6.03^{d} ± 0.01	0.16^{d} ± 0.01
C	7.82^{b} ± 0.01	0.68^{c} ± 0.01	0.43^{c} ± 0.01	10.02^{c}±0.00	0.92^{c} ± 0.01
D	9.06^{a} ± 0.06	1.09^{a} ± 0.02	0.69^{a} ± 0.01	13.30^{a}±0.01	1.12^{b} ± 0.02
E	3.50^{e} ± 0.42	0.98^{b} ± 0.01	0.63^{b} ± 0.01	13.1^{b}±0.00	2.32^{a} ± 0.01
LSD	0.10	0.03	0.02	0.01	0.01

All values are duplicate means ± standard deviation. Different superscripts between columns depict significant difference (P<0.05).
Key: A = 100% *Ogi* + 0% mushroom, B = 90% *Ogi* + 10% mushroom, C =80% *Ogi* + 20% mushroom, 70% *Ogi* + 30 mushroom and E = commercial weaning food (maize based Ceralac).

Table 3: Effect of mushroom inclusion on the mineral content of maize-based Ogi

	mg/100 g				
Sample	Zn	Mg	Fe	K	Ca
A	1.12^{e}± 0.00	37.7^{d}± 0.01	4.72^{e}± 0.01	23.05^{e}± 0.07	125.15^{e}± 0.07
B	1.23^{d}± 0.01	60.0^{c}± 0.06	7.14^{d}± 0.14	80.21^{d}± 0.01	130.56^{d}± 0.63
C	1.54^{c}± 0.01	84.1^{b}± 0.01	9.91^{c}± 0.03	100.05^{c}± 0.07	152.06^{c}± 0.06
D	1.71^{b}± 0.01	102.0^{a}± 0.03	13.23^{b}± 0.01	125.3^{b}± 0.28	160.25^{b}± 0.07

E	$4.31^{a}\pm 0.01$	$0.00^{e}\pm 0.00$	$15.28^{a}\pm 0.03$	$473.1^{a}\pm 0.14$	$177.84^{a}\pm 0.01$
LSD	0.02	0.09	0.05	0.38	0.74

All values are duplicate means ± standard deviation. Different superscripts between columns depict significant difference (P<0.05).
Key: A = 100% *Ogi* + 0% mushroom, B = 90% *Ogi* + 10% mushroom, C =80% *Ogi* + 20% mushroom, 70% *Ogi* + 30 mushroom and E = commercial weaning food (maize based Ceralac).

Table 4: Effect of mushroom inclusion on the anti-nutritional properties of maize-based *ogi*

	mg/100 g			
Sample	Phytate	Oxalate	T.I	Tannin
A	0.36^{a} ± 0.01	0.03^{a} ± 0.00	0.06^{a} ± 0.00	0.83^{a} ± 0.02
B	0.34^{ab} ± 0.01	0.02^{b} ± 0.00	0.04^{b} ± 0.00	0.72^{b} ± 0.01
C	0.32^{b} ± 0.01	0.02^{b} ± 0.00	0.04^{b} ± 0.00	0.66^{c} ± 0.01
D	0.29^{c} ± 0.01	0.03^{c} ± 0.00	0.03^{c} ± 0.00	0.56^{d} ± 0.01
E	0.00^{d} ± 0.00	0.00^{d} ± 0.00	0.00^{d} ± 0.00	0.00^{e} ± 0.00
LSD	0.02	0.00	0.00	0.03

All values are duplicate means ± standard deviation. Different superscripts between columns depict significant difference (P<0.05).
Key: A = 100% *Ogi* + 0% mushroom, B = 90% *Ogi* + 10% mushroom, C =80% *Ogi* + 20% mushroom, 70% *Ogi* + 30 mushroom and E = commercial weaning food (maize based Ceralac), T.I = Trypsin Inhibitor

Table 5: Effect of mushroom inclusion on the functional properties of maize-based *ogi*

