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International Journal of Current Research
Vol. 9, Issue, 10, pp.59664-59671, October, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

DEVELOPMENT OF NIGERIAN BASED FOOD LIKE BISCUIT (GULIGULI) FROM MIXTURES OF SORGHUM, MAIZE, SOYBEAN, MORINGA LEAVE AND CRAYFISH

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ARTICLE INFO

Article History:
Received 28th July, 2017
Received in revised form
26th August, 2017
Accepted 11th September, 2017
Published online 31st October, 2017

Key words:
Acceptable, Biscuits, Composites, Flours, Sensory attributes, Food.

ABSTRACT

Guliguli is a snack like biscuit; a Nigerian base food produced from mixtures of sorghum, maize, soybean, crayfish and moringa leaves. The study investigates functional properties of different flours and their composites. But the successful application of the adopted method in food product development and the acceptability of the final products is the key objective. The proximate composition, physical properties and sensory attributes of the products (guliguli) were also determined. Raw materials were first milled into flours and further formulated into six (6) composite flours. These flour composites were finally processed into their respective guliguli. Flours of sorghum and maize were mixed into ratio 1:1 and percentage soybean added was varied from 0-50% which yielded six (6) formulations. Result of the bulk density of flours ranged from 0.42-0.88 gcm^{-3}, loose bulk density 0.28-0.79 gcm^{-3}, water absorption capacity 1.13-4.03 cm^3g^{-1} and percentage dispersibility 21.00 – 83.33%. The moisture content of guliguli ranged from 9.07-10.46 g, protein 7.60-23.60 g, ash 1.00-3.11 g, fat 1.07-5.00 g, fibre 5.00-6.31 g and soluble carbohydrate 52.91-76.05 g. Weight and spread ratio of guliguli ranged from 1.44-1.59 g and 1.48-1.86 respectively. Sensory attribute of guliguli recorded for consistency ranged from 7.27-7.82, flavour 7.00-7.55, taste 6.82-7.91, colour 6.45-7.73, texture 7.09-7.55, and overall acceptance 7.27-7.73. All result for functional properties of composite flours and proximate composition of guliguli increases upon complementation except for soluble carbohydrate, moisture, bulk density and loose bulk density. Sensory attributes of guligulli varied slightly ($p < 0.05$) and are moderately acceptable. The composition of these food produced was observed to be within a regimen of fat related ailments and each is well fitted for each categories of people besed on protein requirement. The processing technology used was observed to be successful in terms of physical and chemical data obtained and so recommended as other alternative technology especially for producing free-wheat baked products such as breads or biscuits.

Citation: Charles Bristone, Ariahu Chukuma Charles and Paul Yahaya Idakwo, 2017. "Development of Nigerian based food like biscuit (guliguli) from mixtures of sorghum, maize, soybean, Moringa leaves and crayfish", *International Journal of Current Research*, 9, (10), 59664-59671.

INTRODUCTION

Guliguli is a Hausa food (Nigerian indigenous based food). It is usually prepared using sorghum flour. Flour is constituted with water and sweetened with sugar to form stiff paste. It is then wrapped in leaves and steam cooked or roasted. Originally, the stiff paste, the leaves and the steam-heating effect significantly impact some desirable organoleptic profiles especially texture and flavour. This food and its process technology have no available literature. Modern technologies have made food production successful over the years through the use of complementation, enrichment, fortification for improving the quality of many diets. Composite flour technology initially referred to the process of mixing wheat flour with cereal or legume flours for making bread and biscuits have made successes for improving the quality of diets (FAO, 1995; Olowamukomi *et al*., 2011; Hanan and Rasha, 2012; Akubor and Ishiwu, 2013; Amir *et al*., 2015; Ashaya *et al*., 2015; Al-marazeep and Angor, 2017; Ibidapo *et al*., 2017). *Sorghum bicolor* was used extensively for food production because of its health benefits attributed to its polymeric polyphenols (tannins) and flavonoids (FAO, 1995). On the other hand, yellow colour maize has been endowed with those components such as carotenoids; a precursors for vitamin A (Oboh *et al*., 2010; Nuss and Tanumihardjo, 2010; Rouf Shah *et al*., 2016). Many of these phytochemicals are also rich in moringa leaves

