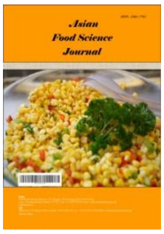

Asian Food Science Journal

20(12): 18-27, 2021; Article no.AFSJ.79826
ISSN: 2581-7752

Physicochemical, Functional and Pasting Properties of Garri Fortified with Soybean Flour

P. C. Obinna-Echem [a*] and P. A. Amgbeye [a]

[a] Department of Food Science and Technology, Rivers State University, Port Harcourt, Rivers State, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2021/v20i1230388

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/79826

Original Research Article

Received 09 October 2021
Accepted 18 December 2021
Published 20 December 2021

ABSTRACT

Aim: This study evaluated the physicochemical, functional and pasting properties of garri fortified with soybean flour.
Methodology: Soybean flour was incorporated into the garri prior to garrification at a ratio of 10, 20, 30, 40 and 50% for samples A, B, C, D and E respectively. Sample without soybean flour served as control. Standard analytical procedure was used in the evaluation of all six samples.
Results: The pH and titratable acidity (TTA) of the samples varied respectively, from 4.59 - 6.48 and 0.08 - 0.17 % lactic acid. There was significant ($P<0.05$) decrease in pH with increase in soybean flour, while the reverse was the case for TTA. Swelling power, bulk density and water absorption capacity of the soybean fortified garri ranged from 8.74 - 17.81%, 0.60 - 0.80 g/ml and 13.44 – 19.43 % respectively. Control sample (100% garri) had hydrogen cyanide (HCN) content of 1.50 mg HCN/100g while samples with soybean flour had no detectable levels. Peak viscosity, trough, breakdown, final viscosity and setback varied significantly ($P<0.05$) from 101.19 - 399.44, 90.92 - 320.19, 10.28 - 79.25, 123.19 - 451.50 and 32.28 - 131.31 RVU respectively. Peak time and pasting temperatures ranged from 5.18 – 6.34 min and 74.28 – 92.88 ^{o}C.
Conclusion: The study revealed that a good quality garri can be produced with the incorporation of soybean flour up to 50%, the garri is safe for consumption as there was no HCN detected, and the decrease in viscosity provides for a soft textured, mouldable garri that is convenient for swallow.

**Corresponding author: Email: patience.obinna-echem@ust.edu.ng, Chisanupat@yahoo.com;*

Keywords: Garri; soybean flour; acidity; hydrogen cyanide; functional and pasting properties.

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a tuberous root crop grown in tropical and subtropical regions where the starchy, tuberous roots are a valuable source of cheap calories, especially in developing countries where calorie deficiency and malnutrition are widespread [1]. In Nigeria and some other African countries, many fermented traditional foods such as garri, tapioca, flour, chips, fufu, etc are processed from cassava roots. These fermented cassava products play key role in the nutrition of the people as they constitute important ingredients for main meals providing cheap source of energy.

Garri is a fermented pre-gelled ready to eat creamy-white grit granules. The production process involves peeling, washing, grating, dewatering by bagging and pressing under heavy weight during which spontaneous fermentation of the grated mash takes place at ambient temperature [2]. This is followed by sieving of the fermented dewatered mash and garrification [3]. Fermentation is a very essential step in the production of garri, as it does not only result in detoxification of the mash, it also improves upon the sensory, safety and overall quality of the product [2]. Fermentation of the grated mash is mostly by endogenous microflora in two stages; the first stage is predominated by lactic acid bacteria such as *Lactobacillus* spp., *Streptococcus*, *Corynebacterium manihol* and *Leuconostoc* [3,4] during which starch is broken down to organic acid with resultant decrease in pH that enables the hydrolysis of linamarin. In the second stage, the produced organic acids stimulate the growth of fungi such as *Geotricum candida*, that produces compounds responsible for the characteristics flavour of garri. These compounds include pyrazines, aldehydes, esters, ketones and alcohols among others [3,5]. The acceptability of garri is related to its sourness [5] and the longer the fermentation, the more the production of organic acids and volatile substances responsible for the sourness and flavor of the garri. This is more acceptable for consumers in the South-west of Nigeria, that prefer an acidic taste. The functional and pasting properties of the processed garri is important in its preparation for consumption which is predominantly consumed as eba (stiff gel made with hot water) in main meal with different kinds of soup or stew, or eaten as snack when soaked in cold water or milk, with sugar or salt, roasted groundnut, dried fish or coconut. Functional properties are significant in explanation of the behaviours of garri under different conditions [6].