Sample	B.D (g/mL)	WAC (g/g)	WRC (g/g)	S.C (mL/g)	L.G.C (%)
A	$0.72^{a}\pm 0.00$	$0.99^{e}\pm 0.01$	$5.21^{d}\pm 0.01$	$3.72^{a}\pm 0.01$	$5.50^{c}\pm 0.71$
B	$0.63^{b}\pm 0.01$	$1.24^{d}\pm 0.01$	$5.25^{c}\pm 0.00$	$3.42^{b}\pm 0.00$	$7.50^{bc}\pm 0.72$
C	$0.62^{b}\pm 0.00$	$1.55^{c}\pm 0.01$	$8.21^{b}\pm 0.01$	$2.67^{c}\pm 0.05$	$8.50^{b}\pm 0.71$
D	$0.58^{c}\pm 0.01$	$2.20^{b}\pm 0.00$	$8.94^{a}\pm 0.01$	$1.75^{e}\pm 0,01$	$9.00^{b}\pm 0.41$
E	$0.55^{d}\pm 0.01$	$2.3^{a}\pm 0.00$	$4.22^{e}\pm 0.01$	$2.48^{d}\pm 0.04$	$12.50^{a}\pm 0.71$
LSD	0.02	0.02	0.02	0.07	0.02

All values are duplicate means ± standard deviation.Different superscripts between columns depict significant difference (P<0.05).Key: A = 100% *Ogi* + 0% mushroom, B = 90% *Ogi* + 10% mushroom, C =80% *Ogi* + 20% mushroom, 70% *Ogi* + 30 mushroom and E = commercial weaning food (maize based Ceralac), B.D = Bull density, W.A.C = Water absorption capacity, W.R.C = Water retention capacity, S.C = Swelling capacity, L.G.C = Least gelation concentration

3.5 Effect of mushroom inclusion on the sensory quality attributes of maize-based *Ogi*

Results indicates significant (P<0.05) difference in sensory scores of appearance, sourness, taste and general acceptability in some samples. There was no significant (P<0.05) difference in sensory scores for appearance between the sample A (100% ogi) and the control sample. Appearance is affected by the composition of food materials and processing conditions. The difference in sourness of the samples could be due to inclusion of mushroom which probably reduced the sour taste in *ogi.* Sourness is a characteristic or distinct mouth feel *ogi* sensory attribute. The control sample was least rated in terms of sourness. The control sample was best rated in terms of taste as compared to flour blends samples. This could be due to product formulation involving sugar, milk and flavoring agents. The control sample was also best rated in aroma. The aroma of the flour blends were least rated and decreased with increasing level of mushroom substitution probably due to deviation from typical *Ogi* aroma as a result of mushroom inclusion. The sensory score rating for general acceptability indicates consumers' preference for Control

sample. Among the flour blends the formulation with 100% *Ogi* was highest rated in terms of general acceptability. The general acceptability is affected by flavour, taste, colour and texture of the diets.

Table 6: Effect of mushroom inclusion on sensoryquality attributes of maize-based *ogi*

Sample(Code)	Appearance	Aroma	Sourness	Taste	General Acceptability
A	7.05^{a} ± 1.32	6.60^{ab} ± 1.27	6.95^{a} ± 0.95	6.30^{b} ± 1.03	6.65^{b} ± 0.99
B	5.90^{b} ± 1.48	5.80^{bc} ± 1.15	5.15^{bc} ± 0.81	5.30^{c} ± 0.92	6.25^{b} ± 1.12
C	4.50^{c} ± 1.07	4.90^{cd} ± 1.07	4.25^{c}± 1.86	3.55^{d} ± 1,15	4.70^{c} ± 1.34
D	3.75^{c} ± 1.48	4.15^{d} ± 2.01	3.12^{d} ± 2.02	3.35^{d} ± 1.95	1.90^{d} ± 0.85
E	7.25^{a} ± 1.89	7.25^{a} ± 1.89	5.45^{b} ± 2.26	7.95^{a} ± 1.23	7.60^{a} ± 1.00
LSD	1.01	0.96	0.03	0.82	0.67

All values are duplicate means ± standard deviation.Different superscripts between columns depict significant difference (P<0.05). Key: A = 100% *Ogi* + 0% mushroom, B = 90% *Ogi* + 10% mushroom, C =80% *Ogi* + 20% mushroom, 70% *Ogi* + 30 mushroom and E = commercial weaning food (maize based Ceralac)

4.0 CONCLUSION

The study established that mushroom inclusion in maize-based *Ogi* improves the micronutrient content making it a good source nutrient for infant and children with great potentials for Protein Energy Malnutrition and micro-malnutrition Prevention. The anti-nutritional factors in the formulated samples were very implying bioavailability of nutrients. The sensory scores indicate that all the samples were generally accepted. The formulation with 30% mushroom inclusion should be adopted for its better nutritional profile.