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(Sengev *et al*., 2013; Singh and Prascad, 2013; Zaku *et al*., 2015). Sorghum, maize, soybeans, moringa leaves and crayfish were extensively used as food and for food formulations in many part of the world because of their nutritional, therapeutic and medicinal benefits (Sengev *et al*., 2013; Singh and Prascad, 2013; Zaku *et al*., 2015). Crayfish is one of those animal sources of proteins reported to be essentially rich in mineral elements including iodine, calcium, zinc, phosphorus. In many places of the world, it was found useful for preparing soup (Fernandez-Kim and Sun-Ok, 2004; Atef and Mohamed, 2014; Samson *et al*., 2014). In addition, Sorghum, maize and soybean have been used successfully in feeding programmes (FAO, 1995). In north- eastern Nigeria due to the ongoing violent armed conflict triggered by the opposition group (Boko Haram) that displaced many; government and non-governmental organizations use diverse means of combating hunger and malnutrition among millions of displaced persons who are currently in need of humanitarian interventions. For this reason, many groups such as health clinics, food companies, licensed individual and research institutions are used and are better engaged in feeding programmes, knowing that the nutritional knowledge and history of food provided through them can easily be ascertained rather than purchasing food from the unknown sources (Action Against Hunger, 2017).

These therefore necessitated development of guliguli from sources that had good history of nutritional significances. Secondly, to offer nutritional solution in Nigeria and other regions of the world that has similar challenges, rather than relying on wheat grain that have history of nutritional consequences on some groups of individuals. Sometimes in many regions of the world, wheat grains had to be imported for food production, which also make food products costly (Akonor *et al.* 2015). The objective of this study is to produce guliguli with acceptable quality attributes which have nutritional significance; at the same time ascertain the production technology relative to the conventional process technology of pastry products.

MATERIALS AND METHODS

Equipment and reagents

Equipment and reagents used were mostly those of the Department of Food Science and Technology, University of Makurdi. Other analytical grade reagents were obtained through recognized distributors in Nigeria.

Source of raw materials

Sorghum, maize, crayfish and sugar were procured in Wurkun market Makurdi. Moringa leaves were plucked from the university farm Makurdi.

Preparation of flours, formulations and production of guliguli

All grains were first sorted to remove contaminant and each was kept separately. Whole soybean grain was toasted slightly at 100^0C for 5 minutes in order to facilitate removal of the seed coat. The seed coat was removed by cracking in disc milling machine. The chaff was winnowed to obtain pure soybean kernels. Each of the raw materials was then milled separately in a hammer mill and allowed to pass through a 0.8 mm mesh size. While moringa leaves and crayfish after drying were pounded in mortar and each was passed through 0.8 mm mesh (see figure 1) as described by Badau *et al.* (2016). Sorghum and maize was then mixed in a ratio of 1:1. The amount of soybean flour was then varied in the mixing ratio: by using 0%, 10%, 20%, 30%, 40% and 50% soybean flours (see figure 2). After that, 5 g of sugar and 0.5 g each of powdered moringa leaves and crayfish were finally added to the flour mixtures. Each of the flour mixture was thoroughly blended to obtain uniformly six (6) composite flours (see Figure 3) as described by Badau *et al*. (2016). Each of the composite flour was measured into 150 g portion and mixed with110 ml of clean water to form thick paste. The pastes were then placed (formed) into various plastic and aluminum trough containers constructed with a dimension of 2 x 1.6 x 0.8 cm^3 and were placed inside polythene bags and tied. They were steam cooked at 100^0C for 10 minutes (see Figure 3). After steaming, materials were removed from their containers and were baked at 210^0C for 20 minutes (see Figure 3 & 4) as described by Adediwura *et al.* (2017).

Determination of functional properties of flours

The bulk density of flours was determined using 50 g each. This was placed into a 100 ml measuring cylinder and was tapped to a constant volume. The bulk density (gcm^{-3}) of flour was determined as weight of flour (g) divided by volume of flour (cm^3) as reported by Adejuyitan *et al*. (2009) and at the same time loose bulk density was also determined (i.e. without tapping the flour). Dispersibility was measured by placing 10 g of the flour sample in a 100-ml measuring cylinder and then the volume was increased by adding water gradually to the 100-ml mark and later stoppered. The mixture was vigorously shaken and allowed to stand for 3 hours. The volume of the settled particles was subtracted from the total volume and the difference was expressed as percentage dispersibility (Asma *et al.,* 2006). However, during this study unusual but similar form of dispersibility occurred with moringa leaves and crafish powder. Water was at the middle of the measuring cylinder separating the flour into two portions; one at the bottom and the other top. Nonetheless, the result of the two portions was added together leaving the portion of water, and the result was still expressed as percentage dispersibility. Water absorption capacity of the flour sample was determined by placing 1 g of flour into 10 ml of water and allowed to stand at room temperature for one hour and it was centrifuged at 200 x g for 30 minutes. The volume of water in the sediment was measured. Water absorption capacity was calculated as ml of water absorbed per gram of flour (Adejuyitan *et al.,* 2009).