Garri is a starchy food processed from cassava roots which contain a high concentration of starch when compared with other food crops hence the addition of protein rich legumes and oilseeds such as soybeans, melon seeds, groundnut etc. in its production. Soybean (*Glycine Max,* Merr) is species of legume native to Asia, widely grown in many parts of the world for its oil and protein [7]. Soybean is a very good source of essential nutrients and an excellent and cheap source of high quality protein [8] which is comparable to other protein food and is suitable for all ages, infants to the elderly. The addition of these legumes and oilseeds to garri in addition to improvement of nutrient, may also affect the overall quality of the garri. This study was therefore aimed at evaluating the physicochemical, functional and pasting properties of garri fortified with soybean flour.

2. MATERIALS AND METHODS

2.1 Raw Materials

Fresh cassava (*Manihot esculenta* Crantz) roots and Soybean (*Glycine max* Merr) was obtained from Rukpokwu main market in Port Harcourt, Rivers State Nigeria.

2.2 Production of Soybean Flour

Soybean flour was produced following the method described by Obinna-Echem et al. [9]. The seeds were sorted, washed, soaked in water for 24 h with a change in water every 6 h before blanching at 85^{o}C for 2 min. The seed testae was removed, the seed washed and dried in an oven (DHG-9140 A, Shanghai, China) at 30^{o}C for 24 h. The dried seeds were milled with an attrition mill (Globe P14, Shanghai, China) into flour and sieved with 150 µm sieve size to obtain soy flour. The flour was packaged in air-tight container and stored in the refrigerator till needed for analysis.

2.3 Production of Garri from Cassava Tubers and its Fortification with Soybean Flour

The traditional processing of Cassava tubers was as described by Okaka [10]. Briefly, the cassava roots were peeled, washed, grated and packed in bags, that was subjected to heavy pressing for 2 days. This was achieved by placing the bagged grated cassava mesh on two paralleled hardwood beams and then placing two other planks on the bag that were tied to those below as tightly as possible thereby pressing out water from the bagged cassava mash. A simultaneous dewatering and fermentation occur during this period, yielding a pulp cake which was sieved to yield a grain mesh and the fibre which is discarded. The mash was garrified in a hot pan over a wood fire with constant stirring until the starch is gelatinized and relatively dry. The stirring was to ensure that the mesh do not char or stick to the pan. The mash prior to garrification was fortified with soybean flour in the ratio shown in Table 1.

2.4 Analysis of Physiochemical of Garri Fortified with Soybean Flour

2.4.1 Determination of pH and Total Titratable Acidity (TTA) of garri fortified with soybean flour

pH and Total titratable acidity (TTA) as % lactic acid was determined following the standard AOAC [11] methods. To 2 g of the fortified garri sample in a beaker was added 20 ml of distilled water that was filtered after 2 min of vigorous stirring. A digital pH meter (Mattler Toledo Seven, Muhl, China) after calibration using standard buffer of pH 4.0 and 7.0, was used to determine the pH of 10 ml of the filtered sample in a beaker. Thereafter, the sample was titrated with a solution of 0.1N sodium hydroxide using 0.3 ml phenolphthalein as indicator and the acidity calculated and expressed as % Lactic acid.

2.4.2 Determination of hydrogen cyanide (HCN) content of garri fortified with soybean flour

The cyanide content of the fortified garri was determined according to the method outlined by AOAC, [11]. After the micro-kjedahl distillation of 10 g of the sample, the distillate was titrated using 0.02N silver Nitrate ($AgNO_3$) until a faint permanent turbidity was achieved. A blank without the sample was also determined. The HCN content was calculated with the milligram (mg) equivalent of $AgNO_3$ to HCN using the formula:

HCN mg/100 g = (Sample Titre ─ blank titre × 1.08 × 100) / Sample weight

2.5 Determination of Functional Properties of Garri Fortified with Soybean Flour

2.5.1 Determination of swelling power

The swelling power of the fortified garri was determined according to the method described by Ayo et al. [12]. The garri (1 g) was mixed with 10 ml of distilled water in a centrifuge tube and heated to 80^{o}C and held for 30 min with continuous shaking. The heated suspension was centrifuged at 1000 x g for 15 min. The weight of the sediment was taken. Swelling power (%) was expressed as weight of sediment divided by the weight of the sample multiplied by 100.

