International Journal of Scientific Research and Management (IJSRM)
||Volume||10||Issue||08||Pages||FT-2022-132-142||2022||
Website: www.ijsrm.in ISSN (e): 2321-3418
DOI: 10.18535/ijsrm/v10i08.ft01

Production and Quality Evaluation of MASA Made From Maize, Rice and Millet Fortified With Soybean and Tigernut

Lawrence I. G

Federal Polytechnic Offa, Food technology department

Abstract:
This work was aimed to evaluate the quality of masa produced from rice, maize, millet fortified with soybean and tiger nut. The proximate and sensory evaluation analyses were carried out on the *masa* samples for the whole grains and as well as the enriched *masa* samples. While functional properties were carried out on the flour produced. The result of the proximate composition showed that lowest moisture value (14.00%)was recorded for sample A among the enriched 'masa' samples while 12.75% was recorded for sample Eamong the whole samples which is good for shelf life stability. Sample C had the highest crude protein(7.87%), sample B had the highest fat content (32.03%), and sample A had the highest fibre (0.16%) and carbohydrate (57.56%). The bulk density, water absorption capacity, oil absorption capacity, swelling capacity and gelation concentration were within the range; 0.64-0.81g/ml, 123.33-180.57%, 93.57-142.21%,47.67-125.33%, 0.20-0.60g respectively. The sensory evaluation showed that with regards to taste, texture, colour, appearance, aroma and overall acceptability sample B was more preferred among the enriched' masa' samples and sample E was more preferred among the whole samples. Enrichment of 'masa' could contribute to improvement of nutritional status if promoted as a nutritious, health indigenous snack not only where 'masa' is already widely consumed, but also in other parts of Nigeria where it has not found wide acceptance.

Keywords: Masa, rice, maize, millet, soybean and tiger nut

1. Introduction

Masa is a yeast-fermented product which is round in shape, and is prepared in Nigeria and some other West African countries from the flour from millet, maize or rice flour (Ayo *et al.,* 2018). Masa is still produced traditionally in the home by the local women and the fermentation is spontaneous and uncontrolled. In Nigeria, 'masa' is as popular as 'ogi' (a fermented gruel from maize), but receive less attention than the latter. It could be eaten with granulated sugar or honey or tomatoes sauce or local spices because of its sour taste. Due to the mode of production of 'masa', there are variations in the taste, flavour, and sourness (Fowoyo and Ogunbanwo, 2010).

Maize is one of the most important food crops world-wide, serving as staple food, livestock feed, and industrial raw material. Maize is one of the earning grain crops and in the world it is perhaps the most versatile. It is

used in the human diet in both fresh and processed forms. The value added has been an economic driver in the specialty corn markets (FAOSTAT, 2012). Rice (*Oryza sativa*) is a staple food in many countries of Africa and other parts of the world. It is the most important staple food for about half of the human race (Imolehim and Wada, 2000). Rice is a good source of thiamine (vitamin B1), riboflavin (vitamin B2) and niacin (vitamin B3). Millet (*Panicum miliaceum*) is a major source of energy and protein for about 130 million people in sub-Sahara Africa (Obilana, 2003). Millets are unique among the cereals because of their richness in calcium, dietary fibre, polyphenols and protein (Devi *et al.,* 2011). Millets generally contain significant amounts of amino acids particularly the sulphur containing amino acids i.e. methionine and cysteine (Obilana and Manyasa, 2002). Soybeans (Glycine max), is known to be a health plant due to good content of protein, lipid contents and other phytochemicals (Aleke *et al.,* 2000) and has been used to fortify traditional foods such as garri (Ayo & Gaffa, 2002), cassava flour (Lafun) (Kuye & Sanni, 2002) and Tapioca flour (Samuel *et al.,* 2006).

Tigernut (*Cyperus esculentus L.)* is an underutilized crop and is also a cosmopolitan perennial crop. It is found to be rich in some unsaturated fatty acids. It has three varieties (black, brown and yellow). The yellow variety yield more milk upon extraction, contains lower fat and more protein and possesses less anti-nutrient factor especially polyphones (Okafor *et al.,* 2003). Tiger nut can be eaten raw, roasted, dried baked or made into refreshing beverages like tiger nut milk; which is a very nutritive and energetic drink for both old and young.

The fermentation process involved in the production of 'masa' is uncontrolled and occurs by chance inoculation. The production of 'masa' is however carried out majorly by lactic acid and the yeast Saccharomyces cerevisae (Oyeyiola *et al.,* 2013 and Ezeama and Ihezie, 2006). Lactic acid bacteria Bacillus and fungi *Aspergillus* and *Penicillium, Rhizopus* and *Saccharomyces* are the most important microorganisms involved in food fermentation.

Cereals are classified as staple foods because they are carbohydrate based starchy foods and deficient in one or two amino acids, but composite flour blends can be prepared via cereals and legumes in order to improve the protein status and limiting amino acids.

Nigeria cereal products have been successfully enriched using legumes, in particular, soybean. Soy-enriched maize pap ('soy-ogi') was developed by the Federal Institute of Industrial Research, Oshodi Nigeria (FIIRO), and has established processed technologies for 'soy-ogi' production for both infants and adults (FIIRO, 2014). The work of Ayo et al., (2008) extended the knowledge frontier on 'masa', however, review of recent literature showed that there is room for more research on enrichment of 'masa'. From past and recent studies, composite flour majorly from legumes and even tubers have been blended with cereals to improve and enhance the nutritional quality of foods produced from them, which in-turn increase the general acceptability and the rate at which such products are being consumed (Anjum *et al.,* 2005). This is a prove that the blending of cereals (maize, millet and rice) with legume (soybean) and tuber (tiger nut) will increase the nutritional composition of masa to be in conformity with specifications and standards. Therefore, research efforts should be geared towards establishment of the quality evaluation of masa made from rice and millet fortified with soybean and tiger nut.