Determination of proximate compositions of guliguli

Moisture in the sample was estimated by oven drying method as described by AOAC (1990). Each sample (5 g) was measured into Petri-dish. Prior to this, the weight of the empty dishes were measured and recorded. The samples were placed in an oven at 105 ± 1^0C for 3 hours. After 3 hours it was removed, cooled in desiccators and reweighed. The sample was returned to the oven again for 30 minutes, cooled and weighed again. This procedure was repeated until a constant weight was obtained. The percentage moisture was calculated as described by AOAC (1990). The ash content which is the inorganic residue resulting from the incineration of the food samples was determined by placing 3 g of the sample each into crucible.

Figure 1. Flours of raw materials

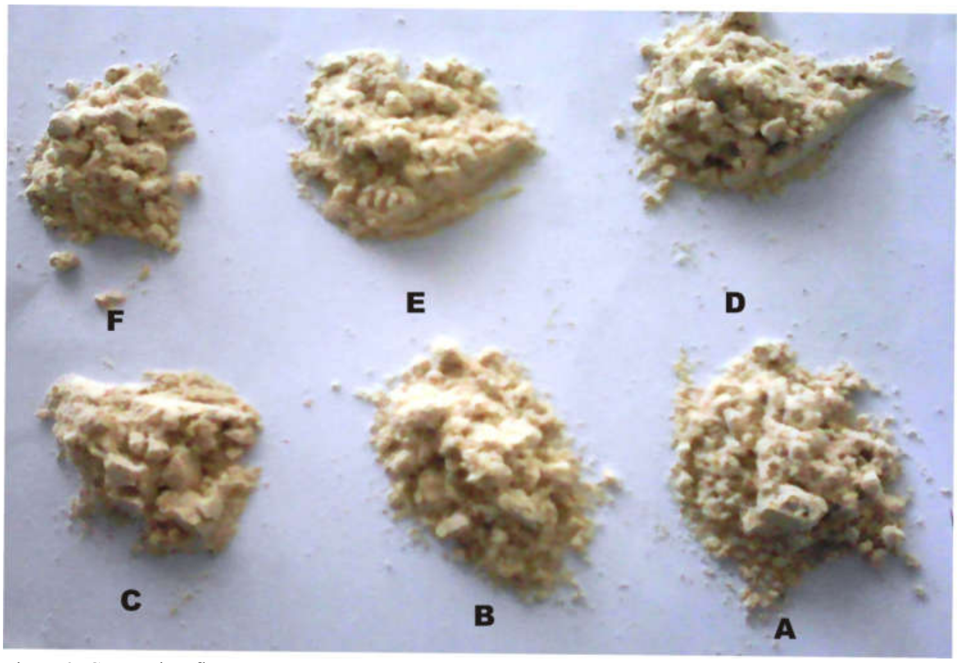


Figure 3: Composites flours
Note:
A = sorghum and maize (1:1) 94 g, soybean 0 g (0%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
B = sorghum and maize (1:1) 85 g, soybean 9 g (10%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
C = sorghum and maize (1:1) 75g, soybean 19 g (20%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
D = sorghum and maize (1:1) 66 g, soybean 28 g (30%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
E = sorghum and maize (1:1) 56 g, soybean 38 g (40%) moringa 0.5 g, crayfish 0.5 g and sugar 5 g
F = sorghum and maize (1:1) 47, soybean 47 g (50%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g

