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EFFECT OF MAIZE FLOUR SUPPLEMENTATION WITH SOYBEAN AND BAMBARA GROUNDNUT ON NUTRITIONAL QUALITY AND SENSORY ATTRIBUTES OF KOKORO

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ABSTRACT:

In Nigeria, many choose snacks over breakfast due to time and financial constraints. Snacks like kokoro, a popular maize-based option, can lead to protein energy malnutrition due to lack of essential amino acids. Kokoro can be enriched with legumes, enhancing its protein quality. This study aimed to develop six variations of kokoro enriched with soybean and bambara groundnut, (100 % maize; 90:10; 80:20 maize:bambara; 90:10; 80:20 maize:soybean; and 80:10:10 maize:bambara:soybean). Nutritional and functional properties of the flours, nutritional, anti-nutritional and sensory attributes of kokoro were determined, using standard methods. Water absorption capacity ranged from 133.54 to 156.39 %. Oil absorption capacity ranged from 89.64 to 108.46 %. Peak viscosity ranged from 3.07 to 12.04 RVU. Moisture content of kokoro ranged from 3.28 to 10.77 %; protein content ranged from 13.13 to 20.41 % and fat from 9.67 to 27%. There were statistically ($p<0.05$) significant differences among the samples. Tannin values ranged from 2.23 to 3.02 % while phytic acid content ranged from 15.81 to 41.83 %. Samples A (100 % maize) and C (90:10 maize:bambara) were scored higher in consumer preference test. This study concludes that enriching kokoro with soybean and bambara groundnut increased its protein content.

Keywords: Maize, Bambara groundnut, Soybean, kokoro, Protein.

1. INTRODUCTION

Kokoro, a maize based indigenous snack is popularly consumed in Nigeria by young and old but lacks adequate protein content. Maize (Zea mays), commonly referred to as corn, holds a paramount position as a staple crop globally, with its origins traced back to wild grass. Leading maize-producing nations such as the United States, China, and Brazil significantly contribute to its yearly production, accounting for a substantial portion of the world's supply (Zafar et al., 2019). In regions like Sub-Saharan Africa (SSA) and Latin America, maize serves as a cornerstone of diets for over 1.2 billion people, highlighting its indispensability in ensuring food security (IITA, 2009). The versatility of maize is evident in its widespread utilization across various sectors. From food to industrial applications, every part of the maize plant serves a purpose. Maize can be processed into an array of products including starch, sweeteners, oil, beverages, and fuel ethanol, underscoring its economic significance (Gimei and Waswa, 2022).

In regions where there are prevalent issues of insufficient macro and micronutrients in the diet, maize flour and cornmeal emerge as suitable candidates for fortification to address nutritional deficiencies (Manjeru et al., 2019). Nutritionally, maize predominantly consists of starch, with moderate levels of protein and fat. This deficiency underscores the importance of exploring complementary sources of protein, such as leguminous crops like soybeans (Glycine max). Furthermore, protein content is relatively low due to the deficiency of essential amino acids like lysine and tryptophan (Maqbool et al., 2021).

Protein-energy malnutrition (PEM) persists as a significant health concern, particularly in regions where maize constitutes a staple food. The supplementation of maize-based products with legumes presents a feasible solution to address this issue by enriching the nutrient content and increasing protein intake, especially crucial for vulnerable populations like children (Awoyale et al., 2011). To address protein-energy malnutrition in communities reliant on maize-based diets, one of the SDG goals, maize flour used in producing the snack can be supplemented with legumes such as soybean or underutilized Bambara groundnut. As previously noted, utilization of maize is diverse, and it includes snacks such as kokoro. Since kokoro is popularly consumed in Nigeria but lacks adequate protein content, it is a candidate for supplementation to remedy malnutrition, particularly among children (Adegunwa et al., 2015).

