
Nutritional, Functional and Sensory Properties of Gari Enhanced with Fermented Maize Residues Flour

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Abstract: The by-product (residue) from fermented yellow maize starch production was dried and milled into flour and designated as fermented yellow maize residues, the residue was added to Gari at 0–30% levels of substitution to produce Gari-residue blends. The blends and control were evaluated for its functional and pasting properties, proximate composition, mineral content and starch digestibility. The Gari-residue blends were reconstituted with hot water into a stiff dough (“Eba”) and its sensory and proximate composition analyzed. Results showed water and oil absorption capacities decreased, and an increase in Bulk density, swelling power and solubility index. Pasting property showed a decrease in peak, breakdown and setback viscosities, a decrease in pasting time while the pasting temperature increased. Proximate composition of stiff dough showed an increase in fat, crude protein and crude fibre with a decrease in carbohydrate content, mineral content determination showed the contents of Ca, Zn, Fe and P increased. Sensory evaluation results showed Gari stiff dough at 5–25% levels of substitution had equal preference with the control for overall acceptability. Values for starch digestibility showed a reduction in glycemic indices with the presence of residue flours. This study has thus shown that fermented maize starch residue enhanced the sensory and nutritional properties of “Eba”.

Keywords: Gari, “Eba”, Fermented Maize Residue, Pasting Properties, Sensory Properties, Nutritional Properties

1. Introduction

Gari is a fermented, gritty, starchy food or a free flowing granular product produced from cassava. Its use as a food source is limited by its perishability, low protein content and potential toxicity [1]. It is the most commonly consumed cassava product across most geopolitical zones in Nigeria and can be reconstituted with hot water to form a stiff paste or gel (“Eba”) eaten usually with various vegetable soups or taken as a snack when soaked in cold water, sweetened with sugar and consumed with roasted groundnut, coconut or dry fish [2, 3].

Several attempts have been made by researchers to enhance the nutritional properties of Gari; through supplementation or fortification with food sources rich in protein and minerals and vitamins all of which are deficient in Gari and makes it a poor source of other nutrients apart from carbohydrate. Oluwamukomi enriched Gari with sesame seed flour and posited an increase in protein and fat content with a decrease in its content of carbohydrate [4].

Alozie and Ekerette fortified Gari with soybean, melon seed and Moringa seed flours and reported significant improvements in nutritive values of the gari products as well as enhanced sensory properties [3]. Onasoga *et al.* fortified gari with African breadfruit residue and they also reported an increase in nutritive value, sensory appeal and a decrease in a cyanide content [1].

Fermented maize residue is a by-product of “Ogi” production (fermented starch). It is the residue generated or left behind after the sieving process. The traditional preparation of Ogi involves soaking of maize kernels in water for 1–3 days and followed by wet milling and sieving to remove bran, hulls and germ [5]. The pomace (residue) which is retained on the sieve is later discarded or air dried as an ingredient for animal feed. Fermented maize residue apart from its substantial use as a feed stuff ingredient has also been found useful by households in Nigeria to increase the bulk of Gari stiff dough (Eba) with a more loosened texture.

Many food processing by-products are useful sources of

nutrients and potential functional ingredients. Fermented maize residue which is now bereft of its starch content, with enhanced protein, fat, mineral and fibre content may contribute to increasing the nutritive value and sensory attributes of Gari and its stiff dough preparation (Eba).

This study was therefore aimed at investigating the nutrient composition, physicochemical properties as well as acceptability of Gari stiff dough enriched with fermented maize residue flour.

2. Materials and Method

2.1. Production of Fermented Maize Residue

The procedure for “Ogi” production was employed. One kg of maize was cleaned to remove dirt and soaked in 4000ml of water for 2 days. The soaked seeds were milled using a grinding mill, sieved and the filtrate allowed to stand for 2 hours. The top water was decanted and the sediment (slurry) bagged to allow more water to drain out. The resultant wet cake was Ogi.

The residue after sieving as earlier mentioned were dried at 50°C for 12 hours, milled using the dry mill component of a blender and packed in container until ready for use.