Figure 3. Composites flours

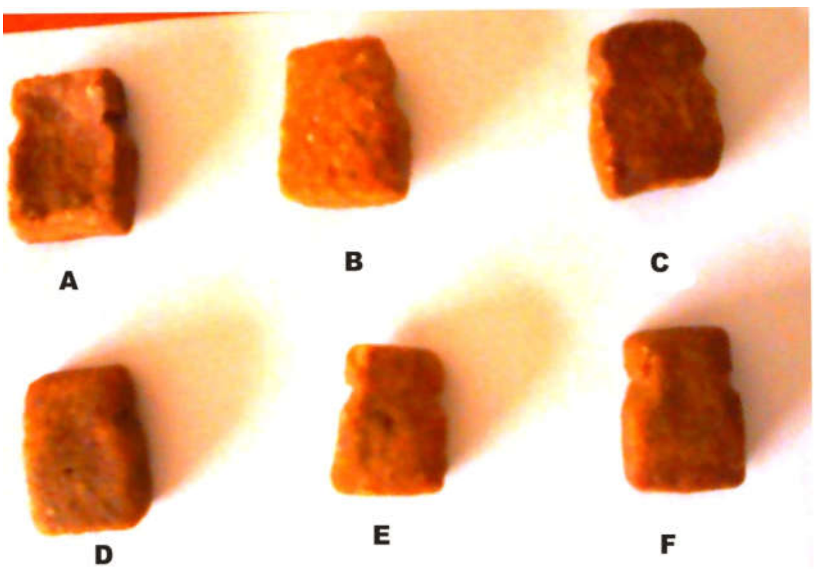
It was pre-ash and placed again in a furnace to ash at 550^0C for 5 hours. It was then taken from the furnace and cooled in a desiccators before weighing and the final result was calculated (AOAC, 1990). For the fat, 3 g of sample was wrapped inside cotton wool and placed in soxhlet thimble. The extraction unit was assembled. Fat was extracted for 5 hours using petroleum ether as extraction medium. Fat was determined by evaporating off excess solvent and dried at 100^0C. The final weight of fat was calculated (Egan *et al.,* 1988; AOAC, 1990). For protein determination, 1 g of the sample was introduced into 100 ml digestion flask.

The following were added into the flask; 2 g anhydrous sodium sulphate, 1 g hydrated cupric sulphate, a pinch of selenium powder, 10 ml of concentrated sulphuric acid. This was digested at 420^0C for 45 minutes until clear digest was obtained. After digestion, distilled water was added into the flask up to the 100 ml mark and then mix thoroughly. Then, 5 ml of boric acid after digestion was introduced into 250 ml conical flask and 2 drops of indicator was added. Then, 5 ml of the diluted digest was introduced into the distillation apparatus. The inlet was closed and blocked with distilled water to prevent escape of ammonia after 20 ml of 40% NaOH was introduced into it. It was then distilled into the 250 ml conical flask containing the boric acid and indicator (bromocresol and methyl red) until about 50 ml – 75 ml of distillate was collected. The distillate in the conical flask was titrated with standard solution of hydrochloric acid (HCl) to the end point. The titre value was recorded, i.e. volume of HCl that exchanged with the indicator and percentage crude protein was calculated (Egan *et al.,* 1988; AOAC, 1990; Nielsen, 2002). For the fibre, 1 g of the sample was added to 0.3N H_2SO_4; 1.5N NaOH was added in excess and boiled again. The residue was filtered and washed with distilled water. This was further washed with 0.3N HCl, water and acetone respectively. The residue was dried and the weight noted. The residue was then transferred into a crucible and was ash in a furnace at 550^0C for 5 hours. After that, the ash (mineral residue) was cooled in desiccators before weighing and the result was calculated (AOAC, 1990). The available percentage of soluble carbohydrate in the sample was estimated by difference i.e. {100% - % (moisture + fibre + protein + ash + fat)} as described by Chibuzo and Ali (1994) and Asma *et al.* (2006).

Determination of the physical properties of guliguli

The physical parameters of guliguli were measured with vernier caliper.

Figure 4. Formation of guliguli(s)



Note:
A = sorghum and maize (1:1) 94 g, soybean 0 g (0%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
B = sorghum and maize (1:1) 85 g, soybean 9 g (10%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
C = sorghum and maize (1:1) 75g, soybean 19 g (20%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
D = sorghum and maize (1:1) 66 g, soybean 28 g (30%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
E = sorghum and maize (1:1) 56 g, soybean 38 g (40%) moringa 0.5 g, crayfish 0.5 g and sugar 5 g
F = sorghum and maize (1:1) 47, soybean 47 g (50%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g

Figure 5. Categories of baked guliguli

The weight of guliguli measured was with analytical balance. Their Volumes were calculated as length × width × height. Density and spread ratio were calculated from these parameters as described by Akubor and Ishiwu (2013) and Oluwamukomi *et al.* (2017).

Determination of sensory attributes of guliguli

Sensory attributes of guliguli were evaluated on the basis of their quality attributes (consistency, taste, texture, colour, flavour, and overall acceptability) using nine-point Hedonic scale. Samples of guliguli were first coded with a random digit number and were presented to eleven panelists who were asked to evaluate them, expressing their degree of like or dislike (Larmond, 1977).