2. Materials and Methods

Local white rice, maize, millet, soybean, tiger nut, baker's yeast, sodium bicarbonate (kanwa or trona water), granulated sugar, salt, vegetable oil, onion and masa frying pan were obtained from Owode market, Offa, Kwara state, Nigeria.

2.1. Rice flour production

The method described by Okpala and Egwu (2015) was used to produce rice flour. The rice grains were sorted manually to remove extraneous materials. The rice was washed with potable water, sundried and milled using hammer mill to pass through a 60 µm mesh sieve size. Flour was stored in airtight plastic container at room temperature until needed.

2.2. Maize flour production

Maize flour was prepared using the method described by Ayo *et al.* (2008) with slight modifications. Maize was thoroughly cleaned by picking out all broken kernels together with other foreign particles and then sorted to obtain the wholesome ones. Then 1kg of maize kernels was washed. The maize were spread on the trays and oven dried at 50 °C for 3 h with occasional stirring at intervals of 30 minutes to ensure uniform drying and ground into flour using attrition mill. The flour samples were passed through 60 µm mesh size sieve. It was then packaged in an air tight polyethylene bag, stored in a plastic container with lid and kept in a freezer until needed for use for further processing.

2.3. Millet flour production

Millet flour was prepared using the method described by Agbara *et al.* (2018) with slight modifications. Pearl millet seeds were sorted, winnowed, then sprinkled with water to condition the seeds, then taken to the mill for dehulling. The dehulled seeds were washed, oven-dried (70 °C for 3 h), then milled in a laboratory hammer mill and sieved (60 µm) to obtain the millet flour, it was bagged in high density polyethylene bag and left at room temperature until needed.

2.4. Preparation of tiger nut flour

Tiger nut flour was prepared using the method described by Adejuyitan (2011) with slight modification. Tiger nut were cleaned to remove extraneous materials, boiled for 30 minutes, drained off boil-water, dried in the hot air oven (50 °C for 12 h). The dried nuts were milled (attrition mill) and sieved through a 60 µm mesh sieve. The

fine tiger nut flour obtained was finally packaged and sealed in polyethylene bags for further use.

2.5. Preparation of soybean flour

Soybean flour was prepared using the method described by Samuel *et al.* (2015) with slight modifications. Soybean seeds were cleaned to remove extraneous materials, boiled for 30 minutes, drained off boil-water, dried in the hot air oven (50 °C for 12 hrs), coarse-milled to loosen the hull and then winnowed to remove the detached hulls. The dehulled seeds were milled (attrition mill) and sieved through a 60 µm mesh sieve. The fine defatted soybean flour obtained was finally packaged and sealed in polyethylene bags for further use.

2.6. Production of masa

The masa (*waina*) was produced according to the modified method of Samuel *et al.* (2015). The flour was mixed with 600 ml of cleaned water. The resulting batter was inoculated with baker's yeast and it was allowed to ferment for 2-4hours. The batter was then diluted and mixed with trona (kanwa water) and then all other ingredient (sugar, salt, onion) were added to it. The batter was stirred vigorously with mortar and pestle to incorporate air. The batter was measure with medium sized spoon and shallow pot was placed on fire, 3-5ml of vegetable oil was added to the kasko masa pot. Batter was fried for 2minutes on each side.

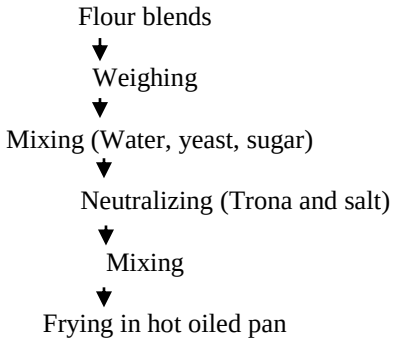

Fig. 1: Flow chart for the production of *masa*
Source: Samuel *et al.* (2015)

3. Proximate Analysis

Proximate composition was analyzed according to the official method of analysis described by the Association of Official and Analytical Chemist (AOAC, 2012).

3.1. Determination of moisture content

The moisture content was determined by oven drying method. About 5 g of each sample was weighed using analytical balance into previously weighed Petri-dishes (W). The weighed samples in the Petri dish were allowed to dry in an oven at 105 ^{o}C for 3 hours. The samples were removed and cooled in desiccators to room temperature and the weight was noted, then it was returned into the oven at 105 ^{o}C for 30 min until a constant weight was obtained for each sample. The differences in weight between each Petri-dish and dried residue were recorded as the percentage of the initial sample. The percentage moisture was calculated as:

$$\%\ moisture\ content\ = \frac{W1 - W2}{Ws}\ x100$$

Where
W = *Initial weight of crucible + Sample*
$W1$ = *Final weight of crucible + Sample*
Ws = *Weight of sample*

3.2. Determination of protein content

Exactly 0.5g of sample was weighed into a digestion flask and kjeldahl catalyst tablet was added, 10ml of conc.H_2SO_4 was added and digested for 4 hours until a clear solution was obtained (blue green color). The digest was cooled and transferred into 100ml volumetric flask and made up to mark with distilled water. 20ml of boric acid was dispensed into a conical flask and 5 drops of indicator and 75ml of distilled water was added to it. 10 ml of the digest was dispensed into Kjedahl distillation flask, the conical and the distillation flask were fixed in place and 20ml of 2% NaOH was added through the glass funnel into the digest. The steam exit was closed and timing started when the solution of the boric acid and indicator turned green. The distillation was done for 15 minutes and the distillate was titrated with 0.05NHCl solution till the appearance of pink color. A blank was also run through all steps as above.