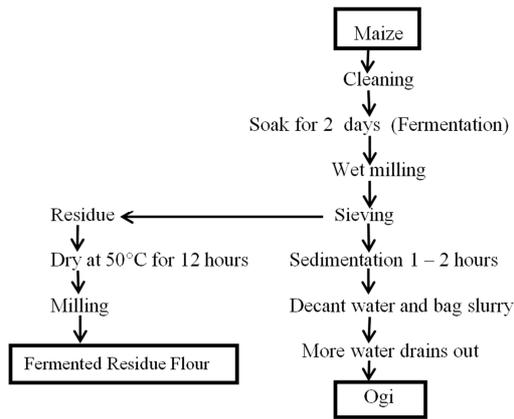


Figure 1. Flow diagram for fermented maize residue.

The composite flour blends for stiff dough preparations using Gari were formulated as shown in the table below:

Table 1. Gari–Maize Residue Composite Flour Blend.

Sample Code	Component A (Gari)	Component B (Residue)
G0b	100	-
G1b	95	5
G2b	90	10
G3b	85	15
G4b	80	20
G5b	75	25
G6b	70	30

- G0b:=Gari 100%
- G1b=Gari + Residue at 5% substitution
- G2b=Gari + Residue at 10% substitution
- G3b=Gari + Residue at 15% substitution
- G4b=Gari + Residue at 20% substitution
- G5b=Gari + Residue at 25% substitution
- G6b=Gari + Residue at 30% substitution

2.2. Functional Properties

Water and Oil Absorption Capacities were determined using the method of Beuchat [6], bulk density by the method described by Wang and Kinsella [7], swelling volume, swelling power and solubility were carried out using the method of Takashi and Sieb [8].

2.3. Pasting Properties

The pasting properties of the gari and its blends were carried out using a Rapid Visco-Analyser (RVA model 3C, new port scientific Sydney) as described by Sanni *et al.*, [9].

2.4. Preparation of Gari-Residue Stiff Dough

One hundred gram (100g) of Gari-composite flour blends as presented in Table 1 was weighed. 400ml of boiled water was added to the flour in a bowl and stirred with a wooden Gari turner until a well-mixed stiff dough was formed.

2.5. Sensory Evaluation

The Gari stiff dough (Eba) was evaluated for the following attributes of texture, colour, aroma and mouldability (Ease of rolling into balls on the palm of the hand), using a five-point hedonic scale by a twenty-member panelist consisting of women in the neighbourhood of Rivers State University staff quarters. The overall acceptability was calculated using the average score of all the attributes.

2.6. Proximate Composition

Proximate compositions were determined according to the methods of the Association of Official Analytical Chemist [10].

2.7. Mineral Content

The following minerals: Ca, Mg, Zn, Fe and P were determined using the Atomic Absorption spectro photometer (Bulk Scientific-210V6P, USA) after preparation of their Ash solutions using the method of AOAC, [10].

2.8. Glycemic Index Prediction

The glycemic index prediction was carried out by the method of Goni *et al.*, [11] as described by Kiin-Kabari and Giami [12].

3. Results

3.1. Functional Properties

Table 2 show result of functional properties of Gari-fermented yellow maize residue blend.

Water absorption capacity ranged from 3.47 g/g in sample G6b to 4.38 g/g in sample G0b, Oil Absorption Capacity (g/g) ranged from 1.62 in G5b to 1.84 in G0b, bulk density (g/ml) ranged from 0.59 in sample G0b and G1b to 0.72 in sample G6b, swelling power (g/g) ranged from 5.78 in G0b to 8.06 in G4b, swelling index (%) ranged from 27.74 in G6b to 50.44 in G0b.

Table 2. Functional Properties of Gari and Fermented Yellow Maize Residue Blends.