REFERENCES

[1] Ahmed, T., Hossain, M., & Sanin, K. I. (2013). Global burden of maternal and child undernutritionandmicronutrient deficiencies. *Annals of Nutrition and Metabolism*, 61(suppl 1), 8-17. https://doi.org/10.1159/000345165

[2] Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., de Onis, M., … Uauy, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet*, 382(9890), 427-451. https://doi.org/10.1016/S0140-6736(13)60937-X

[3] Clark, H., Coll-Seck, A. M., Banerjee, A., Peterson, S., Dalglish, S. L., Ameratunga, S. and Costello, A. (2020). A future for the world's children? A WHO–UNICEF–Lancet Commission. *The Lancet*, *395*(10224), 605-658.

[4] UNICEF, (2013). Joint statement on improving existing reccomendations on treatment of moderate malnutrition in children under 5. Geneva

[5] Afolayan, M. O., Afolayan, M. and Abuah, J. N. (2010). An Investigation into Sorghum Based Ogi (Ogi-Baba) Storage Characteristics, *Advanced Journal of Food Science and Technology*, 2 (1): 72-78.

[6] Oguntoyinbo F.A and Narbad A. (2012). Molecular characterization of lactic acid bacteria and in situ amylase expression during traditional fermentation of cereal foods. *Food Microbiology* ;31(2):254–262.

[7] Ajala, A. S. and Taiwo T.F. (2018). Study on supplementation of 'ogi' with oyster mushroom flour (Pleurotusostreatus). *Journal of Nutritional Health Food Engineering.* 2018;8(3): 287–291. DOI: 10.15406/jnhfe.08.00284

[8]Ijarotimi, O. S. (2022). Macronutrient composition, amino acid profiles and acceptability of maize-based complementary foods enriched with defatted white melon seed and Moringa oleifera leaf powder. *Croatian journal of food science and technology*, 14(1), 63-73.

[9] Bolaji, O. T., Awonorin, S. O., Sanni, L. O., & Shittu, T. A. (2018). Modelling of mechanical properties of five maize varieties at critical processing conditions in the production of fermented slurry-ogi. *International journal of food properties*, 21(1), 1619-1632.

[10] Akingbala JO, Rooney LW, Faubion JM. A laboratory procedure for the Preparation of 'Ogi' fermented food. Science Journal. 1987;46(5):1523–1526.

[11] AOAC (2005). Official Methods of Analysis: 18th Edition. Association of Official Analytical Chemists. Washington, DC. pp. 210.

[12] Woldegiorgis, A. Z., Abate, D., Haki, G. D. and Ziegler, G. R. (2015). Major, Minor and Toxic Minerals and Anti-nutrients Composition in Edible Mushrooms Collected from Ethiopia. *Food Processing Technology.* 6:134–142.

[13] Onwuka GI (2005). Functional properties in: Food analysis and instrumentation. Naphtali Prints Lagos. Pp 134-135

[14] Robertson JA, de Monredon FD, Dysseler P, Guillon F, Amadó R, Thibault JF. Hydration properties of dietary fibre and resistant starch: a European collaborative study. Lebensm.-Wiss. u.-Technol. 2000; 33: 72-79.

[15] Kaur, M. and Singh, N. (2005). Studies on functional, thermal and pasting properties of flours from different chickpea (*Cicer arietinum* L.) cultivars. *Food Chemistry* 91(3): 403-411

[16] Iwe, M. O. (2002). Handbook of Sensory Analysis and Methods. Projoint Communications Services Ltd., Enugu. pp 70-72.

[17] Abraham, S. I., Ifeanyi, N., & Stephen, S. (2016). Effect of crayfish inclusion on the chemical and sensory properties of ogi prepared from maize, millet and sorghum. *International Journal of Nutrition and Food Sciences.* 2016; 5(6): 378-383.

[18] IOM (Institute of Medicine)(2005). Dietary reference intake: Water, potassium, sodium, chloride and sulfate. National Academy press, Washington, DC.