2.5.2 Determination of bulk density

Bulk density was determined according to the standard method of AOAC, [11]. Briefly, 3 g of the fortified garri was added to a 20 ml graduated measuring cylinder. The cylinder was tap gently until the samples was closely packed. The volume occupied by the sample was noted and the bulk density (g/ml) was calculated as weight of garri (g) divided by its volume (ml).

2.5.3 Determination of water absorption capacity

The method by Mbofung et al. [13] was adopted in the determination of the water absorption capacity (WAC). About 0.5 g of sample was added to 10 ml of distilled water in a pre-weighed centrifuge tube. The centrifuge tube and content was agitated on a start scientific orbital shaker for 5 min and centrifuged at 3000 rpm for 10 min in a centrifuge (L. 600, China). WAC was expressed in percentage as the ml of the clear supernatant was subtracted from 10 ml of distilled water and divided by the sample weight.

2.6 Pasting Properties of the Garri Fortified in Soybean Flour

The pasting properties of the fortified garri was analysed using a Rapid Visco Analyzer (Newport Scientific PTY Ltd, RVA 3D, Sydney). Briefly, 3 g of each fortified garri sample was transferred into the water surface in the canister. The paddle was placed into the canister and the blade was vigorously jogged through the sample up and down until the garri was no longer found on the surface of the water or the paddle. The paddle was properly centred into the canister and the measurement cycle initiated. The RVU pasting curve was automatically plotted. The viscosities, temperature and time were expressed in RVU, degree Celsius (°C) and minutes respectively.

Table 1. Ratio for the fortification of garri with soybean flour

Sample code	Control	A	B	C	D	E
Sieved cassava mash	100	90	80	70	60	50
Soybean flour	0	10	20	30	40	50

2.7 Statistical Analysis

All analysis was carried out in duplicates Minitab (Release 18.0) Statistical Software (Minitab Ltd., Coventry, UK) was used for the analysis of the data obtained. Statistical differences were obtained using analysis of variance (ANOVA) under the general linear model and Fisher pairwise comparison at 95% confidence level.

3. RESULTS AND DISCUSSION

3.1 pH and Total Titratable Acidity (TTA) of Garri Fortified with Soybean Flour

The pH and TTA (% Lactic acid) of garri fortified with soybean flour are presented in Fig. 1. There was significant (P<0.05) increase in pH with increase in the substitution with soybean flour, while TTA (% lactic acid) decreased with increase in soybean addition.

The pH values varied from 4.59 - 6.48 for the control (CLT) and Sample E respectively. pH of the control, sample A, B and C were comparable with the pH of 4.76 – 5.15 report by Agbara et al. [14] for garri from peeled, incompletely peeled cassava fortified with 10% of soybean flour and 4.79 – 5.16 garri fortified with 12% (w/w) malted soybean and soy protein [15]. While Sample D and E had higher pH. The pH for sample D and E with 40 and 50% soybean flour respectively was near neutral. The low pH value of the control is an indication of the microbial activities of the fermenting microorganisms during the fermentation process. Fermenting microorganisms hydrolyse the carbohydrate (starch) in the grated cassava mash to sugar, organic acids and alcohol [16]. The increase in pH with the addition of the soybean flour was expected as the soybean flour was not fermented. Low pH ensures good keeping quality of any sample.