Sample**	Water Absorption (g/g)	Oil Absorption (g/g)	Bulk Density (g/ml)	Swelling Power (g/g)	Solubility Index (%)
G0b	4.38 ^a ±0.14	1.84 ^a ±0.01	0.59 ^d ±0.01	5.78 ^b ±0.50	50.44 ^a ±1.88
G1b	3.92 ^a ±0.33	1.71 ^a ±0.12	0.59 ^d ±0.00	5.86 ^b ±0.43	47.81 ^{ab} ±0.99
G2b	3.89 ^a ±0.42	1.73 ^a ±0.19	0.62 ^d ±0.01	7.29 ^{ab} ±0.36	44.33 ^b ±0.00
G3b	3.74 ^a ±0.15	1.70 ^a ±0.02	0.66 ^c ±0.01	6.76 ^{ab} ±0.09	37.04 ^c ±0.06
G4b	3.81 ^a ±0.22	1.76 ^a ±0.02	0.69 ^b ±0.60	8.06 ^a ±0.42	32.50 ^{cd} ±1.64
G5b	3.76 ^a ±0.02	1.62 ^a ±0.24	0.70 ^{ab} ±0.01	7.87 ^a ±0.70	32.34 ^d ±0.18
G6b	3.47 ^a ±0.19	1.70 ^a ±0.05	0.72 ^a ±0.00	7.48 ^{ab} ±0.24	27.74 ^d ±1.56

* Values are Means of Duplicate Determinations±Standard Deviation.

Means with different superscript within a column are significantly different (P>0.05).

** Sample

G0b=100% Gari

G1b=95% Gari: 5% Residue Flour

G2b=90% Gari: 10% Residue Flour

G3b=85% Gari: 15% Residue Flour

G4b=80% Gari: 20% Residue Flour

G5b=75% Gari: 25% Residue Flour

G6b=70% Gari: 30% Residue Flour

Table 3. *Pasting Properties of Gari and Fermented Yellow Maize Residue Blends.

Sample**	Peak 1 (RVU)	Trough (RVU)	Breakdown (RVU)	Final Visc (RVU)	Set back (RVU)	Peak time (Min)	Pasting Temperature (°C)
Gob	452.90 ^{ab} ±5.94	209.60 ^{abc} ±6.93	243.30 ^{bc} ±0.99	315.80 ^{ab} ±7.21	105.80 ^a ±0.28	4.60 ^c ±0.09	82.48 ^a ±1.16
G1b	503.60 ^a ±1.03	230.60 ^a ±7.50	273.95 ^{ab} ±1.43	320.85 ^a ±11.95	98.75 ^a ±7.57	4.57 ^c ±0.05	70.95 ^d ±0.00
G2b	503.45 ^a ±2.60	218.50 ^a ±9.05	284.95 ^a ±17.04	319.35 ^a ±9.83	100.85 ^a ±0.78	4.67 ^{bc} ±0.00	70.95 ^d ±1.16
G3b	432.80 ^{bc} ±2.17	196.80 ^{bc} ±9.48	236.00 ^{cd} ±1.23	291.90 ^b ±5.52	95.10 ^a ±14.99	4.84 ^{ab} ±0.05	71.70 ^{cd} ±0.00
G4b	410.80 ^{bc} ±5.66	202.1 ^{bc} ±3.11	208.7 ^{bc} ±2.55	303.60 ^{ab} ±1.70	101.50 ^a ±1.70	4.878 ^a ±0.00	73.50 ^{bc} ±0.00
G5b	396.55 ^c ±3.61	193.05 ^c ±0.21	203.50 ^{cd} ±3.82	295.65 ^{ab} ±0.21	102.0 ^a ±0.42	4.93 ^a ±0.00	73.4 ^{bc} ±0.04
G6b	387.35 ^c ±4.60	199.9 ^{bc} ±0.57	187.45 ^c ±4.03	306.15 ^{ab} ±2.62	106.25 ^a ±2.05	5.00 ^a ±0.00	74.30 ^b ±0.00

* Values are Means of Duplicate Determinations±Standard Deviation

Means with different superscript within a column are significantly different (P>0.05)

** Sample

G0b=100% Gari

G1b=95% Gari: 5% Residue Flour

G2b=90% Gari: 10% Residue Flour

G3b=85% Gari: 15% Residue Flour

G4b=80% Gari: 20% Residue Flour

G5b=75% Gari: 25% Residue Flour

G6b=70% Gari: 30% Residue Flour

Table 4. Mean Sensory Scores of "Eba" from Yellow Gari-Fermented Yellow Maize Residue Blends.