Soybean, originating from Eastern Asia, has gained recognition as a plant-based protein source with substantial protein content compared to other plants (Cheng et al., 2019). Rich in protein, carbohydrates, dietary fiber, vitamins, and minerals, soybeans offer a nutritionally dense option for supplementation and fortification of various food products. Despite containing antinutritional components, such as phytate and tannin, which can be mitigated through processing methods, soybeans remain a valuable resource for enhancing the nutritional profile of maize-based products (Anderson and Bush, 2011).

Another leguminous crop, bambara groundnut (Vigna subterranea (L.) Verdc.), native to Africa, boasts a rich nutritional composition and resilience to challenging environmental conditions. Although underutilized, its nutritional value, including high protein content and essential amino acids, positions it as a valuable contributor to food security (Mayes et al., 2019).

Kokoro, a traditional cereal-based snack from Nigeria, primarily composed of maize, presents an opportunity for nutritional enhancement through the incorporation of legumes like soybeans and bambara groundnuts. Despite being carbohydrate-rich, kokoro lacks adequate protein content, making it suitable for fortification to combat malnutrition, particularly among children (Adegunwa et al., 2015). This research explores the feasibility and impact of fortifying kokoro with legumes to enhance its nutritional value and contribute to addressing protein-energy malnutrition in communities reliant on maize-based diets.

2. MATERIALS AND METHODS

The soybean and maize seeds varieties used was sourced from IITA (International Institute of Tropical Agriculture, Ibadan). The bambara groundnut seeds, onions (Allium cepa), salt and vegetable oil were sourced from an open market in Bodija, Ibadan.
Sample preparation
Maize, soybean and bambara flours
The maize grains (1.5 kg); soybean (500 g) and bambara (500 g) seeds were sorted and cleaned. Maize was dry milled as reported by Oluwafemi et al. (2018). Soybean and Bambara seeds were soaked in 5 L of potable water for 12 h and 72 h respectively according to Tasnim and Suman (2015); and Arise et al. (2018). After which the seeds were dehulled and oven-dried using an electric convection oven (Linkrich model YXD-4A, China) at 65 ℃ for 9 h. Dried seeds were milled and sieved with (0.01mm mesh size), packaged and stored at room temperature until used. Flowchart for maize, soybean and bambara flour production is presented in Figure 1.