Therefore, the crude protein content was determined by multiplying percentage Nitrogen by a constant factor of 6.25

i.e. % $crudeprotein$ = % Nx 6.25.

$$\%(\%N) = titreValuexAtomicmassofnitrogenxNormalityofHClusedx\ 4$$

3.3. Determination of fat

Fat was determined by ether extract method using Soxhlet apparatus.

1g of sample was weighed and wrapped in filter paper, placed in fat free thimble plugged lightly

with cotton wool and extracted with petroleum ether (N-Hexane)in soxhlet apparatus set up for 5 hours. Water and heater were turned on to start extraction. After 4-6 siphoning, ether was allowed to evaporate and beaker was disconnected before the last siphoning. Extract was transferred into clean glass dish with ether washing and evaporated ether on water bath. The residue extract in dish was then placed in an oven at 105^{o}C for 2 hours and cooled in a desiccator and weighed. The fat content will be calculated as;

$$\%\, fat = \frac{(Weight\ of\ filter\ paper + weight\ of\ sample) - Weight\ of\ residue}{Sample\ weight} \quad x\ 100$$

3.4. Determination of ash content

Clean empty crucible was placed in a muffle furnace at 600^{o}C for an hour, cooled in dessicator and weighed (W). One gram of each sample was weighed in crucible (W_2). The sample was ignited over a burner with the help of blowpipe until it is charred. Then the crucible was placed in a muffle furnace set at 550^{0}C and left for 12-24h. The appearances of gray white ash indicated complete oxidation of all organic matter in the sample. The crucible with the sample was cooled and weighed (W_3).The crucible with the sample was weighed and the percentage ash calculated as;

$$\%\, Ash\ content = \frac{W3 - W1}{W2} \quad x\ 100$$

Where W_3 = weight of the sample with crucible before ashing

W_2 = weight of the sample with crucible after ashing

W= weight of the sample

3.5. Determination of crude fibre

About 5g of the sample was accurately weighed into flask; 200ml of running water and 1.25ml H_2SO_4 was added. The mixture was heated under reflux for 30 minutes. The hot mixture was filtered through a fibre muslin cloth. The obtained filtrate was thrown off and the residue was returned to the fibre flask of which 200ml of running water and 1.25g NaOH was added and heated for another 30 minutes. The residue was removed using N-hexane and ethanol and finally transferred into already weighed crucible. The crucible and the residue was oven dried at 105^{O}C overnight to drive off the moisture. The oven dried crucible containing the residue was cooled in a dessicator and later weighed to obtain the W_1. The crucible with W_1 was transferred to the muffle furnace for ashing at 550^{0}C for 4 hours. The crucible containing white or grey ash (Free of carbonaceous materials) was cooled in the dessicator and weighed to obtain W_2.

The difference $W_1 - W_2$ gives the weight of fibre.

$$\%Fibre = \frac{W1 - W2}{weight\ of\ sample} \quad x100$$

3.6. Determination of carbohydrate content

The total carbohydrate was determined by difference. The sum of percentages moisture, ash, crude lipid, crude protein and crude fibre was being subtracted from 100%.

$Carbohydrate = 100 - (\%\ moisture + \%\ ash + \%\ protein + \%\ lipids + \%\ fiber)$.

4. Determination of the mineral contents

The mineral contents of the soy cheese samples were determined using the methods of the AOAC (2012) methods. Calcium, magnesium and iron were determined by atomic absorption spectrometry. Briefly, about 1.0 g of rice sample was first digested with 20 ml of acid mixture (650 ml Conc. HNO3, 80 ml perchloric acid, 20 ml H_2SO_4) by weighing the sample into a digestion flask followed by addition of the 20 ml acid mixture. The digestion flask containing the sample and the digestion acid mixture was heated until a clear digest was obtained. The digest was later diluted with distilled water to 500 ml mark. After obtaining the digest, aliquots of the clear digest were used for atomic absorption spectrophotometer using filters that matched the different elements. The concentration of calcium, magnesium and iron were determined with their calibration curves prepared with their standard solutions. The percentage values were later calculated by multiplying the concentrations by 100.

5. Functional Properties

5.1. Water absorption capacity (WAC)

Water Absorption Capacity is an index of the amount of water retained within a food matrix under certain conditions. It usually refers to entrapped water but includes bound water and hydrodynamic water and depends upon the condition of determination. It was determined using the procedure of Adebowale *et al.* (2012).