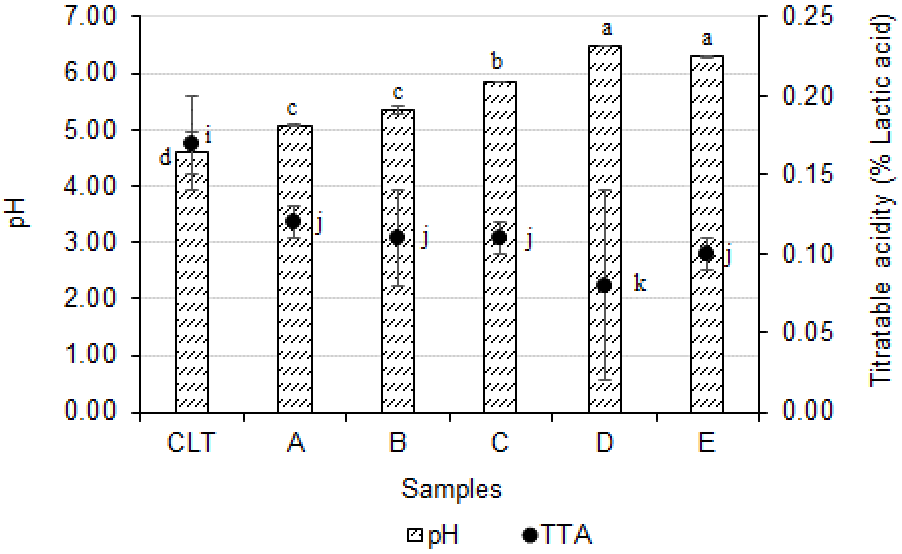

Fig. 1. pH and total titratable acidity (% lactic acid) of garri fortified with soybean flour

Bars/Points are means ± standard deviation of duplicate samples
Bars/Points bearing different letter differ significantly (P<0.05)
CTL - 100% cassava garri
A - 90% garri with 10% soybean
B - 80% garri with 20% soybean
C - 70% garri with 30% soybean
D - 60% garri with 40% soybean
E - 50% garri with 50% soybean

Total Titratable acidity (TTA) ranged from 0.08 - 0.17 % lactic acid. The control had significantly (P<0.05) the highest TTA while sample D had the least. This acidity values are lower than the values of 0.54 - 0.81 % lactic acid reported by Ahoata et al. [15] for garri fortified with malted soy flour and soy protein and fermented at 30°C for 72 h. The difference could be attributed to the variation in the treatment of the soybean and the fermentation process. Ahoata et al. [15], added malted soybean flour to the cassava mash before fermentation and fermented the fortified mash, while in this present study, the soybean flour was not malted and its addition was prior to garrification, it was not fermented alongside with the mash. The variation in the TTA implied that it was not just the lactic acid that was responsible for the acidity of the samples. The acidity of the samples is important in the sourness or the garri which is desirable attribute in its production. The more acidic the garri sample the better its acceptability by consumers in the South-west of Nigeria [5].

3.2 Hydrogen Cyanide (HCN) of Garri Fortified with Soybean Flour

Hydrogen cyanide (HCN)was detected only in the control sample (100% garri) at a level of 1.50 mg HCN/100g, the samples with soybean flour had no detectable levels. This is at variance with other finding where different levels of HCN were detected such as 0.11 - 0.37 mg/100g cyanide in garri from peeled, incompletely peeled cassava fortified with 10% of soybean flour [14] and 1.1 - 1.5 mg/100g cyanide in garri produced from selected cassava cultivars in River State Nigeria [17]. Fresh cassava tubers have been reported to contain 10 - 500 mg/kg of HCN [18]. Chikezie and Ojiako [19] reported level of 4.07 – 5.20 mg/100g from fresh cassava tubers while garri processed from the tubers had 1.44 – 3.95 mg/100. According to Chikezie and Ojiako [19], the WHO recommended maximum safe intake of HCN is 10 mg HCN/kg body for humans and animals. The result of this study on HCN content of garri fortified with soybean flour revealed the effectiveness of the 2 days' fermentation process in the degradation of the cyanogenic glucoside in the mashed cassava, while the addition of soybean flour resulted to none detectable levels, as soybean is not known to contain cyanide. This soybean fortified garri would not be of any safety concerns to the consumers.

3.3 Functional Properties of Garri Fortified with Soybean Flour

The swelling power, bulk density and water absorption capacity of the garri fortified with soybean flour are shown in Table 2.