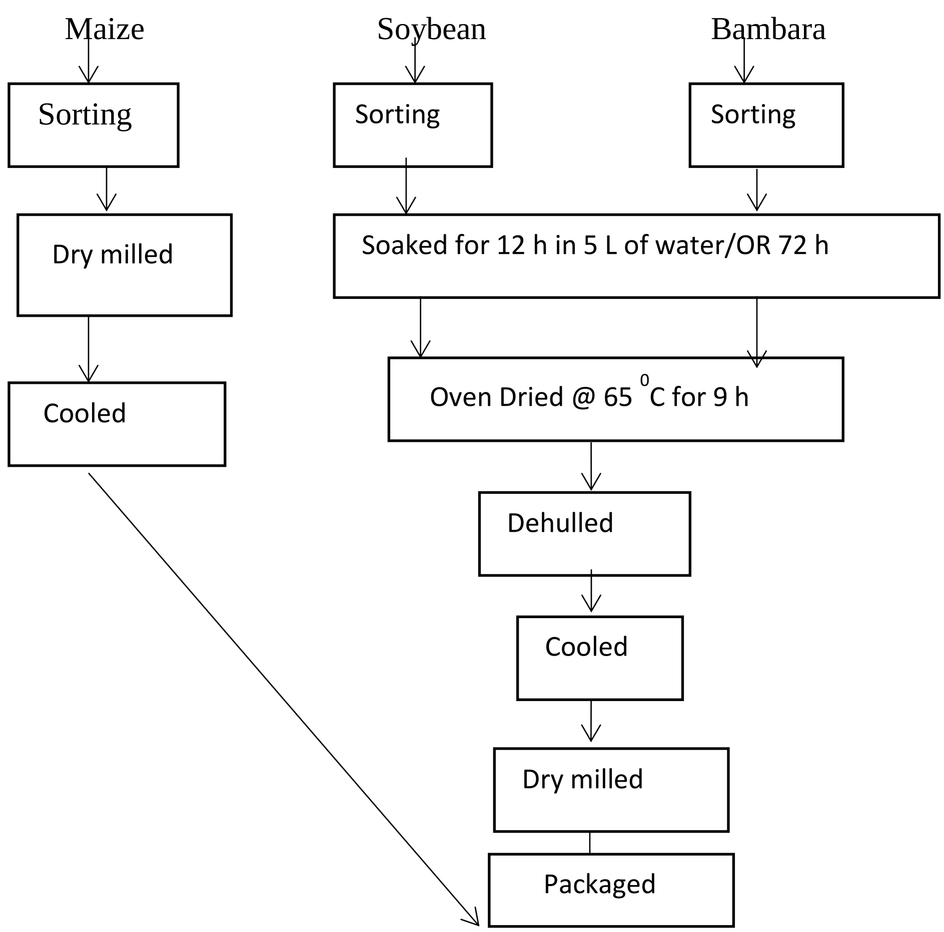

Figure 1. Flow chart for maize, soybean and bambara groundnut flours production.
Production of kokoro

Maize snack (kokoro) was produced as described by Uzo-Peters, (2008) with slight modification. The formulation for sample production is presented in Table 1.

Table 1: Formulation of flour blends for kokoro samples

Sample	Raw materials (g)					
	Corn flour	Soybean flour	Bambara flour	Onion	Salt	Water (mL)
MCF	100	0	0	8	2	100
MBF1	80	0	20	8	2	100
MBF2	90	0	10	8	2	100
MSF1	90	10	0	8	2	100
MSF2	80	20	0	8	2	100
MBSF	80	10	10	8	2	100

Maize: Bambara: soybean flour; MFC (100:0), MBF1 (80:20), MBF2 (90: 10), MSF1(90: 10), MSF2 (80: 20), MBSF (80: 10: 10).

The composite flour (corn, soybean and Bambara groundnut) was thoroughly mixed. Then about 100 mL of water was boiled in a stainless pot and 8 g of onions and 2 g of salt were added. Followed by the addition of 65 g of the flour blend into the boiling water, with continuous stirring until a dough was formed. The dough was allowed to cool, followed by the addition of the remaining 35 g of the flour during kneading to form a hard dough. The dough was then moulded by hand to form the kokoro stick shape. The hand moulded sticks were deep fried in heated vegetable oil until golden-brown colour developed Figure 2.

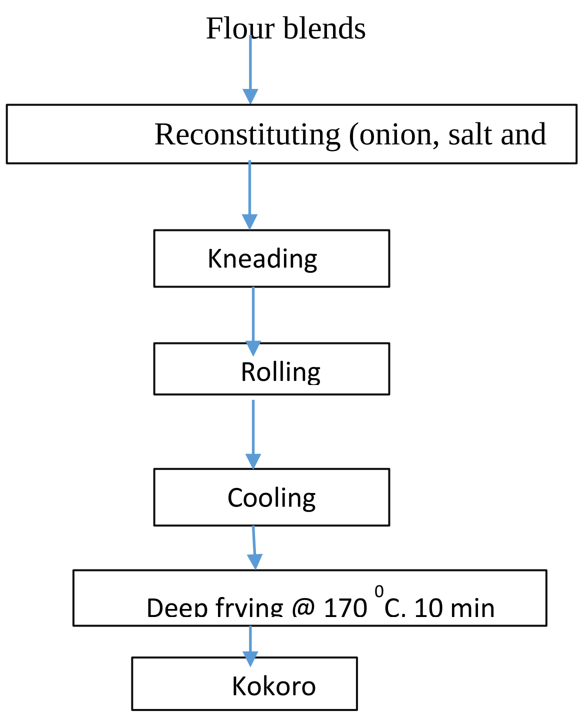

Figure 2: Flow chart for kokoro production (Arise et al., 2018)

Chemical Analyses

Functional properties of the flour blends

Bulk density was carried out using the method of Wang and Kinsella (1976); water and oil absorption capacity were carried out using the method of Solsulski (1962); swelling power was carried out using the modified method of Riley et al. (2006). The pasting characteristics were assessed using the Rapid Visco Analyzer (RVA) model 4500 series by (Newport Scientific PTY. Ltd, Warriewood, Australia), with the assistance of Thermocline for Windows version (1996).