Procedure:

10ml of distilled water was added to 1.0g of each flour sample, the suspension was stirred using magnetic stirrer for 3 minutes. The suspension was transfer into centrifuge tubes and centrifuge at 3,500rpm for 30minutes. The supernatant obtained was measured using a 10ml measuring cylinder. The density of the water was assumed to be 1g per ml. The water absorbed by the sample was

calculated as the difference between the initial water used and the volume of the supernatant obtained after centrifuge. The result was express as a percentage of water absorbed by the blends on %g/g basis.

$$\% \text{ WAC} = \frac{\text{Weight of water absorbed} \times \text{Density of water} \times 100}{\text{Weight of sample}}$$

5.2. Oil Absorption Capacity (OAC)

Oil Absorption Capacity is an index of the amount of oil retained within a protein matrix under certain condition. It was determined using the method of Adebowale *et al.,* 2005

Procedure:

10ml of oil of known specific gravity was added to 1g of sample in a beaker. The suspension was stirred using magnetic stirrer for 3 minutes. The suspension obtained was thereafter centrifuged at 3500 rpm for 30 minutes and the supernatant was measured into a 10ml graduated cylinder. The density of oil was 0.931 g/ml. The oil absorbed by the flour was calculated as the difference between the initial volume of the oil and the volume of the supernatant.

$$\% \text{ OAC} = \frac{\text{Volume of oil absorbed} \times \text{Density of oil} \times 100}{\text{Weight of sample}}$$

5.3. Bulk density determination

The method of Awolu *et al.* (2017) was used with slight modification.

Procedure: 20g of flour sample was weighed and poured into 100ml measuring cylinder. The samples were pressed down into the cylinder until it can no longer be pressed. The volume was determined and density calculate

$$\text{Density} = \frac{\text{Mass (g/ml)}}{\text{Volume}}$$

5.4. Swelling capacity determination

The swelling capacity of the samples was determined by the method of Awolu *et al*. (2017). 10g of the flour sample was weighed and poured into a 100ml measuring cylinder and the initial volume was taken. 60ml of water was then added and allowed to stand for 4h after stirring and then the level of swelling was observed.

$$\text{Swelling index} = \frac{\text{Vol. After soaking} - \text{Vol. before soaking X 100}}{\text{Weight of sample}}$$

5.5. Gelation Capacity

The method of Onwuka, (2005) was adopted in the determination of gelation capacity. A sample suspension of 0.2%, 0.4%, 0.6%, 0.8% and 1% (w/v) in 5ml of distilled water was prepared in test tubes. The samples were heated for 1h in a boiling water bath followed by rapid cooling under running cold tap water. The test tubes were then cooled further for 2h at 4°C. The gelation capacity is the least gelation concentration determined as the concentration when the sample from the inverted test tube will not fall or slip.

6. Sensory evaluation

The sensory evaluation of the masa samples were carried out immediately and also at two weeks interval for 6 weeks for consumer acceptance and preference using 50 panelists who were randomly selected among the students of the Department of Food Technology Offa, Kwara State, Nigeria. A 9 point hedonic scale ranging from 1-extremely dislike to 9-extremely like was used.

7. Statistical Analysis

The data collected was subjected to statistical analysis using Minitab 16; analyses of variance (ANOVA) were used to determine the differences at 5% level of significance. In cases where differences occurred, the means was separated using Duncan test.

8. Results and Discussion

8.1. Proximate composition of the samples

The results of the proximate composition are shown in table 4.1 above. The moisture content of the *masa* samples ranged between 12.75-16.65%. There was no significant difference between sample A and sample D with sample A having the highest value (14.00%) and sample B having the least value (13.56%). The moisture content is in range with the report of Ayo *et al.* (2008). The moisture content of sample B and sample E differed significantly with sample B having the highest value (16.62%). The moisture contents of sample B and E were lesser to the report of Samuel *et al.* (2015) for Rice Based *Masa* Enriched with Soybean and Crayfish. The moisture content of sample C and sample F are not significantly different, but sample C had the highest value (14.14%), the moisture content of these samples were a bit higher than the report of Ayo *et al.* (2008). It was observed that the moisture content of all the enriched *masa* were higher as compared to their whole samples. This might suggest that tiger nut flour is hydroscopic in nature and had caused the increase of moisture in sample A, B, and C. These values were however lower to the moisture content of traditionally baked masa which was 56% as reported by Samuel *et al.* (2015).

The crude fat of the samples ranged between 21.42-32.03%. Sample D had the highest crude fat (26.35%) as compared to sample A. Sample B had the highest crude fat (32.03%) as compared to sample E and also sample C had the highest crude fat (24.01%) as compare to sample F. It was

observed that the fat content of the enriched *masa* increased significantly as compared to the report of Akande *et al.* (2018). This could be as a result of fortification with soybean and tiger nut. Soybean which is rich in fat had fat content of about 19% (USDA, 2007) and it has been reported that the fat content of tigernut varies between 22.8 and 32.8/100g (Adegunwa *et al.*, 2017). The function of fat in food contributes greatly to the energy value of foods and also slows down the rate of utilization of carbohydrate (Samuel *et al.*, 2006).

The crude fibre of the samples ranged between 0.04-0.89%. Sample A had the highest crude fibre (0.16%) as compared to sample D; sample E had the highest crude fibre (0.08%) as compared to sample B while sample F had the highest crude fibre (0.89%) as compared to sample C. The fibre contents in this report were lesser to the report of Akande *et al*. (2018). Fibre content may contribute to bulk and encourage bowel movement, discourage constipation and piles, reduce blood cholesterol and help prevent cancer of the colon (Hung *et al.*, 2004).

Ash content is an indication of the presence of mineral elements. The ash content of the samples ranged between 0.54-0.83%. Sample D had the highest ash content (0.63%) as compared to sample A. Sample B had the highest as compared to sample E, while sample F had the highest as compared to sample C. The ash contents in this report were in range with the report of Samuel *et al.*, (2015) and Akande *et al.* (2018).