Swelling power is the ability of the starch to imbibe in water. The swelling power of the fortified garri decreased with increase in soybean flour addition. The values varied from 8.74 - 17.81% for sample E and the control respectively. This values are higher than the report of 2.14 – 3.34% for garri with the inclusion of palm oil [20]. Swelling power of a product points at the cumulative effects of starch quality, specifically amylose/amylopectin ratio as reflected by the volume of gel produced when heated with an excess of water [21]. Soybean is not a starchy food; its addition may have resulted in decrease in the starch quality (amylose/amylopectin ratio) of the garri, leading to decrease in swelling power with increase in fortification. Garri is expected to absorb water and gelatinize, the high swelling power therefore

Table 2. Functional properties of garri fortified in soybean flour

Samples	Swelling Power (%)	Bulk Density (g/mL)	Water Absorption Capacity (%)
CLT	17.81±0.13^{a}	0.60±0.00^{c}	13.44±0.40^{d}
A	13.76±0.25^{b}	0.63±0.06^{c}	17.44±0.34^{c}
B	12.39±0.89^{cd}	0.80±0.00^{a}	18.29±0.07^{b}
C	12.76±0.05^{bc}	0.67±0.06^{bc}	18.27±0.06^{b}
D	11.34±0.13^{d}	0.77±0.06^{ab}	18.36±0.19^{b}
E	8.74±0.16^{e}	0.77±0.06^{ab}	19.43±0.48^{a}

Values are means ± standard deviation of triplicate samples
Values bearing different superscripts in the same column differ significantly (P<0.05)
CTL - 100% cassava garri
A - 90% garri with 10% soybean
B - 80% garri with 20% soybean
C - 70% garri with 30% soybean
D - 60% garri with 40% soybean
E - 50% garri with 50% soybean

is a desirable quality in garri. According to Awoyale et al. [22], a good quality garri should be able to swell three times its original size when soaked in water. The decrease in the swelling power of the soybean flour fortified garri with addition of soybean flour implied a reduction in one of the good qualities of garri and the values were lower than 22.45 - 33.81% for cassava mash reported by Awoyale et al. [2]. This implies that the fortification process had a significant influence on the cassava-soy flour garri.

There was significant (P<0.05) variations in the bulk density with increase in soybean flour. The values ranged from 0.60 - 0.80 g/ml for the control (100% cassava) and sample B respectively. These values were higher than those reported for garri with palm oil inclusion (0.56 – 0.65) and mango fruit mesocarp flour (0.51 - 0.66) reported by Ndefi et al. [21] and Akume et al. [23]. The high bulk density of the soybean fortified garri is desirable as the higher the bulk density the lower the ability of the samples to float in water. Floatation of garri samples on top of water, may lead to rejection of the product by consumers [24]. High bulk density means that the garri will be able to absorb water and gelatinize during preparation of the still gel (eba), therefore, high bulk density is crucial for the production of a mouldable (eba) that would not scatter while dipping in the carrier (soup). This implies a good quality garri from fortification with soybean flour .

Water absorption capacity (WAC) ranged from 13.44 – 19.43%. These values are lower than that report by Agbara et al. [14]. WAC increased significantly (P<0.05) with increase in soybean flour such that the control CLT had significantly (P<0.05) the lowest value while sample E had the highest value. The increase in WAC of sample B, C and D was not significantly (P<0.05) different. WAC is the ability of any material to the absorb water when soaked in it. For the garri samples it represented the mass of water absorbed per unit mass of the sample. It is therefore a function of the particle size and indication of the structure of the garri. A low and high WAC designates compactness and lose structure of the sample respectively [25]. The control sample with the lowest WAC could be said to be more compact while the addition of soybean flour reduced the compatibility providing room for more absorption of water. This quality is also relevant to the gelatinization of the garri for a good quality and acceptable eba.

3.4 Pasting Properties of Garri Fortified with Soybean Flour

Pasting properties of the soybean flour fortified garri are shown in Table 3. There was significant (P<0.05) decrease in the viscosities of the samples with increase in the addition of soybean while the time and temperatures increased. Peak viscosity varied significantly (P<0.05) from 32.25 - 399.44 RVU. The control had significantly (P<0.05) the highest peak viscosity, followed by sample A (218.33 RVU) while sample E had the least. The peak viscosity of the control is similar to that report by Awoyale et al. [2] for back slopped and spontaneously fermented cassava mash. Peak viscosity indicates the water binding capacity of the starch grains and the flimsiness of swollen granules [26]. The decrease in the peak viscosity with increase in soybean suggest that the soybean flour may have allowed more water binding ability as evidenced in the WAC of the garri samples. Peak viscosity also reflects the ease of cooking of the starch fraction and a good texture of cooked starch [27,28]. This implies that for a quick gelatinization and firmer textured garri the samples with high peak viscosity like the control and sample A would be preferred while for a soft texture, the higher fortification would be better.