Nutritional Composition of composite flour blends and kokoro samples

Moisture content was carried out using the gravimetric method, protein was according to Kjeldah using block digestion and steam distillation with the FOSS Kjeltec distilling system (AACC, 2005) and fat content was determined using the automated method Soxtec IM 8000, USA (AACC, 2005). Ash content was carried out using the method of AOAC, (2006) and the crude fibre was determined using FOSS Fibertec ™M 2010 (United States), according to (AOAC, 2012). Carbohydrate content was determined by difference. The mineral content was determined using the method of (AOAC, 2012). While the antinutritional properties was determined using the method described by Adegunwa et al. (2011).

Sensory Evaluation of kokoro

The sensory evaluation exercise was done using twenty trained panelists at IITA (Food Nutrition Science Laboratory) who are conversant with the consumption of kokoro. using Hedonic scale (1 – 9). Hardness = Not hard: {1, 2, 3}; Slightly hard: {4, 5, 6}; Hard: {7, 8, 9}. Water was provided to cleanse palate in between sampling.

Statistical Analysis

All data were statistically analysed using SPSS 20. The analysis of variance (ANOVA) was used to establish significant differences at $p < 0.05$. The means were separated using Duncan's multiple range tests (DMRT).

3. RESULTS AND DISCUSSIONS

Table 2 shows the result of functional properties for the flour blends. The bulk density of the flour blends ranged from 0.25 to 0.43 g/ml. Sample MBF1 (80:20 maize:bambara flour) displayed the highest bulk density while samples MBF2 (90:10 maize:bamara flour) and MSF2 (80:20 maize:soybean flour) had the lowest values. These results agree with prior studies conducted by Abegunde et al. (2014) and Akoja and Ogunsina (2018) who reported for kokoro made from maize-cowpea blends and maize-pigeon pea blends respectively. The bulk density of the flours is affected by particle size and is relevant during packaging, transportation, storage and distribution (Adebowale et al., 2008). The water absorption capacity ranged from 133.54 % to 156.39 %, with sample MSF1 demonstrating the highest and sample MBF1 showing the lowest values. These finding is within the range observed by Akoja and Ogunsina (2018). The oil absorption capacity of the flour samples ranged from 89.64 % to 108.46 %, with sample MSF2 displaying the highest and MBF1 lowest values. The swelling capacity of the flour samples ranged from 5.28 % to 6.25 %. Although the differences were not statistically significant, sample MBSF exhibited the highest swelling capacity, while sample MSF1 had the lowest. This closely mirrors finding by Akoja and Ogunsina (2018) but contradicts the observation of Abegunde et al. (2008).

Table 2: Functional properties of the flour blends

Sample	Functional properties of the flour blends (%) (%)			
	Bulk density (g/ml)	Water absorption	Oil absorption	Swelling capacity
MCF	0.28±0.04[a]	148.37±1.95[c]	106.18±1.53[d]	5.93±0.06[b]
MBF1	0.43±0.04[a]	133.54±1.41[a]	89.64±1.61[c]	5.80±0.11[ab]
MBF2	0.25±0.07[a]	145.58±2.58[bc]	98.29±1.03[b]	5.71±0.03[ab]
MSF1	0.33±0.11[a]	156.39±3.72[d]	101.19±0.71[c]	5.28±0.18[a]
MSF2	0.25±0.00[a]	142.37±2.63[b]	108.46±0.35[d]	5.98±0.46[b]
MBSF	0.38±0.11[a]	149.59±0.40[c]	99.74±0.38[bc]	6.25±0.16[b]
p-value	0.000	0.000	0.000	0.000

Values are means of duplicate ± standard deviation. Values with same superscript along the column are not significantly different from one another ($p<0.05$). Maize: Bambara: soybean flour; MFC (100:0), MBF1 (80:20), MBF2 (90: 10), MSF1(90: 10), MSF2 (80: 20), MBSF (80: 10: 10).