There was increase in the protein content of the enriched *masa* samples A, B and C as compared to their whole samples. This is in accordance to the earlier observation of Ayo *et al.* (2008) for *Masa* Produced from different Cereals and it was also in range with the report of Samuel *et al.* (2015). This could be as a result of the addition of soybean in the formulation of *masa* samples. There have been reports of improvement in protein content of soy-maize snacks (Lasekan and Akintola, 2002), also in Kunnu zaki fortified with soy (Ayo and Gaffa, 2002).The carbohydrate ranged from 45.30-57.56%. The carbohydrate content in this report is higher compared to the report of Samuel et al. (2015) for Nutritional and Sensory Evaluation of Rice-based *masa* Enriched with Soybean and Crayfish and in accordance with the report of Akande *et al.* (2018). This shows that all the *masa* samples qualify as rich sources of energy which is typical for snacks generally.

Table 4.1: Proximate Properties of *Masa* Samples

Sample	Moisture	% C. Fat	% C. Fibre	Ash	%C. Protein	CHO
A	14.00 ± 0.3^{a}	21.42 ± 0.1^{a}	0.16 ± 0.01^{d}	0.54 ± 0.0^{a}	6.31 ± 0.18^{d}	57.56 ± 0.72^{d}
B	16.62 ± 0.25^{b}	32.03 ± 0.07^{e}	0.04 ± 0.00^{a}	0.83 ± 0.02^{d}	5.17 ± 0.03^{bc}	45.30 ± 0.32^{a}
C	14.14 ± 1.28^{a}	25.10 ± 0.01^{c}	0.10 ± 0.00^{bc}	0.56 ± 0.01^{a}	7.87 ± 0.06^{e}	52.23 ± 1.33^{b}
D	13.56 ± 0.41^{a}	26.35 ± 0.39^{d}	0.13 ± 0.02^{cd}	0.63 ± 0.01^{b}	5.42 ± 0.09^{c}	53.89 ± 0.09^{bc}
E	12.75 ± 0.04^{a}	25.87 ± 0.11^{d}	0.08 ± 0.00^{b}	0.54 ± 0.02^{a}	5.08 ± 0.07^{b}	55.78 ± 0.33^{cd}
F	13.97 ± 0.32^{a}	24.01 ± 0.19^{b}	0.89 ± 0.03^{e}	0.73 ± 0.02^{c}	4.61 ± 0.11^{a}	55.80 ± 0.59^{d}

Means that do not share the same super script in the same column are significantly different ($p>0.05$).
KEYS: A- 70% Maize flour + 20% Soybean flour + 10% Tigernut flour**,** B- 70% Rice flour + 20% Soybean flour + 10% Tigernut flour**,** C- 70% Millet flour + 20% Soybean flour + 10% Tigernut flour**,** D- 100% Maize flour**,** E- 100% Rice flour**,** F- 100% Millet flour.

8.2. Functional properties

Functional properties determine the application and the uses of food materials for various food products. The functional property of the samples in table 4.2 shows the Bulk density, Water Absorption Capacity, Oil Absorption Capacity, Swelling capacity, and Gelation concentration.

Bulk density is an indication of the porosity of a food product which may affect its package design and it is a function of its wet-ability. The bulk density of sample A compared to sample D showed that there was no significant difference between the two samples, but sample A had the highest value (0.71g/ml). The bulk density of sample B compared to sample E showed that the samples differed significantly with sample E having the highest value (0.81g/ml), also sample C and sample F are not significantly different with

sample F having the highest values (0.70g/ml). Kaur and Singh (2005) reported that flours with high bulk density had an advantage of stalking.

Water absorption capacity represents the ability of the products to associate with water under conditions when water is limiting such as dough and pastes (Malomo and Abiose, 2018). The water absorption capacity of the masa flour ranged between 104.90-180.57%. No significant difference was observed between the enriched masa flour samples and their whole samples. Sample A had the highest values (128.67%) as compared to sample D. This is a bit higher to the report of Malomo and Abiose (2018). This could be because the addition of soybean flour and tiger nut flour improved the reconstitution ability (Adebayo-oyetoro et al., 2017). Sample E had the highest value (180.57%) as compared to sample B. Sample C had the highest water absorption capacity (127.33%) as compared to sample F; this could be because the addition of soybean flour and tiger nut flour improves the reconstitution ability (Adebayo-oyetoro *et al.,* 2017). Increase in water absorption capacity implies increase in digestibility of the product (Adebayo-oyetoro *et al.,* 2017).

The oil absorption capacity of the masa flour ranged between 63.80-142.20%. Sample A had the highest value (123.67%) as compared to sample D). Sample E had the highest value (142.21%) as compared to sample B. Sample C also had the highest value as compared to its control (sample F). The oil absorption capacity of the masa flours is a bit higher to the report of Malomo and Abiose (2018) for Protein Quality and Functional Properties of *Masa* Produced from Maize, Acha and Soybean; this could be as a result of high level of oil present in tiger nut. The major component affecting oil absorption capacity is protein, which is composed of both hydrophilic and hydrophobic parts (Jitngarmkusol *et al.,* 2008). Oil absorption capacity is important since oil acts as flavor retainer and increases mouth feel of foods (Aremu *et al.,* 2008). Hence, make the flour suitable in facilitating enhancement in flavor and mouth feel when used in food production. The ability of proteins of these flours to bind with oil makes it useful in food system where optimum oil absorption is desired (Adegunwa *et al.,* 2017).