Statistical analysis of flours and guliguli

All samples were analyzed three times, except for physical properties and sensory attributes which were five (5) and eleven (11) times respectively. Data generated were subjected to analysis of variance (ANONA) using IBM SPSS statistics version 20 and means were separated by Duncan's Multiple Range Test (DMRT) at 5% significance level (Duncan, 1955, Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Functional properties of flours of raw materials and their blends

The bulk and the loose bulk density of flours of raw materials and blends (Table 1) were in the range of 0.42 – 0.88 gcm^{-3} (i.e. from crayfish to sugar) and 0.28 – 0.79 gcm^{-3} (i.e. still from crayfish to sugar) respectively. Also those of water absorption capacity and percentage dispersibilty (Table 2) were in the range of 1.13 – 4.03 cm^3g^{-1} (i.e. from sorghum to moringa) and 21.00 – 83.33% (i.e. from maize, blend containing 0% soybean to moringa) respectively. It was observed that as the percentage soybean increases upon formulations, both bulk and loose bulk density decreases. Water absorption capacity and dispersibility increases. These effects were observed (Table 1) to be due to the much significant difference ($p < 0.05$) between sorghum, maize and soybeans which are the major material base used in the formulations, since other materials were kept constant in the proportions. Significant variation was observed throughout in the flours of raw materials and their composites (blends). Similarly, from this research, it was observed that flours from grains of sorghum and maize had less ability to absorb much water as soybean, moringa and crayfish. One can easily envisage functional properties of flours of food materials knowing one of its unique functional properties. It was observed that the higher the bulk density of these flours the lower the water absorption capacity and percentage dispersibility.

Functional properties of foods are the physicochemical characteristics of food systems which negatively or positively affect its utilizations, operations or processing. These properties give useful information before, during or after food processing and have the ability to influence consumers' acceptability (Asma *et al*., 2006; Omidiran *et al*., 2015). It was observed that the bulk density of composites flour containing 50% soybean corresponded with 0.57 – 0.63 gcm^{-3} as reported by Mepba *et al*. (2007). The percentage dispersibility and water absorption capacity (i.e. 23.52 – 53.41% and 1.03 – 1.89 cm^3g^{-1}) reported by Adeyeye and Yildiz (2016) slightly correlate with the flours of guliguli.

Formulations	Sorghum & maize	Soybeans	Vitamin A fortified sugar	Dried moringa leaves	Crayfish	Total
A	94.00	0.00	5.00	0.50	0.50	100
B	85.00	9.00	5.00	0.50	0.50	100
C	75.00	19.00	5.00	0.50	0.50	100
D	66.00	28.00	5.00	0.50	0.50	100
E	56.00	38.00	5.00	0.50	0.50	100
F	47.00	47.00	5.00	0.50	0.50	100

Figure 2. Formulated composites (per 100g)

Table 1. Functional properties of flours of raw materials and their blends

Flours	Bulk density (gcm^{-3})	Loose bulk density (gcm^{-3})	Water absorption capacity (cm^3g^{-1})	Percentage dispersibility (%)
Raw materials				
Sugar	0.88 ± 0.00^a	0.79 ± 0.00^a	NA	NA
Sorghum	0.71 ± 0.00^d	0.42 ± 0.02^d	1.13 ± 0.12^f	21.33 ± 1.15^h
Moringa	0.43 ± 0.01^i	0.29 ± 0.01^f	4.03 ± 0.06^a	83.33 ± 1.15^a
Soybeans	0.59 ± 0.01^h	0.35 ± 0.01^e	2.10 ± 0.10^c	39.33 ± 1.15^c
Maize	0.79 ± 0.00^b	0.51 ± 0.01^b	1.20 ± 0.00^f	21.00 ± 1.00^h
Crayfish	0.42 ± 0.00^i	0.28 ± 0.00^f	2.40 ± 0.00^b	44.00 ± 1.00^b
Blends				
A	072 ± 0.01^c	0.49 ± 0.01^b	1.20 ± 0.00^f	21.00 ± 0.00^h
B	0.72 ± 0.01^c	0.49 ± 0.01^b	1.20 ± 0.00^f	22.00 ± 0.00^{gh}
C	0.68 ± 0.00^e	0.44 ± 0.01^c	1.23 ± 0.06^f	23.00 ± 0.00^{fg}
D	0.68 ± 0.00^e	0.45 ± 0.01^c	1.40 ± 0.00^e	24.00 ± 0.00^f
E	0.65 ± 0.00^f	0.42 ± 0.00^d	1.57 ± 0.06^d	26.00 ± 0.00^e
F	0.63 ± 0.01^g	0.42 ± 0.01^d	1.57 ± 0.06^d	27.33 ± 1.15^d

Each value is a mean ± SD of triplicate determinations. Mean values in a column not sharing a common superscript letters are significantly (P>0.05) different.