Pasting profile

Table 3 shows the results of the pasting profile of the flour blends. The peak viscosity among the flour samples ranged from 3.07 to 12.04 RVU) and significant differences were observed, which also indicate variations in their swelling ability, gel formation, and starch breakdown during heating. Trough viscosity, representing the minimum viscosity during cooling after peak viscosity, displayed significant differences among samples and ranged from (1.02 to 8.77 RVU). This parameter signifies the ability of the flour to maintain viscosity post-cooking or processing. These results align with prior studies conducted by Otunola et al. (2012), indicating consistency in the observed variations across different flour blends. MCF (100:0) maize demonstrated the highest trough viscosity, indicating its potential in retaining viscosity in processed foods compared to MSF2 (80:20) maize: soybean exhibited the lowest trough viscosity. Breakdown values range from 2.05-3.65 RVU with MCF having the highest value (3.65 RVU) while MSF2 had the lowest (2.05 RVU). Higher breakdown values suggest greater susceptibility to shear forces and reduced stability during heating, potentially impacting the overall quality of food products.

The final viscosity, which indicates the viscosity at the end of the heating and cooling cycle, varied significantly among samples, ranging from (16.62 to 40.58 RVU). This parameter influences textural attributes like thickness and mouthfeel in food products. These results are similar with study conducted by Ayinde et al. (2012). MCF had the highest final viscosity and could be suitable for applications requiring thicker consistency. Setback viscosity, representing the setback in viscosity during cooling after peak viscosity, exhibited significant differences among samples, ranging from (15.82 to 32.83 RVU). A higher setback viscosity implies higher retrogradation or reassociation of starch molecules upon cooling, contributing to the firmness or hardness of the final product. Peak time ranged from 7.05-7.15 min, and pasting temperature ranged from 50.64-59.85 0C, although not significantly different, provide insights into the time and temperature required for gelatinization, respectively, which can affect cooking processes and end-product qualities. These results align with prior studies conducted by Otunola et al. (2012), the differences in peak viscosity may be due to the starch concentration of the flour blends.

Table 3: Pasting properties of the flour blends

Sample	Pasting properties of the flour blends (RVU)						
	Peak viscosity	Trough viscosity	Breakdown	Final Viscosity	Setback	Peak Time (Min)	Pasting Temp (°C)
MCF	12.04±0.06^{f}	8.77±0.38^{e}	3.65±0.21^{c}	40.58±0.35^{f}	32.83±1.41^{c}	7.05±0.07^{a}	59.85±0.14^{c}
MBF1	6.73±0.14^{d}	4.78±0.40^{c}	2.58±0.35^{b}	28.17±0.35^{d}	24.02±0.14^{b}	7.15±0.21^{a}	50.65±0.63^{a}
MBF2	9.80±0.07^{e}	6.27±0.14^{d}	3.53±0.07^{c}	37.27±0.14^{e}	31.54±0.76^{c}	7.10±0.14^{a}	50.70±0.70a
MSF1	5.43±0.14^{c}	3.11±0.16^{b}	2.40±0.09^{ab}	25.98±0.32^{c}	23.39±0.91^{b}	7.05±0.07^{a}	50.80±0.77^{a}
MSF2	3.07±0.11^{a}	1.02±0.03^{a}	2.05±0.70^{a}	16.62±0.42^{a}	15.82±0.14^{a}	7.05±0.26^{a}	50.64±0.62^{a}
MBSF	3.68±0.14^{b}	1.55±0.18^{a}	2.23±0.08^{ab}	18.71±0.41^{b}	17.11±0.16^{a}	7.11±0.12^{a}	55.75±0.49^{b}
P-value	0.00	0.00	0.00	0.00	0.00		0.00

Values are means of duplicate ± standard deviation. Values with same superscript along the column are not significantly different from one another ($p<0.05$). Maize: Bambara: soybean flour; MFC (100:0), MBF1 (80:20), MBF2 (90: 10), MSF1(90: 10), MSF2 (80: 20), MBSF (80: 10: 10).