Swelling capacity is the ability of flour to retain water within a given period. This was within the range of 47% and 125.33%. Sample D had the highest value (58.88%) as compared to sample A. Sample E also had the highest value (125.33%) as compared to sample B. Also sample F had the highest value (91.24%) as compared to sample C. It was observed that the enriched masa flour had lesser swelling capacity as compared to their whole sample which could cause significant reduction in the volume of the masa and as well affect the batter formation and stability. The result of Malomo and Abiose (2018) also showed that the control sample had the highest swelling capacity. This could be as a result of the addition of the soybean and tiger nut. Adegunwa *et al.* (2011) reported that the presence of naturally occurring non-carbohydrates such as lipid and formation of amylase lipid complexes can restrict swelling and solubilisation. Higher protein content in flour may cause the starch granules to be embedded within a stiff protein matrix, which subsequently limits the access of the starch to water and it restricts the swelling power (Aparianita *et al.,* 2009).

The gelation concentration of the samples ranged from 0.20-0.60g. Sample A and sample D differed significantly with sample A having the highest gelation concentration (0.60g). Sample B and sample E differed significantly with sample E having the highest value (0.40g). There was significant difference between sample C and sample F, but sample C had the highest gelation concentration (0.23g). Kaushal *et al.* (2012) reported that the lower the gelation concentration, the better the gelation ability and the swelling ability of the flour will be enhanced. The variation in the gelling properties maybe ascribe to ratios of the different constituents such as protein, carbohydrate and lipids in different flours, suggesting that interaction between such component may also have significant role in functional properties (Aremu *et al.,* 2007).

8.3. Sensory evaluation

Taste referred to as a gustatory sense of detecting stimuli when dissolved by saliva and the use of taste board while located on the surface of the tongue. There was no significant difference between sample A and sample D, but there was significance difference between sample B and E and also between sample C and F when compared to the control sample. Though, the taste of sample E had the highest mean score and followed by sample F, while samples A, B, C and D had the least mean score with the same value.

Texture is a sensory attribute which is used to feel smoothness and roughness. In texture, there was no significance difference between each sample as compared to their control samples. Sample E had the highest value followed by sample F and sample A and C had the least value.

In colour, there was no significant difference between sample A and D, but sample A had the highest mean score value. There was significant difference between samples B and E and also there was significant difference between sample C and F, but of all the samples sample E had the highest value and sample C had the least value.

Appearance is the visual quality of the sample. There was significant difference between sample A and D. There was no significant difference between sample B and sample E and also there was significant difference between sample C and F. Sample E had the highest mean score.

In aroma, there was no significant difference between each sample as compared to their base. Sample E had the highest value and sample A had the least value.

For overall acceptability, it expresses the rate at which the panelists accept the samples. There was significant difference between sample A and sample D, but sample D had the highest value. Sample B and sample E differed significantly, but sample E had the highest value. Sample C and sample F also differed significantly with sample F having the highest mean score. Generally of all the samples, sample E had the highest mean score for overall acceptability.

Table 4.2: Functional Properties of *Masa* Samples

Samples	Bulk Density (g/ml)	Water Absorption (%)	Oil Absorption (%)	Swelling Capacity (%)	Gelation Concentration (g)
A	0.71 ± 0.02^{a}	128.67 ± 4.73^{a}	123.67 ± 1.89^{d}	47.67 ± 9.29^{a}	0.60 ± 0.00^{c}
B	0.67 ± 0.01^{a}	164.03 ± 4.79^{b}	94.00 ± 0.97^{b}	86.50 ± 0.79^{b}	0.27 ± 0.12^{ab}
C	0.64 ± 0.01^{a}	127.33 ± 3.21^{a}	99.01 ± 1.39^{c}	80.60 ± 0.60^{b}	0.23 ± 0.06^{a}
D	$0.69\pm0.02^{a}0.81\pm0.07^{b}$	104.90 ± 2.25^{a}	93.59 ± 1.14^{b}	58.88 ± 1.58^{a}	0.40 ± 0.00^{b}
E	0.70 ± 0.02^{a}	180.57 ± 3.23^{b}	142.21 ± 1.86^{e}	125.33 ± 5.51^{c}	0.40 ± 0.00^{b}
F		123.33 ± 2.89^{a}	63.82 ± 1.60^{a}	91.24 ± 1.44^{b}	0.20 ± 0.00^{a}

s

Means that do not share the same super script in the same column are significantly different ($p>0.05$).

Table 4.3: Mean Scores for the Samples

Samples	Taste	Texture	Colour	Appearance	Aroma	Overall acceptability
A	6.20 ± 0.79^{a}	6.20 ± 0.79^{a}	7.10 ± 0.74^{bc}	7.20 ± 0.92^{ab}	6.10 ± 1.20^{a}	6.50 ± 0.85^{a}
B	6.20 ± 1.23^{a}	6.80 ± 1.03^{a}	7.20 ± 0.63^{bc}	7.40 ± 0.70^{b}	6.40 ± 1.35^{a}	7.10 ± 1.10^{ab}
C	6.20 ± 1.23^{a}	6.20 ± 1.23^{a}	5.60 ± 1.07^{a}	5.70 ± 1.34^{a}	6.20 ± 1.32^{a}	6.40 ± 1.26^{a}
D	6.20 ± 1.32^{a}	6.50 ± 1.43^{a}	7.00 ± 0.82^{bc}	7.40 ± 1.35^{b}	6.50 ± 1.08^{a}	6.90 ± 1.20^{ab}
E	7.90 ± 1.20^{b}	7.30 ± 1.42^{a}	8.00 ± 0.94^{c}	7.80 ± 0.92^{b}	7.50 ± 1.08^{a}	8.20 ± 1.23^{b}
F	7.50 ± 1.18^{ab}	7.00 ± 1.05^{a}	6.60 ± 1.34^{ab}	7.00 ± 1.49^{ab}	6.90 ± 1.20^{a}	7.10 ± 0.88^{ab}

Means that do not share the same super scrip tin the same column are significantly different ($p>0.05$).
KEYS: A- 70% Maize flour + 20% Soybean flour + 10% Tigernut flour**,** B- 70% Rice flour + 20% Soybean flour + 10% Tigernut flour**,** C- 70% Millet flour + 20% Soybean flour + 10% Tigernut flour**,** D- 100% Maize flour**,** E- 100% Rice flour**,** F- 100% Millet flour.