[19] Mandell, L., and Arendt, M. (2022). What is Codex, and Why is it Important?: The Codex Committee on Nutrition and Foods for Special Dietary Uses: Report November 2021. *Journal of Human Lactation*, *38*(2), 367-370.

[20] Ross, S. A., McCaffery, P. J., Drager, U. C. and De Luca, L. M. 2000. Retinoids in Embryonal Development. *Physiological Reviews*, 80: 1021-54.

[21] FAO and World Health Organization, "Vitamin and mineral requirements in human nutrition Second edition," *World Heal. Organ.*, pp. 1–20, 1998, doi: 92 4 154612 3

[22] Fattal-Valevski, A. (2011). "Thiamin (vitamin B1)". Journal of Evidence-Based Complementary and Alternative Medicine, 16 (1): 12–20.

[23] Mariam, S. (2005). Nutritive Value of Three PotentialComplementary Foods Based on Cereals and Legumes. *African Journal of Food and Nutrition Series* 5(2): 1-14

[24] Zoellner, J., Van Horn, L., Gleason, P. M. and Boushey, C. J. (2015). What is translational research? Concepts and applications in nutrition and dietetics. *Journal of the Academy of Nutrition and Dietetics*, *115*(7), 1057-1071.

[25] Adeoti, O.A. and Osundahunsi, O.F. (2017). Nutritional Characteristics of Maize-based Complementary Food Enriched with Fermented and Germinated Moringa Oleifera Seed Flour. *International Journal of Food Science, Nutrition and Dietetics* (IJFS). Diet. 6(2), 350-357

[26] Ocheme, B.O., Ugochukwu, H. A., Caleb, M. Y., Chiemela, E. C.,Olajide, E. A. (2017).Proximate composition, functional, and pasting properties of wheat and groundnut protein concentrate flour blends.Food Science and Nutrition. 6(5): 1173–1178

[27] Adejuyitan, J.A, Otunola E.T, Akande, E.A, Bolarinwa, I.F, Oladokun, F.M (2009) Some physicochemical properties of flour obtained from fermentation of tigernuts (Cyperusesculentus) sourced from a market in Ogbomoso, Nigeria. *African Journal of Food Science*. 3(2): 51-55.

[28] Isah AP, Danladi Y, Ejike OJ (2013) Proximate composition and some functional properties of flour from the kernel of African star apple (Chrysophyllualalbidum). *International Journal of Agricultural Policy Research*1(3): 062-066.

[29] Chopra, N., Rani, R., & Singh, A. (2018). Physico-nutritional and sensory properties of cookies formulated with quinoa, sweet potato and wheat flour blends. *Current Research in Nutrition and Food Science Journal*, *6*(3), 798-806.

[30] Rashwan, A. K., Yones, H. A., Karim, N., Taha, E. M., & Chen, W. (2021). Potential processing technologies for developing sorghum-based food products: An update and comprehensive review. *Trends in Food Science and Technology*, 110, 168-182.

[31] Ajani, A.O., Fasoyiro, S.B., Arowora, K.A., Ajani, O.O., Popoola, C.A., and Zaka, K.O. (2016). Functional Properties of Composite Flour made from Wheat and Breadfruit. *Applied Tropical Agriculture Volume 21, No.2 (Special Issue*), 89-93, 2016

[32] Jackson R.M., Daniel N. S., Glaston M. K., Ariel K.B. (2018). Nutritional and Functional Properties of Mushroom (Agaricusbisporus&Pleurotusostreatus) and Their Blends with Maize Flour. *American Journal of Food Science and Technology,* 2018, 6 (1), 33-41

[33] Cordero-Clavijo, L. M., Serna-Saldívar, S. O., Lazo-Vélez, M. A., González, J. F. A., Panata-Saquicilí, D., & Briones-Garcia, M. (2021). Characterization, functional and biological value of protein-enriched defatted meals from sachainchi (Plukenetiavolubilis) and chocho (Lupinusmutabilis). *Journal of Food Measurement and Characterization*, *15*, 5071-5077..

[34]Zhang, Y., Lu, X., Zeng, S., Huang, X., Guo, Z., Zheng, Y., ... & Zheng, B. (2015). Nutritional composition, physiological functions and processing of lotus (NelumbonuciferaGaertn.) seeds: a review. *Phytochemistry Reviews*, *14*, 321-334.

.