Proximate composition of composite flour blends

The proximate composition of the flour blends is presented in Table 4. There were statistically ($p< 0.05$) significant differences observed in moisture, protein, crude fiber, fat, ash, and carbohydrate contents. Moisture content ranged from 5.5 % to 6.21 %, with MCF (100 % maize) observed to have the highest value and MBF1 the lowest respectively. This finding aligns with reports by other researchers (Arise et al., 2018; Uzoh-Peters et al., 2008 and Adelakun et al., 2005), showing a decrease in the moisture content with the incorporation of soybean and bambara groundnut flour when compared to the control. Regarding protein content, MSF2 (80:20 maize:soybean flours) exhibited the highest value (31.70 %), while the control sample, MCF, recorded the lowest (12.94 %). The substitution of maize with legume improved the protein content of the composite flour samples. This trend was also observed by Arise et al. (2018); Abegunde et al. (2014); Uzoh-Peters et al. (2008); Adelakun et al. (2005). The fat content in composite flours varies, with MBF1 (80:20 maize:bambara) observed to have the highest value (16.16 %) and MSF2 (80:20 maize:soybean) the lowest (4.95 %). The influence of ingredient composition, especially the inclusion of higher-fat content like soybean was observed. Ash content of the flour blends ranged from 1.37 % and 2.12 %, with MBF1 observed to have the highest value and MCF the lowest. The reports of Arise et al. (2018) and Adeola et al. (2011) agrees with the result in this study, indicating an increase in the ash content with the addition of the legumes when compared to the control. Crude fiber content varied from 1.19 % (MCF) to 2.81 % (MSF2), consistent with earlier findings (Arise et al., 2018; Adelakun et al., 2005). In terms of carbohydrate content, MCF presented the highest value (70.72 %), while MSF2 recorded the lowest (52.66 %). This aligns with previous studies (Adeola et al., 2011; Fasasi et al., 2013; Arise et al., 2018), indicating a decrease in the carbohydrate content with an increase in protein content as legumes are not rich in carbohydrates.

Table 4: Proximate composition (%) of the flour blends

Sample	Proximate composition (%) of the flour blends					
	Moisture	Ash	Fat	Protein	Crude fiber	Carbohydrate
MCF	6.21±0.10^{b}	1.37±0.02^{a}	7.57±0.04^{d}	12.94±0.14^{a}	1.19±0.01^{a}	70.72±0.23^{f}
MBF1	5.5±0.45^{a}	1.70±0.07^{bc}	16.16±0.04^{f}	21.61±0.57^{c}	2.07±0.01^{b}	52.96±0.21^{c}
MBF2	5.93±0.02^{ab}	1.49±0.02^{ab}	5.44±0.09^{b}	18.61±.1.18^{b}	2.23±0.01^{d}	66.30±0.01^{e}
MSF1	6.02±0.11^{ab}	1.67±0.03^{abc}	10.90±0.14^{e}	24.66±0.28^{d}	2.54±0.01^{e}	54.21±0.13^{b}
MSF2	5.76±0.20^{ab}	2.12±0.06^{d}	4.95±0.34^{a}	31.70±.1.80^{f}	2.81±0.01^{f}	52.66±0.21^{a}
MBSF	5.74±0.24^{ab}	1.89±0.28^{cd}	6.77±0.03^{c}	27.31±0.33^{e}	2.10±0.01^{c}	56.19±0.01^{d}
P-value	0.000	0.000	0.000	0.000	0.000	0.000

Values are means of duplicate ± standard deviation. Values with same superscript along the column are not significantly different from one another ($p<0.05$). Maize: Bambara: soybean flour; MFC (100:0), MBF1 (80:20), MBF2 (90: 10), MSF1(90: 10), MSF2 (80: 20), MBSF (80: 10: 10).