The trough viscosity which is also known as the holding strength is the minimum viscosity after the peak, normally occurring around the commencement of sample cooling. The value varied from 29.50 – 320.19 RVU. Sample E and the control had significantly the least and highest values respectively. As with the final viscosity it implies that the samples with the soybean flour may not form very stiff and firm gel (eba) compared to the control.

The breakdown viscosity of the samples varied from 2.75 - 79.25 RVU for sample E and the control respectively. These values are lower than that report by Awoyale et al. [2] for garri from back slopped and spontaneously fermented cassava mash, but comparable with some of the values reported by Ogueke et al. [29] for different samples of garri. Breakdown viscosity reflects the ability of the sample to withstand sheer stress and heating during cooking. This implies that the starch grains of the garri with high levels of soybean flour lack the integrity to withstand stress from the mechanical agitation in visco analyzer and therefore raptured earlier leading to decreased viscosity. The garri with 30 - 50% soybean flour (Sample C to E) may be unable to withstand cooking without losing firmness.

Table 3. Pasting properties of garri fortified with soybean flour

Samples	Viscosities (RVU)					Peak Time (min)	Pasting Temperature (^{O}C)
	Peak	Trough	Breakdown	Final Viscosity	Set Back		
CLT	399.44±3.43^{a}	320.19±3.57^{a}	79.25±1.27^{a}	451.50±1.97^{a}	131.31±4.26^{a}	5.42±0.11^{bc}	74.28±0.08^{e}
A	218.33±5.86^{b}	173.64±0.22^{b}	44.69±4.53^{b}	259.67±8.45^{b}	86.03±6.57^{b}	5.58±0.10^{bc}	85.58±0.08^{d}
B	128.33±6.88^{c}	113.06±3.88^{c}	15.28±4.46^{c}	169.83±6.05^{c}	56.78±3.25^{c}	6.34±0.24^{a}	89.08±1.29^{c}
C	101.19±6.50^{d}	90.92±3.85^{d}	10.28±2.66^{cd}	123.19±4.09^{d}	32.28±3.13^{d}	5.78±0.28^{b}	88.25±0.36^{c}
D	50.08±1.39^{c}	47.89±1.69^{e}	2.19±0.32^{de}	77.08±1.946^{de}	29.19±0.34^{de}	5.18±0.05^{c}	90.73±0.49^{b}
E	32.25±1.86^{f}	29.50±2.47^{f}	2.75±0.69^{e}	50.20±3.96^{f}	20.69±1.67^{e}	5.18±0.09^{c}	92.88±0.08^{a}

Setback viscosity ranged from 20.69 – 131.31 RVU for Sample E and the control respectively. The setback viscosity of the control is comparable to garri from back slopped and spontaneously fermented cassava mash [2]. Setback is related to the degree of polymerization of the amylose fraction leached during swelling, hence it is an indication of resistance of the starch to retrograde [30,31]. The addition of soybean flour may have lowered the degree of polymerization of the garri starch thereby leading to lower set back in the test samples.

The final viscosity varied significantly ($P<0.05$) from 50.20 - 450.50 RVU. The control had the highest final viscosity and Sample E had the least. The final viscosity of the control is higher than 279.46 – 337.55 for garri from back slopped and spontaneously fermented cassava mash [2]. The final viscosity of the garri samples where higher than the peak viscosity. Final viscosity marks the ability of starch to form viscous paste after cooking and cooling [26]. The decrease in final viscosity of the garri with increase in soybean addition implies that soybean decreased the ability of the garri to form stiff gel on cooling. However, the garri with soybean fortification were still mouldable when stirred in hot water for the preparation of stiff gel (eba). This is a desirable quality for consumers as the stiff gel (eba) is moulded with the palm, and consumed by dipping in soup or stew before swallowing [16].