Sample	Colour	Texture	Aroma	Mouldability	Overall Acceptability
G0Y	5.00 ^a ±0.00	4.84 ^a ±0.37	4.84 ^a ±0.37	4.84 ^a ±0.37	4.88 ^a ±0.16
G1Y	4.62 ^{ab} ±0.50	4.61 ^a ±0.76	4.69 ^{ab} ±0.63	4.84 ^a ±0.37	4.69 ^a ±0.41
G2Y	4.00 ^{abc} ±1.00	4.07 ^{ab} ±0.86	4.07 ^{ab} ±1.11	4.31 ^a ±0.75	4.11 ^a ±0.80
G3Y	4.07 ^{abc} ±0.86	4.07 ^a ±0.86	4.00 ^{ab} ±1.08	4.23 ^{ab} ±0.72	4.09 ^{ab} ±0.72
G4Y	3.92 ^{abc} ±0.95	4.23 ^{ab} ±0.72	4.07 ^{ab} ±1.11	4.15 ^{ab} ±0.68	4.09 ^{ab} ±0.72
G5Y	3.15 ^{cd} ±0.98	3.53 ^{bc} ±0.87	3.62 ^b ±1.04	3.38 ^b ±1.19	3.46 ^b ±0.75
G6Y	3.00 ^d ±1.08	3.07 ^c ±1.11	3.61 ^b ±1.26	3.31 ^b ±1.31	3.25 ^c ±0.97

* Values are Means of Duplicate Determinations±Standard Deviation

Means with different superscript within a column are significantly different (P>0.05)

** Sample

G0Y=100% Gari

G1Y=95% Gari: 5% Residue

G2Y=90% Gari: 10% Residue

G3Y=85% Gari: 15% Residue

G4Y=80% Gari: 20% Residue

G5Y=75% Gari: 25% Residue

G6Y=70% Gari: 30% Residue

3.2. Pasting Properties

Table 3 showed results of pasting properties of Gari and

fermented yellow maize residue blends. The Peak Viscosity ranged from 387.35 in G6b to 503.60 RVU in G1b, Trough Viscosity ranged from 193.05 in G5b to 230.60 RVU in G1b,

Breakdown Viscosity ranged from 187.45 in G6b to 284.95 RVU in G2b, Final Viscosity ranged from 291.90 in G3b to 320.85 RVU in G1b, Setback Viscosity ranged from 95.10 in G3b to 106.25 RVU in G6b, Peak Time ranged from 4.57 in G1b to 5.00 mins in G6b while Pasting temperature ranged from 70.95 in G1b and G2b to 82.48°C in G0b.

3.3. Sensory Evaluation

Table 4 showed the result of the mean sensory scores of “Eba” (Gari stiff dough) from yellow Gari-fermented yellow maize residue blend. The colour attribute ranged from 3.00 in G6Y to 5.00 in G0Y, texture ranged from 3.07 in G6Y to 4.84 in G0Y, Aroma ranged from 3.61 in G6Y to 4.84 in G0Y

mouldability ranged from 3.31 in G6Y to 4.84 in G0Y and G1Y with overall acceptability ranging from 3.25 in G6Y to 4.88 in G0Y.

3.4. Proximate Composition

Table 5 showed results of proximate composition of Yellow Gari-fermented yellow maize residue blends. Moisture content (%) ranged from 9.98 in G5Y to 11.35 in G0Y, Ash (%) ranged from 0.84 in G3Y to 1.24 in G0Y, Fat (%) ranged from 1.00 in G0Y to 2.20 in G5Y, Crude protein (%) ranged from 0.61 in G0Y to 4.11 in G6Y, Crude fibre (%) ranged from 2.00 in G0Y to 9.18 while carbohydrate (%) ranged from 73.06 in G6Y to 83.81 in G0Y.

Table 5. Proximate Composition of Yellow Gari-Fermented Yellow Maize Residue Blends.