Note:

A = sorghum and maize (1:1) 94 g, soybean 0 g (0%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
B = sorghum and maize (1:1) 85 g, soybean 9 g (10%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
C = sorghum and maize (1:1) 75g, soybean 19 g (20%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
D = sorghum and maize (1:1) 66 g, soybean 28 g (30%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
E = sorghum and maize (1:1) 56 g, soybean 38 g (40%) moringa 0.5 g, crayfish 0.5 g and sugar 5 g
F = sorghum and maize (1:1) 47, soybean 47 g (50%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
NA = not applicable

Table 2. Proximate composition of guliguli (g/100g)

Guliguli	Moisture	Ash	Fat	Protein	Fibre	Carbohydrate
A	9.28 ± 0.49[cd]	1.00 ± 0.00[c]	1.07 ± 0.11[d]	7.60 ± 0.01[f]	5.00 ± 0.00[d]	76.05 ± 0.38[a]
B	9.90 ± 0.47[abc]	2.07± 0.06[b]	3.04 ± 0.06[c]	10.80 ± 0.01[e]	5.03 ± 0.06[d]	69.16 ± 0.43[b]
C	10.30 ± 0.47[ab]	2.08 ± 0.07[b]	3.11± 0.11[c]	14.00 ± 0.00[d]	5.07 ± 0.12[d]	65.44 ± 0.26[c]
D	10.46 ± 0.18[a]	2.14 ± 0.15[b]	4.00 ± 0.01[b]	17.40 ± 0.00[c]	6.00 ± 0.00[c]	60.13 ± 0.30[d]
E	9.73 ± 0.25[bcd]	3.00 ± 0.00[a]	4.01 ± 0.01[b]	20.40 ± 0.00[b]	6.16 ± 0.12[b]	56.72 ± 0.36 [e]
F	9.07 ± 0.03[d]	3.11 ± 0.18[a]	5.00 ± 0.00[a]	23.60 ± 0.00[a]	6.31 ± 0.01[a]	52.91 ± 0.19[f]

Each value is a mean ± SD of triplicate determinations. Mean values in a column not sharing a common superscript letters are significantly (P>0.05) different.

Note:

A = sorghum and maize (1:1) 94 g, soybean 0 g (0%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
B = sorghum and maize (1:1) 85 g, soybean 9 g (10%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
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D = sorghum and maize (1:1) 66 g, soybean 28 g (30%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
E = sorghum and maize (1:1) 56 g, soybean 38 g (40%) moringa 0.5 g, crayfish 0.5 g and sugar 5 g
F = sorghum and maize (1:1) 47 g, soybean 47 g (50%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g

Table 3. Physical properties of guliguli

Guliguli	Length (cm)	Width (cm)	Height (cm)	Volume (cm^3)	Weight (g)	Density (gcm^{-3})	Spread Ratio
A	1.86 ± 0.05[a]	1.46 ± 0.05[a]	0.83 ± 0.10[b]	2.25 ± 0.27[a]	1.52 ± 0.05[abc]	0.68 ± 0.07[a]	1.77± 0.18[ab]
B	1.84 ± 0.05[a]	1.46 ± 0.05[a]	0.80 ± 0.00[b]	2.11 ± 0.09[ab]	1.59 ± 0.09[a]	0.76 ± 0.04[a]	1.83 ± 0.07[ab]
C	1.86 ± 0.05[a]	1.46 ± 0.05[a]	0.81 ± 0.05[b]	2.20 ± 0.17[a]	1.51 ± 0.08[abc]	0.69 ± 0.06[a]	1.81 ± 0.14[ab]
D	1.83 ± 0.04[a]	1.41 ± 0.05[ab]	0.76 ± 0.05[b]	1.96 ± 0.14[b]	1.44 ± 0.06[c]	0.74 ± 0.05[a]	1.86 ± 0.14[a]
E	1.80 ± 0.07[a]	1.39 ± 0.02[ab]	0.83 ± 0.04[b]	2.08 ± 0.16[ab]	1.46 ± 0.08[bc]	0.71 ± 0.09[a]	1.68 ± 0.08[b]
F	1.84 ± 0.05[a]	1.36 ± 0.07[b]	0.92 ± 0.04[a]	2.29 ± 0.10[a]	1.56 ± 0.07[ab]	0.68 ± 0.05[a]	1.48 ± 0.10[c]

Each value is a mean ± SD of triplicate determinations. Mean values in a column not sharing a common superscript letters are significantly (P>0.05) different.