Peak time and pasting temperature correspond to time (min) and temperature (^oC) at which the peak viscosity occurred. It was observed that the peak time (5.18 – 6.34 min) and pasting temperatures (74.28 – 92.88^oC) increased with the addition of the soybean flour. These values are comparable with the values reported by Ogueke et al. [29] for different samples of garri but higher than those of garri from back slopped and spontaneously fermented cassava mash [2]. Though the viscosity of the fortified garri samples were lower than the control, it took longer time and higher temperature to achieve the peak viscosity, this means that more time at higher temperature is required for the garri to be stiff for moulding. That is the water for preparation of eba from the soybean fortified garri should be at boiling temperature and the stirred garri should be allowed to stand for some time to achieve a stiff mouldable eba.

4. CONCLUSION

The pH and total titratable acidity of the soybean fortified garri is similar to that of other studies accept for samples with 40 and 50% substitutions that were near neutral and there was no HCN found in the samples. This is an indication that the soybean flour fortified garri is safe for human consumption. Pasting properties revealed a decrease in the viscosities of the samples with increase in the addition of soybean while pasting time and temperatures increased. This implies that for a quick gelatinization and firmer textured garri the samples with high peak viscosity (Control and Sample A) would be preferred while for a soft texture, those with more soybean flour would be better. A good quality garri can therefore be made with the incorporation of soybean flour up to 50%.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

ACKNOWLEDGEMENTS

The authors sincerely appreciate the technical assistance of Mr. Friday Owuno of the analytical laboratory unit of the Department of Food Science and Technology, Rivers State University, Port Harcourt, Rivers State, Nigeria

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bayata A. Review on nutritional value of cassava for use as a staple food. Sci J Ana Chem. 2019;7(4): 83-91.
DOI: 10.11648/j.sjac.20190704.12
2. Awoyale W, Oyedele H, Adenitan AA, Alamu EO, Maziya-Dixon B. Comparing the functional and pasting properties of gari and the sensory attributes of the eba produced using backslopped and

spontaneous fermentation methods, Cogent Food Agric. 2021;7(1):1883827. DOI: 10.1080/23311932.2021.1883827

3. Ouwamanam CI, Ogueke CI, Achinewuu SC, Barimala IS. Quality characterization of garri as affected by pre-ferment liquor, temperature and duration of fermentation. Am J Food Technol. 2011;6:374-384**.**
4. Meraz M, Shirai K, Larralde P, Revah S. Studies on the bacterial acidification process of cassava (*Manihot esculenta*). J Sci Food Agric. 1992;60(4):457-463. Available:https://doi.org/ 10.1002/jsfa.2740600409
5. Abass AB, Dziedzoave NT, Alenkhe BE, James BD. Quality management manual for the production of Gari. International Institute of Tropical Agriculture IITA, Enugu; 2012.
6. Adeleke RO, Odedeji JO. Functional properties of wheat and sweet potato flour blends. Pak. J. Nutr. 2010;9:535-564.
7. Sedaghati E and Hokmabadi H 2014 Safety of Food and Beverages: Oilseeds and Legumes, In: Motarjemi Y, editor. Encylopedia of Food Safety. Academic press Vol 3.331-339; 2014. Available:https://www.sciencedirect.com/science/article/pii/B9780123786128004431
8. Agengo FB, Serrem C, Wamunga F. Evaluation of protein nutritional quality of four soybean varieties grown in western Keenya. J Food Res. 2018;7(5):6-9. DOI: 10.5539/jfr.v7n5p69
9. Obinna-Echem PC, Barber L, Confidence E. Proximate composition and sensory properties of complimentary food-formulated from malted pre-gelatinized maize, soybean and carrot flours. J Food Res. 2018;7(2):17- 24.
10. Okaka JC. Food composition, spoilage and shelf life extension. Organco Academic pulishers. 2001;233-234.
11. AOAC, Association of Official Analytical Chemist, Official methods of analysis, 19th edition, Washington D.C., USA; 2012
12. Ayo JA, Adedeji OE, Ishaya G. Phytochemical composition and functional supported by properties of flour produced from two varieties of tigernut (*Cyperus esculentus*). FUW Trends Sci Technol J. 2015;1(1):261-266.
13. Mbofung CMF, Abuobakar YN, Njintang A, Abduo Boubak, Balaam F. Physico-chemical and functional properties of six varietes of Taro (*Colocasia esculenta* L. Schott) flour. J. Food Technol. 2006;4(2):135-142.
14. Agbara GI, Ibekwe PC. Effects of melon seed or soybean meal supplementation on the physicochemical and sensory properties of incompletely peeled cassava garri. J Food Technol Res. 2020;7(1):125-135.
15. Ahaotu I, Ogueke CC, Owuamanam CI, Ahaotu NN, Nwosu JN. Protein improvement in gari by the use of pure cultures of microorganisms involved in the natural fermentation process. Pak. J. Biol. Sci. 2011;14:933-938.
16. Achinewhu SC, Owuamanam CI. Garrification of five improved cassava cultivars, physiochemical and sensory properties of garri yield. Afri J Root Tuber Crop. 2001;4:18-21.
17. Achinewhu S, Barber L, Ijeoma I. Physicochemical properties and garification (gari yield) of selected cassava cultivars in rivers state, Nigeria. Plant Food Hum Nutri. 1998;52(2):133-140.
18. Mburu FW, Swaleh S, Njue W. Potential toxic levels of cyanide in cassava (*Manihot esculenta* Crantz) grown in Kenya. Afr J Food Sci. 2012;6:416-20.
19. Chikezie PC, Okey A, Ojiako OA. Cyanide and aflatoxin loads of processed cassava (Manihot esculenta) tubers (Garri) in Njaba, Imo State, Nigeria. Toxicol Int. 2013;20 (3):61-267.
20. Ndife J, Nwaubani O, Aniekpeno IE. Effect of palm oil inclusion on the quality of garri produced from white and yellow cassava (*Manihot esculenta* cranz) roots. Int J Food Sci Nutri. 2019;4(3):180-185.
21. Awoyale W, Asiedu R, Kawalawu WKC, Abass A, Maziya-Dixon B, Kromah A, Edet M, Mulbah S. Assessment of the suitability of different cassava varieties for gari and fufu flour production in Liberia. Asian Food Science Journal. 2020;14(2):36–52. Available:https://doi.org/10.9734/afsj/2020/v14i230128
22. Buckman ES, Oduro I, Plahar WA, Tortoe C. Determination of the chemical and functional properties of yam bean (*Pachyrhizus erosus* (L.) Urban flour for food systems. Food Sci Nutri. 2018;6(2):457–463.
23. Akume JN, Ariahu CC, Acham IO. Quality evaluation of ready-to-eat garri made from cassava mash and mango fruit mesocarp blends. Asian J Food Sci Technol. 2019;8(3):1-9.