Sample**	Moisture Content (%)	Ash (%)	Fat (%)	Crude Protein (%)	Crude Fibre (%)	Carbohydrate (%)
G0Y	11.35 ^a ±0.36	1.24 ^a ±0.05	1.00 ^d ±0.00	0.61 ^d ±0.00	2.00 ^d ±0.56	83.81 ^a ±0.98
G1Y	1.88 ^a ±0.70	1.23 ^a ±0.19	1.19 ^{cd} ±0.01	1.04 ^{ef} ±0.01	3.08 ^{cd} ±1.28	82.08 ^a ±0.09
G2Y	12.78 ^a ±0.13	1.19 ^a ±0.13	1.20 ^{cd} ±0.28	1.20 ^{de} ±0.30	4.88 ^{bcd} ±0.12	78.69 ^a ±0.21
G3Y	12.19 ^a ±0.72	0.84 ^a ±0.07	1.48 ^{bcd} ±0.12	1.70 ^a ±0.31	5.11 ^{ab} ±0.31	78.68 ^{ab} ±1.29
G4Y	12.66 ^a ±2.36	1.04 ^a ±0.07	1.80 ^{abc} ±0.01	2.36 ^c ±0.00	5.27 ^{bc} ±0.66	76.89 ^{ab} ±2.93
G5Y	9.98 ^a ±2.12	1.04 ^a ±0.07	2.20 ^a ±0.00	3.2 ^b ±0.02	6.79 ^{ab} ±1.40	76.75 ^{ab} ±3.59
G6Y	10.56 ^a ±0.03	1.10 ^a ±0.01	1.99 ^{ab} ±0.26	4.11 ^a ±0.01	9.18 ^a ±0.41	73.06 ^b ±0.20

* Values are Means of Duplicate Determinations±Standard Deviation

Means with different superscript within a column are significantly different (P>0.05)

** Sample

G0Y=100% Gari

G1Y=95% Gari: 5% Residue Flour

G2Y=90% Gari: 10% Residue Flour

G3Y=85% Gari: 15% Residue Flour

G4Y=80% Gari: 20% Residue Flour

G5Y=75% Gari: 25% Residue Flour

G6Y=70% Gari: 30% Residue Flour

Table 6 showed results of proximate composition of ‘Eba’ (Gari-stiff dough) produced from Gari-fermented yellow maize residue blends. Moisture content (%) ranged from 65.96 in G4Y to 70.32 in G2Y, Ash (%) ranged from 0.36 in G5Y to 0.44 in G0Y, Fat (%) ranged from 0.37 in G0Y to 0.77 in G5Y, Crude protein (%) ranged from 0.22 in G0Y to 1.47 G6Y, Crude fibre (%) ranged from 0.75 in G0Y to 3.29 in G6Y with carbohydrate (%) ranging from 26.23 in G6Y to 30.25 in G0Y.

Table 6. *Proximate Composition of “Eba” Prepared from Yellow Gari-Fermented Yellow Maize Residue Blends.

Sample**	Moisture Content (%)	Ash (%)	Fat (%)	Crude Protein (%)	Crude Fibre (%)	Carbohydrate (%)
G0Y	67 ^a ±0.40	0.44 ^a ±0.00	0.37 ^c ±0.00	0.22 ^d ±0.00	0.75 ^d ±0.20	30.25 ^a ±0.17
G1Y	69.67 ^a ±2.28	0.43 ^a ±0.02	0.41 ^c ±0.02	0.36 ^{cd} ±0.03	1.05 ^{cd} ±0.36	28.09 ^a ±2.60
G2Y	70.32 ^a ±2.10	0.41 ^a ±0.07	0.40 ^c ±0.07	0.44 ^{cd} ±0.13	1.66 ^{bcd} ±0.15	26.78 ^a ±1.81
G3Y	69.77 ^a ±1.24	0.39 ^a ±0.01	0.52 ^{bc} ±0.04	0.57 ^c ±0.07	2.45 ^{ab} ±0.02	26.39 ^a ±1.33
G4Y	65.96 ^a ±2.59	0.41 ^a ±0.07	0.69 ^{ab} ±0.03	0.92 ^b ±0.04	2.04 ^{bc} ±0.15	29.98 ^a ±2.62
G5Y	68.54 ^a ±0.01	0.36 ^a ±0.03	0.77 ^a ±0.02	1.13 ^b ±0.02	2.37 ^{ab} ±0.54	26.83 ^a ±0.64
G6Y	67.91 ^a ±0.09	0.40 ^a ±0.01	0.71 ^{ab} ±0.09	1.47 ^a ±0.01	3.29 ^a ±0.14	26.23 ^a ±0.13

* Values are Means of Duplicate Determinations±Standard Deviation

Means with different superscript within a column are significantly different (P>0.05)