9. Conclusion

This study showed that soybeans and tiger nut can be employed as enrichment materials in the production of traditional maize, rice and millet based masa to increase the nutritional content of the masa. It was observed that whole rice masa sample was the most preferred sensorial, but nutritionally the enriched masa were more preferred. Thus, acceptable masa both nutritionally

sensorial could be produced by addition of soybean and tiger nut which will as well combat malnutrition and advance the utilization of tiger nut and soybeans.

10. Recommendation

The processing methods of the samples are simple and not very different from what is practiced in the Northern and some Western parts of Nigeria where masa consumption is high. The work however recommends the promotion of the production of masa with our locally sourced materials such as soybean and tiger nut to improve and enhance the nutritional quality of masa consumed. I recommend that further work should be carried out by varying the proportion of the soybean and tiger nut in each base of the masa sample and as well determining the anti-nutritional composition and the antioxidant of the formulations.

11. References

1. Adebayo-Oyetoro, A.O., Ogundipe, O.O., Lofinmakin, K.F., Akinwande, F.F., Aina, D.O., and Olalekan-Adeyeye, S.A. (2017). Production and acceptability of chinchin snack made from wheat and tigernut (*Cyperus esculentus*) flour. *Cogent Food & Agriculture*, 3:1282185.
2. Adebowale A.A., Adegoke M.T., Sanni, S.A., Adegunwa, M.O., and Fetuga, G.O. (2012). Functional Properties and Biscuit Making Potentials of Sorghum-wheat Flour Composite. *American Journal of Food Technology*, 7: 372-379.
3. Adebowale, Y.A., Adeyemi, I.A. and Oshodi, A.A. (2005). Functional and Physicochemical Properties of Flours of Six *Mucuna* species. *Afr. J. of Food Biotechnology*, 4(12), 1461-1468.
4. Adegunwa, M.O., Adelekan, E.O., Adebowale, A.A., Bakare, H.A., and Alamu, E.O (2017). Evaluation of Nutrtional and Functional Properties of Plantain (*Musa paradisiacal* L.) and Tigernut (*Cyperus esculentus* L.) flour blends for food formulations. *Analytical Chemistry*, 3: 1383707.
5. Adejuyitan J. A. (2011). Tigernut processing: Its Food uses and health benefits. *American Journal of Food Technology*, 6: 197-201.
6. Akande, O.A., Jolayemi, O.S., Familusi, A., and Idowu, B. (2018). Nutritional, Antioxidant and Sensory Properties of Rice-Base *Masa* enriched with Grain Amaranth and Carrot Powder. *Annals Food Science and Technology*, 19: 650-653.
7. Aleke, D.L, Germain, A.S., and Oeterson C.T. (2000). Isoflavone-rich soy protein isolate attenuates bone loss in the lumbar spine of perimenopausal women. *Am. J. Clin. Nutr*. 72(3):844-52.
8. Anjum, F.M., Khan, M.I., Butt, M.S., Hussain, S., and Abrar, M. (2005). Functional properties of Soy hulls supplemented wheat flour. *Nutrition Food Science, 36(2): 82-89.*
9. AOAC. Association of Official Analytical Chemical (2012). *Official Methods of Analysis.* 18th edition. Washington D.C. USA.
10. Aparianita A., Purwandari V., Watson B., and Vasijevic T. (2009). Physico-chemical properties of flour and starches from selected commercial tubers available in Austrialia. *International Food Research Journal* 16: 507-520.
11. Aremu M.O, Olaofe O, and Akintayo E.T. (2007). Functional properties of some Nigerian varieties of legume seed flour concentration effect on foaming and gelation properties. *J. Food Technol.* 5(2):109–115.
12. Aremu, M. O., Olaofe, O., Akintayo, E.I., and Adeyeye, E. I. (2008). Foaming, water absorption, emulsification and gelation properties of kersting's groundnut (*Kerstingiellageo carpa*) and bambara groundnut (*Vigna subterranean*) flour as influenced by neutral salts and their concentrations. *Pakistan Journal of Nutrition*, 7, 194–201.
13. Ayo, J.A., Agu H., Ayo V.A. and Famoriyo, O.F. (2008) Effect of Groundnut Paste on the Quality of Maize Based Masa. *Pakistan Journal of Nutrition,* 7, 557-560.
14. Ayo J.A., Agu H, and Famoriyo A.F (2008). Effect of different cereals on quality of Masa. *Pakistan J. Nutr.* 7(4): 530-533.
15. Ayo, J.A and Gaffa T. (2002). Effect of undefatted soybean flour on the protein