24. Sanni LO, Adebowale AA, Awoyale W, Fetuga GO. Quality of gari (roasted cassava mash) in Lagos state, Nigeria. Nigerian Food J. 2008;26(1):125-134.
25. Okolie NP, Brai MN, Atoyebi OM. Comparative study on some selected garri samples sold in Lagos metropolis. J. Food Studies. 2012; 1(1):52-63.
26. Obinna-Echem PC. Effect of processing method on pasting morphological and sensory properties of Akamu-a Nigerian fermented maize product. Am J Food Sci Technol. 2017;5(3):101–108.
27. Ikegwu OJ, Nwobasi VN, Odoli MO, Oledinma NU. Evaluation of the pasting and some functional properties of starch isolated from some improved cassava varieties in Nigeria. Afr J Biotechnol. 2009;8(10):2310–2315. Available:https:// doi.org/10.5897/AJB09.161
28. Ikeagwu OJ, Okechukwu PE, Ekumankana EO. Physio chemical and pasting characteristics of flour and starch from Achi (*Brachystegia eurycoma*) seed. J. Food Technol. 2010;8(2):58-66.
29. Ogueke CC, Ehirim C, Owuamanam CI, Ahaotu I and Olawuni IA. Quality characteristics and HCN in gari as affected by fermentation variables. Int J Life Sci. 2013;2(1):21-28.
30. Chung H-J, Jeong H-Y, Lim S-T. Effect of acid hydrolysis and defatting on crystallinity and pasting properties of freeze-thawed hugh amylose corn starch. Carbohydrate Polymers. 2003;54(4):449 – 455.
31. Sanni LO, Ikumola DO, Sanni SA. Effect of length of fermentation and varieties on the qualities of sweet potato gari. Proceedings of the 8th triennial symposium of the International Society for Tropical Root Crop, African Branch (ISTRC – AB) (ed. Akoroda, M. O), IITA, Ibadan, Nigeria. 2001;208–211.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/79826