** Sample

G0Y=100% Gari

G1Y=95% Gari: 5% Residue Flour

G2Y=90% Gari: 10% Residue Flour

G3Y=85% Gari: 15% Residue Flour

G4Y=80% Gari: 20% Residue Flour

G5Y=75% Gari: 25% Residue Flour

G6Y=70% Gari: 30% Residue Flour

3.5. Mineral Content

Table 7 showed result of the mineral content of yellow Gari-fermented yellow maize residue. Value for calcium ranged from

4.75 in sample G0Y to 9.42mg/100g in sample G3Y, Magnesium ranged from 2.50 in sample G6Y to 3.20 mg/100g in sample G2Y, Zinc ranged from 0.05 in G0Y to 1.24 mg/100g in sample G6Y, Iron ranged from 5.70 in G0Y to 8.88 mg/100g in sample G6Y with Phosphorus ranging from 4.02 in sample G4Y to 4.67 mg/100g in sample G6Y.

Table 7. Mineral Content (mg/100g) of Yellow Gari-Fermented Yellow Maize Residue.

Sample	Ca	Mg	Zn	Fe	P
G0Y	4.75 ^c ±0.07	3.07 ^a ±0.00	0.05 ^d ±0.00	5.70 ^c ±0.00	4.04 ^{dc} ±0.01
G1Y	5.97 ^d ±0.04	2.97 ^{ab} ±0.01	0.06 ^d ±0.00	5.91 ^f ±0.01	4.43 ^b ±0.02
G2Y	8.05 ^e ±0.00	3.20 ^a ±0.28	0.23 ^c ±0.04	6.50 ^d ±0.07	4.13 ^{cd} ±0.04
G3Y	9.42 ^a ±0.02	2.59 ^b ±0.02	0.14 ^{cd} ±0.14	7.12 ^c ±0.02	4.49 ^b ±0.00
G4Y	9.13 ^b ±0.04	3.08 ^a ±0.05	0.24 ^c ±0.05	8.86 ^a ±0.00	4.02 ^c ±0.02
G5Y	9.07 ^b ±0.02	2.94 ^{ab} ±0.02	0.68 ^b ±0.00	8.42 ^b ±0.02	4.19 ^c ±0.00
G6Y	9.12 ^b ±0.00	2.50 ^b ±0.09	1.24 ^a ±0.01	8.88 ^a ±0.02	4.67 ^a ±0.02

* Values are Means of Duplicate Determinations±Standard Deviation

Means with different superscript within a column are significantly different (P>0.05)

** Sample

G0Y=100% Gari

G1Y=95% Gari: 5% Residue

G2Y=90% Gari: 10% Residue

G3Y=85% Gari: 15% Residue

G4Y=80% Gari: 20% Residue

G5Y=75% Gari: 25% Residue

G6Y=70% Gari: 30% Residue

3.6. Glycemix Index

Table 8 showed result of Glycemic Index of Gari-fermented white maize residue. The Glycemic Index (GI) ranged from 52.54% in sample G5Y to 64.59% in sample GOY.

Table 8. Glycemic Index of Gari-fermented Yellow Maize Residue.

Samples	GI (%)
GOY	64.59 ^a ±0.001
G1Y	57.31 ^b ±0.007
G2Y	53.93 ^c ±0.003
G3Y	53.74 ^d ±0.003
G4Y	53.04 ^e ±0.006
G5Y	52.54 ^f ±0.004
G6Y	53.92 ^c ±0.003

Means with the same superscript in the same column show that there is no significant difference (P>0.05).

G0Y=100% Gari

G1Y=95% Gari: 5% Residue

G2Y=90% Gari: 10% Residue

G3Y=85% Gari: 15% Residue

G4Y=80% Gari: 20% Residue

G5Y=75% Gari: 25% Residue

G6Y=70% Gari: 30% Residue

4. Discussions

Result of Functional Properties

Results of functional properties showed Water Absorption Capacity (WAC) decreased with increase in the amount of residue flour from 4.38 g/g in the control to 3.47 g/g in sample G6b (30% residue addition). Gari has a high water absorption capacity and a dilution effect with a fibre residue will obviously lead to a decrease in it WAC. The Oil Absorption Capacity (OAC) also decreased but by way of comparison the WAC of the blends were higher than the OAC.