content and sensory quality of "kunun - zaki". *Nig. Food J.* 20: 7- 9.
16. Bhardwaj, H.L. Hamama, A.A. Rangapam, M. J. Joshi, M. and Sapra, V.T. (2007). *WJAS*, 3(2), 140-144.
17. Crittenden R.G, and Bennett L. E. (2005). Cow's milk allergy: A complex disorder. *J Am Coll Nutr* 24: 582S-91S.
18. Ezeama, C.F. and Ihezie, C.I. (2006). Microbiological and sensory evaluation of fermented rice snack (masa) supplemented with soybean. *J. Food Technol.* 4(4): 345-349.
19. FAOSTAT (2012). Food balance sheet. Available online: http://www.faostat.fao.org Accessed on 20 Jun 2012.
20. Fasoyiro, S.B., Babalola, S.O. and Owosibo, S.B. (2011). Chemical composition and sensory qualities of fruit flavoured roselle (Hibiscus sabdariffa). *World Journal of Agricultural Research* 1 (2): 161 – 164.
21. Fowoyo, P.T. and Ogunbanwo, S.T. (2010). Phenotypic diversity of lactic acid bacteria isolated from 'masa', a fermented maize dough. *Afr. J. Microbiol. Res*. 4(24):2682-2691.
22. Geetanjali, K., Santosh, S. and Naik, S.N. (2010). Effect of domestic processing techniques on the nutritional quality of the Soybean Mediterranean. *Journal Nutritional Metabolism* 3: 39–46.
23. Han B.Z, Rombouts F.M, and Nout M.J.R (2001) A Chinese soybean fermented food. *Int J Food Microbiol* 65:1–10
24. Hung, H.C., Joshpura, K.J and Jiang, R. (2004). Fruit and vegetable intake and risk of major chronic disease. *Journal of National Institute* 96: 1577-84.
25. Ibironke SI, and Alakija O. (2018). Production of Soy Cheese from Vegetable Protein Using Different Coagulants. *Am J Food Nutr* 5: 95-8.
26. Ibrahim A.K, Ukeyima M, and Ikya J.K. (2018). Effect of Some Selected Coagulants on the Proximate and Microbiological Quality of Cheese Produced from Soy Milk. *International Journal of Science and Research (IJSR)* 7.426 Volume 8.
27. Imolehin, E.D. and Wada, A.C. (2000). *Meeting the Rice Production and Consumption demand of Nigeria with improved Technologies.* National Cereal Research Institute, Badeggi, P.M.B 8, Niger State, Nigeria. pp1-11.
28. Jitngarmkusol, S., Hongsuwankul, J. and Tananuwong, K. (2008). Chemical compositions, functional properties, and microstructure of defatted macadamia flours. *Food Chemistry,* 110, 23–30.
29. Kaushal P, Kumar V, and Sharma H.K. (2012). Comparative study of physico-chemical, functional, anti-nutritional and pasting properties of taro (*Colocasia esculenta*), rice (*Oryza sativa*), pegion pea (*Cajanus cajan*) flour and their blends. *LWT-Food Science and Technology*. 48:59–68.
30. Kuye A., and Sanni L.O. (2002). Analysis of sorption data from Lafun and Soyaflour. J. *of Modeling, Design and Management of Engineering system*. (1): 66-71.
31. Lasekan O.O. and Akintola A.M. (2002). Production and Nutritional Evaluation of Puffed Soy – Maize Snack. Nig. Food J. 20: 15 – 19.
32. Malomo, A.A and Abiose, S.H. (2018). Protein quality and functional properties of masa produced from maize, acha and soybean. Rynnye Lyan Resources
33. Obilana, A.B. (2003). Overview: importance of millets in Africa. Published online athttp://www.afripro.org.uk/papers/Paper02 Obil ana.pdf
34. Obilana, A.B., and Manyasa, E. (2002) *Millets In 'Pseudo-cereals and less common cereals: grain properties and utilization potential'.* Belton, P.S. and Taylor, J.R.N. (ed), Springer Verlag, New York, USA. pp: 177-217.
35. Okafor J.N.C, Mordi J.I, Ozumba A.U, Solomon H.M, and Olatunji I, editors (2003). *Preliminary studies on the characterization of contaminants in tigernut (yellow variety).* PNIFSTC 2003. Proceeding of 27th Annual Nigeria Institute of Food Science and Technology Conference. 2003, Nigeria: Nigeria Institute of Food Science and Technology; c2003.
36. Onwuka. G.I. (2005). *Food analysis and instrumentation theory and practice* (Napthali prints. Lagos. 2005).
37. Oyeyiola, G. P., Agbaje A. B. and Adetunji C. O. (2013). Determination of the Soil Microflora of a Soil Near Microbiology

Laboratory at the University of Ilorin Main Campus. Egy. *Acad. J. Biol. Sci*. 5(1): 3541.
38. Samuel F.O, Ayoola E.O, and Ayinla F.O, (2006). Chemical Analysis and consumer acceptability of tapioca fortified with soybeans. *Int. J. of Food and Agric Res.* 3 No (1): 1-5.
39. Samuel, F.O., Ishola, O.R. and Otegbayo, B.O. (2015). Nutritional and Sensory Evaluation of Rice- Based Masa Enriched with Soybean and Crayfish. *Food and Nutrition Sciences*, 6, 234-241.
40. USDA (2007). Table of Nutrient Retention Factors, Release 6" (PDF). USDA. USDA. Dec 2007.
41. USDA (2007). USDA Table of Nutrient Retention factors, Release 6" USDA. Prepared bythe Nutrient Data Laboratory, Beltsville Human Nutrition Research Center (BHNRC), Agricultural Research Service (ARS), U.S. Department of Agriculture (USDA),December,2007.https://www.ars.usda.gov/ARSUserFiles/80400525/Data/retn/retn6pdf