Note:

A = sorghum and maize (1:1) 94 g, soybean 0 g (0%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
B = sorghum and maize (1:1) 85 g, soybean 9 g (10%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
C = sorghum and maize (1:1) 75g, soybean 19 g (20%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
D = sorghum and maize (1:1) 66 g, soybean 28 g (30%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
E = sorghum and maize (1:1) 56 g, soybean 38 g (40%) moringa 0.5 g, crayfish 0.5 g and sugar 5 g
F = sorghum and maize (1:1) 47 g, soybean 47 g (50%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g

Table 4. Sensory attributes of guliguli

Guliguli	Consistency	Flavour	Taste	Colour	Texture	Overall acceptance
A	7.63 ± 1.12[a]	7.00 ±1.26[a]	7.36 ±1.03[ab]	6.45 ± 1.37 [b]	7.09 ±1.14[a]	7.27 ± 0.79[a]
B	7.82 ± 0.75[a]	7.36 ± 0.92[a]	6.82 ± 0.87[b]	7.00 ± 0.89[ab]	7.18 ± 0.98[a]	7.55 ± 0.69[a]
C	7.27 ± 0.79[a]	7.36 ±1.03[a]	7.18 ± 0.87[ab]	7.18 ± 0.87[ab]	7.55 ± 0.69[a]	7.36 ± 0.81[a]
D	7.45 ± 0.69[a]	7.09 ± 0.83[a]	7.09 ± 0.54[ab]	7.18 ± 0.40[ab]	7.27± 0.90[a]	7.45 ± 0.52[a]
E	7.64 ±1.03[a]	7.45 ± 0.69[a]	7.55 ± 1.13[ab]	7.27 ± 0.79[ab]	7.45 ± 0.93[a]	7.55 ± 0.82[a]
F	7.64 ± 0.67[a]	7.55 ± 0.69[a]	7.91 ± 0.83[a]	7.73 ± 0.90[a]	7.18 ± 0.60[a]	7.73 ± 0.90[a]

Each value is a mean ± SD of triplicate determinations. Mean values in a column not sharing a common superscript letters are significantly (P>0.05) different.

Note:

A = sorghum and maize (1:1) 94 g, soybean 0 g (0%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
B = sorghum and maize (1:1) 85 g, soybean 9 g (10%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
C = sorghum and maize (1:1) 75g, soybean 19 g (20%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
D = sorghum and maize (1:1) 66 g, soybean 28 g (30%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g
E = sorghum and maize (1:1) 56 g, soybean 38 g (40%) moringa 0.5 g, crayfish 0.5 g and sugar 5 g
F = sorghum and maize (1:1) 47 g, soybean 47 g (50%), moringa 0.5 g, crayfish 0.5 g and sugar 5 g

However, the raw material flours of moringa leave and crayfish exhibited higher percentage dispersibility, water absorption capacity and low bulk density. It was observed that these attributes possibly depend on the amount of starch in those food materials and so affected their functional properties.

Proximate composition of guliguli

The proximate composition of guliguli is indicated in Table 2. The result of moisture content ranged from 9.07 – 10.46 g, protein 7.60 – 23.60 g, ash 1.00 – 3.11 g, fat 1.07 – 5.00 g, fibre 5.00 – 6.31 g and soluble carbohydrate 52.91 – 76.05 g. The results obtained shows significant difference ($p < 0.05$) especially in their protein and carbohydrate contents. As the amount of soybean was increased upon complementation, it was observed that ash, fat, proteins and fibre contents of all guliguli were also increased and with decrease in soluble carbohydrate.

However, moisture did not show such changes. Variation among these guliguli was observed to follow a sequential order that each can fit into toddler, pre-school or school children and also adult snacks. Many of these results obtained agree with many research works done on baked products such as biscuits. Ibidapo *et al.* (2017) obtained moisture content of biscuit from 5.50 – 7.60 g. These results correspond slightly with the results of moisture of guliguli obtained. However, many researchers recommend moisture content of foods to be less than 10% moisture for good storage stability. Various forms of biscuits produced by many researchers have their moisture content varied from low moisture to higher moisture levels. Al-marazeep and Angor (2017) produces biscuits with low moisture content of 3.77 – 4.12 g, Ashaya *et al.* (2015) recorded moisture of content of 3.00 – 4.81 g, Hanan and Rasha (2012) had 5..30 – 7.50 g. These values are better for storage stability as reported by many researchers.