The bulk density increased with increase in the content of

the residue flour, from 0.59 g/ml in the control (G0b) and G10 to 0.70 g/ml in sample G5b. The increase could possibly be as a result of the fact that the Gari has a higher density when compared to the maize residue and being a gelatinized product is more compact in its structure and so the addition of the residue was not sufficient to decrease its overall density thereby making it to have more weight per volume. The values for swelling power increased with substitution and also could be a function of the WAC of the added fibre residue. Swelling power increased from 5.78 g/g in the control to 8.36 g/g in sample G46 (20% level of substitution), though the results did not show a gradation with increase in substitution levels. The solubility index (%) decreased from 50.44% in the control to 29.74% in sample G6b (30% substitution). The decreased solubility could be as a result of the insoluble fibre content of the fermented maize residue. Insoluble fibre are major constituents of whole grains. Ozyurt and Otlis [13] reported whole grain cereals contain greater quantities of insoluble fibre and that the type of dietary fibre either soluble or insoluble define their physical behavior in water.

The pasting characteristics of Gari-fermented yellow maize residue blends show the peak viscosity decreased with increase in residue flours. Trough also followed the same pattern as observed except at G1b (5% residue) and G2b (10% residue) but overall values for trough decreased. Breakdown viscosity also increased at G2b at 10% levels of substitution before a decrease. The final viscosity also increased at 5 and 10% levels of substitution at sample G1b and G2b. Final viscosity increased at 5 and 10% levels of substitution, decreased at 15% (G3b), 20% (G4b), 25% (G5b) and 30% (G6b). Setback viscosity decreased upto G5b (25% residue) before an increase at 30% level of substitution. Pasting temperature decreased from the control while the pasting time increased with residue content.

Mean sensory scores of "Eba" from yellow Gari-fermented yellow maize residue blend show the control sample (G0Y)

was the most preferred for colour with a score of 5.0 and followed closely by G1Y with a score of 4.62, G3Y with a score of 4.07 and G2Y with a score of 4.00, sample G6Y with 30% level of substitution was the least preferred with a score of 3.00. For texture the control sample was still the most preferred with a score of 4.84 and followed closely by G1Y (4.61), G4Y (4.23) and G2Y and G3Y with a score of 4.07, the least preferred sample for texture is sample G6Y (3.07). Sample GOY was still the most preferred for Aroma (4.84) though value did not differ significantly from samples G1Y, G2Y and G3Y G3Y and G4Y. For mouldability (ease of moulding) sample GOY and G1Y were the most preferred with sensory scores of 4.84, but value did not differ significantly from samples G2Y, samples G3Y, samples G5Y and G6Y were the least preferred but values did not differ significantly from G2Y, G3Y. For overall acceptability, samples GOY and G1Y were the most preferred with scores of 4.88 and 4.69, but the values did not differ significantly from G2Y, G3Y and G4Y, sample G5Y and G6Y had equal preference and their means were not significantly different. The results thus show that for the sensory attributes of overall acceptability Eba at 5, 10, 15 and 20% levels of substitution with fermented yellow maize residue compared favourably with the control as the mean sensory scores did not differ significantly ($P > 0.05$). Oluwamukomi [4] reported that addition of defatted sesame to Gari gave acceptable Eba at 10% level of substitution.

The moisture content (%) of Gari ranged from 9.98 in GOY to 12.78 in G2Y, values were not significantly different ($P > 0.05$) and are within ranges for Gari samples, Akume *et al.*, [14] reported moisture contents of 8.55–12.60% in Gari fortified with mango fruit mesocarp. Awoyale *et al.*, gave values of moisture content of Gari of between 3.53–7.25% [15]. Values for ash dropped with increase in the presence of residue flour from 1.24 in the control to 0.84% in G3Y. Akume *et al.*, also presented a decrease in ash content of Gari fortified with mango mesocarp, from 2.94 in the control to 2.30 at 30% level of substitution with mango fruit mesocarp flour [14]. The fat content also increased from the control (1.00) to 2.20% in G5Y. Alozie and Ekerette indicated an increase in fat content of Gari fortified with soybean, melon seed and moringa seed flour. The values for fat as reported increased from the control, 6.34% to 10.74% for melon seed Gari, 8.81% for soy Gari and 7.6% for moringa seed Gari [3]. Crude protein (%) increased from 0.61 in the control to 4.11 in G6Y (30% substitution level). Akume *et al.*, also reported an increase in protein of Gari from 1.01 in the control to 1.42% at 30% substitution level with mango fruit mesocarp [14], Onasoga *et al.*, also reported an increase in protein content of Gari composited with African bread fruit residue from 1.96 in the control to 9.62% at 30% level of substitution [1]. Crude fibre also increased with residue substitution while values of carbohydrate decreased with increase in substitution with residue flour. Proximate composition of “Eba” showed Moisture content ranged from 65.96–70.32% and did not show any significant difference among the means, values for ash was also not significantly different, result for fat showed an increase with substitution with residue flours with sample G5Y and G6Y (25% and 30%