Proximate composition of kokoro from composite flour (maize, bambara and soybean.

The results of proximate composition of kokoro produced from blends of maize, soybean and bambara groundnut flours are presented in Table 5. The relatively low moisture content (ranging from 3.28 % to 10.77 %) was observed in the kokoro samples. Sanchez-Maldonado et al. (2018), noted that foods with low moisture content are less prone to spoilage. The fat and protein contents of kokoro ranged from 9.67 % to 27.00 % and 13.13 % to 20.41 %, respectively. There were increase in fat and protein contents as legumes were substituted for maize, hence there was a corresponding decrease in carbohydrate content across all kokoro samples. Legumes the inherently higher fat and protein contents compared to cereals (Uzor-Peters et al., 2008). A decrease in the protein content of the flour blends was observed, compared to the resulting kokoro samples. This is attributed to the various unit operations used during processing, such as frying temperature and time which may have led to protein denaturalisation. This was also observed during studies on food enrichment using bambara groundnut and soybean seeds (Uzor-Peters et al., 2008; Adeola et al., 2011; Arise et al., 2018; Akinsola et al., 2020).

Table 5: Proximate composition (%) of kokoro produced from the flour blends

kokoro Sample	Proximate composition (%)					
	Moisture	Ash	Fat	Protein	Crude fiber	Carbohydrate
MCK	3.28±0.45^{a}	1.63±0.01^{a}	9.67±1.18^{a}	13.13±0.31^{a}	1.29±0.01^{a}	71±0.23^{f}
MBK1	10.77±0.11^{e}	2.87±0.02^{d}	21.21±0.04^{c}	16.31±0.31^{c}	2.10±0.01^{b}	46.74±0.21^{c}
MBK2	7.85±0.16^{cd}	2.45±0.00^{b}	18.49±0.71^{c}	14.56±0.28^{b}	2.31±0.01^{d}	54.34±0.01^{e}
MSK1	8.28±0.16^{d}	2.69±0.04^{c}	13.93±0.49^{b}	17.16±0.01^{d}	2.63±0.01^{e}	44.69±0.13^{b}
MSK2	7.49±0.29^{c}	2.71±0.04^{c}	27.00±2.37^{d}	20.41±0.01^{f}	2.86±0.01^{f}	39.53±0.21^{a}
MBSK	6.81±0.01^{b}	2.75±0.04^{c}	22.23±0.74^{e}	18.57±0.28^{e}	2.16±0.01^{c}	47.48±0.01^{d}
P-value	0.000	0.000	0.000	0.000	0.000	0.000

Values are means of duplicate ± standard deviation. Values with same superscript along the column are not significantly different from one another ($p<0.05$). Maize: Bambara: soybean flour; MFC (100:0), MBF1 (80:20), MBF2 (90: 10), MSF1(90: 10), MSF2 (80: 20), MBSF (80: 10: 10).

Mineral content of kokoro

Table 6 shows the results of the mineral content determination of kokoro made from the flour blends. Phosphorus content ranged between 220 ppm and 410 ppm, with significant differences noted among samples. Calcium levels fluctuated between 160 ppm and 290 ppm, with kokoro MSK2 displaying the highest calcium content and MBK2 the lowest. Magnesium content ranged from 70 ppm to 100 ppm, potassium levels demonstrated a wide range between 450 ppm and 1610 ppm, showcasing