However, the moisture content of biscuits reported by Amir *et al.* (2005) ranged from 8.90 – 10.10 g, while Chinma and Gernah (2007) recorded moisture of 9.05 – 10.32 g which corresponds with the moisture of guliguli produced. In another broad study conducted by Passos *et al.* (2013) and Norhayati *et al.* (2015) found out that moisture contents of most commercial biscuits lie between the ranges of 1.70 – 5.00 g and 1.50 – 5.30 g respectively. Most of these studies reported protein contents within the range of 6.57 – 16.60 g (Chinma and Gernah, 2007; Mepba *et al*., 2007; Olowamukomi *et al*., 2011; Hanan and Rasha, 2012; Akubor and Ishiwu, 2013; Amir *et al*., 2015; Ashaya *et al.,* 2015; Al-marazeep and Angor, 2017; Ibidapo *et al*., 2017). These studies corresponds with guliguli containing 0 – 50% soybean level of complementation. The commercial biscuits reported by Norhayati *et al*. (2015) had protein ranged from 5.65 – 9.92 g which are not far from the 0% and 10% soybean complementation. Most of these biscuits reported above had higher amount of fats ranging from 11.98 – 25.75 g including the commercial ones, though there are some few cases which had 1.50 – 8.40 g fat. All the biscuits reported except for the very few ones and the commercial biscuits had fibre and ash contents less than zero in their composition.

Physical properties of guliguli

The physical properties of guliguli are shown in Table 3. These physical properties indicate no much variation. The ranges of values obtained for these physical parameters are: length 1.80 – 1.86 cm, width 1.36 – 1.46 cm, height (thickness) 0.76 – 0.92 cm, volume 1.96 – 2.29 cm^3, weight 1.44 – 1.59, density 0.68 – 0.76 gcm^{-3} and spread ratio 1.48 – 1.86. Weight and spread ratio are very important in evaluating quality of cookies especially when viewed for commercial purpose. Apart from uniformity or consistency of a particular product in terms of weight, it also entails the benefits of commodity which consumers are gaining after purchasing. Spread ratio measures the width (diameter) and thickness (height) of cookies based on the ability of certain flour that yield more spread. These two features are the most preferred quality of cookies as reported by Akonor *et al*. (2015). It was also observed that composites flours with higher level of soybean complementation indicated slight reduction in spread. This also corresponds with the quality of wheat-based biscuits and their mixtures reported by Akonor *et al*. (2015). Also biscuits produced from composites flours containing soybean exhibits similar behavior as for spread ratio as reported by Chinma and Gernah (2007).

Sensory attributes of guliguli

Table 4 indicates sensory attributes of guliguli. The result showed no significant difference ($p > 0.05$). Sensory scores for all the samples of guliguli ranged from 6.45 (like slightly) to 7.91 (like moderately). For the consistency of guliguli sample ranged from 7.27 - 7.82, flavour 7.00 – 7.55, taste 6.82 – 7.91, colour 6.45 – 7.73, texture 7.09 – 7.55 and overall acceptance 7.27 – 7.73. Organoleptic profiles of foods are important primary sensory attributes which influences consumers appetite as well as decision to purchase a food products (Akonor *et al.* 2015). During this study, many observations were made by the panelists in comparing these foods with the conventional baked products such as harder than biscuits; much appealing taste comes after first chewing and encourages one for second attempt. However, there was no much distinction upon soybean complementation in term of sensory attributes.

A product such as these sweetened with low sugar (5 %) and which still gave high ratings (like moderately) is an indication that it would match with conventional baked products. The sensory attribute of biscuits observed by many studies had panelists ratings between the range of 4.4 - 8.5 on average (Mepba *et al*., 2007; Olowamukomi *et al*., 2011; Hanan and Rasha, 2012; Amir *et al*., 2015; Ashaya *et al*., 2015; Al-marazeep and Angor, 2017). This means that there are still some few sensory quality defects that are not well satisfied by the panelists that still need improvement.

Conclusion

The methods used successfully produced acceptable food and have demonstrated production of guliguli from composite flours. It can also be considered as other alternative technology for producing free-wheat cookies. Most importantly, each of those food produced was observed to fit each categories of human protein requirements starting from those which require moderately low to higher dietary level of proteins.

Conflict of Interest

There is no conflict of interest.

Acknowledgement

We appreciate the efforts of Madam Bege Charles and the Chief Technologist Malam Shehu Abdullahi for their assistance toward the success of this work.

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