residue addition) being significantly different from all others. Results for crude protein and crude fibre also follow the observed trend as values increased with residue substitution with sample G6Y being significantly different from others while carbohydrate decreased with substitution and the values did not show any significant difference among the means.

The addition of maize residue increased the calcium content of the Gari from 4.75 mg/100g in the control to 9.18 mg/100g. Akume *et al.*, [14] also reported an increase in the calcium content of Gari supplemented with mango fruit mesocarp.

The values for the control 4.75 mg/100g was higher than 1.02 mg/100g reported by [16] and lesser than 16.20 mg/100g and 9.2 mg/100g reported by [17, 18].

Result for magnesium showed no defined pattern as to the effect of residue addition on the magnesium content but values were least in sample G6Y with 30% residue addition with samples G0Y, G2Y and G4Y being significantly different.

Results for Zinc showed the content of Zinc increased with residue addition from 0.05 mg/100g in G0Y to 1.24 mg/100g in G6Y. Values for Iron (Fe) increased from 5.70 mg/100g in G0y to 8.88 mg/100g in G6y, thus showing an increase in the Iron content of the Gari samples with maize residue addition with samples G4y and G6y being significantly different. Result for phosphorus showed an increase in phosphorus content with residue flour addition from 4.04 mg/100g in the control to 4.67 mg/100g in the highest level of substitution G6Y.

The addition of residue also reduced the value of Glycemic Index (GI) from 64.59% in the control to 52.54% in sample G5Y with 25% level of substitution with residue flours.

The reduction in GI upon addition of residue flours can be attributed to the fact that the fibre flour increases the indigestible carbohydrate content of the gari samples.

In the classification of resistance starch into their further sub-class of type 1, type 2, type 3 and type 4, partly milled grain and seeds were classified as resistant starch, so the reduction in the GI of the samples from the control can also be added to a likely increase in its content of resistant starch.

Scazzina *et al.*, reported that high contents of indigestible carbohydrate in products such as bread has a beneficial effect on glycaemic response [19]. Glycaemic response refers to the effect of food on blood glucose after consumption. Krawecka *et al.*, also reported that Dietary fibre as a group of compounds comprising plant polysaccharides, oligosaccharides, lignins, fructans and β -glucans does not increase the level of glycaemia and also reported that cereal grains are rich mainly in the insoluble fraction of dietary fibre, and the greatest amount of fibres are found in whole-grain milled products and that higher consumption of such products is associated with reduction of the type 2 diabetes risk in subjects with glucose intolerance. They also indicated that the glycaemic response of bread appears to be lower after the incorporation of whole or cracked rye or barley grains [20].

5. Conclusions

Addition of fermented maize residue led to a decrease in

water absorption capacity a decrease in oil absorption capacities, increase bulk density and swelling power while solubility decreased. This study also shows that addition of the residue also affected pasting properties, increased the content of protein, crude fibre, fat with a decrease in carbohydrate content. Result of sensory evaluation of “Eba” showed that for overall acceptability levels of substitution upto 20% compared favourably with the control. The content of Ca, Zn, P and Fe content increased with addition of the fermented Maize residue. This study also shows a decrease in glycemic index of Gari upon the addition of residue flours. This study thus suggests that fermented maize residue can find utilization in human food formulations. Further studies to evaluate the prebiotic and probiotic potentials of food products with fermented maize residue addition is recommended.

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