Kokoro Sample	Mineral composition of *kokoro* (ppm)					
	P	Ca	Mg	K	Mn	Fe
MCK	220±0.03^{a}	170±0.03^{a}	80±0.02^{a}	450±0.02^{a}	13.3±0.22^{c}	3.25±0.12^{a}
MBK1	270±0.04^{b}	180±0.04^{a}	80±0.01^{a}	660±0.05^{c}	10.8±0.12^{a}	3.27±0.25^{a}
MBK2	240±0.12^{ab}	160±0.09^{a}	70±0.06^{a}	540±0.03^{b}	10.8±0.14^{a}	4.34±0.13^{b}
MSK1	410±0.04^{c}	220±0.10^{b}	90±0.01^{a}	700±0.01^{d}	21.2±0.21^{d}	5.41±0.24^{c}
MSK2	270±0.05^{b}	290±.0.05^{c}	100±0.02^{a}	1160±0.06^{f}	18.6±0.25^{c}	5.41±0.13^{c}

MBSK	240±0.01[ab]	170±0.04[a]	90±0.05[a]	820±0.05[e]	21.1±0.13[d]	5.39±0.45[c]
P-value	0.000	0.000	0.000	0.000	0.000	0.000

Table 6: Mineral composition of kokoro made from the flour blends (ppm)

Significant differences among samples, the value of manganese ranged from 10.81 - 21.18 ppm, the value of iron ranged from 3.25 - 5.41 ppm. Samples MSK1 and MSK2 recorded the highest value of 5.41 ppm, while MCK, recorded the lowest value of 3.25 ppm, these results align with findings of Oluwafemi et al., (2018).

Values are means of duplicate ± standard deviation. Values with same superscript along the column are not significantly different from one another ($p<0.05$). Maize: Bambara: soybean flour; MFC (100:0), MBF1 (80:20), MBF2 (90: 10), MSF1(90: 10), MSF2 (80: 20), MBSF (80: 10: 10).

Antinutrient content of kokoro

Table 7 shows the anti-nutritional properties of kokoro. Tannin values ranged from 2.23 % to 3.02 %, and there were significant differences ($p<0.05$) among the samples. Tannins, a class of compounds known for their ability to hinder nutrient absorption, showed relatively consistent levels across the samples (Ewulo et al., 2017). In contrast, the phytic acid content displayed a wider variability among the kokoro samples, ranging from 1.58 % to 4.18 %. This significant variation suggests that the choice of flour blend influences the phytic acid content considerably. MSK2 recorded the highest phytic acid content, while MCK had the lowest. This variability might be attributed to the inherent phytic acid levels present in the individual flours used in the formulation of kokoro. The substantial difference in phytic acid content among samples underscores the importance of flour selection in managing the anti- nutritional properties of kokoro.

Table 7: Anti- nutritional properties of kokoro (%)

Kokoro Sample	Anti nutritional properties of *kokoro* (%)	
	Phytic acid	Tannin
MCK	1.58±1.42[a]	2.37±0.10[b]
MBK1	2.41±0.95[b]	2.23±0.00[a]
MBK2	2.30±1.41[b]	2.54±0.00[c]
MSK1	2.90±1.41[c]	2.76±0.01[d]
MSK2	4.18±2.37[e]	3.02±0.04[e]
MBSK	3.49±0.47[d]	2.40±0.01[b]
P-value	0.000	0.000

Values are means of duplicate ± standard deviation. Values with same superscript along the column are not significantly different from one another ($p<0.05$). Maize: Bambara: soybean flour; MFC (100:0), MBF1 (80:20), MBF2 (90: 10), MSF1(90: 10), MSF2 (80: 20), MBSF (80: 10: 10).

Sensory evaluation of kokoro from maize, bambara and soybean flour

The results of the sensory evaluation of kokoro made from the flour blends are presented in Figure 3. Findings show that taste, influenced by ingredients like onions and salt, consistently exhibited slight sweetness across samples. Aroma varied, with maize-based MCF having a more appealing scent. Despite formulation differences, all samples had a golden-brown color. Crispness varied, with MCF being the crispiest. Hardness remained consistent, with all variants slightly hard. Overall acceptability favored MCF, indicating its higher desirability. These results align with prior studies conducted by Arise et al. (2018), indicating consistency in the observed variations across kokoro produced from the different flour blends.

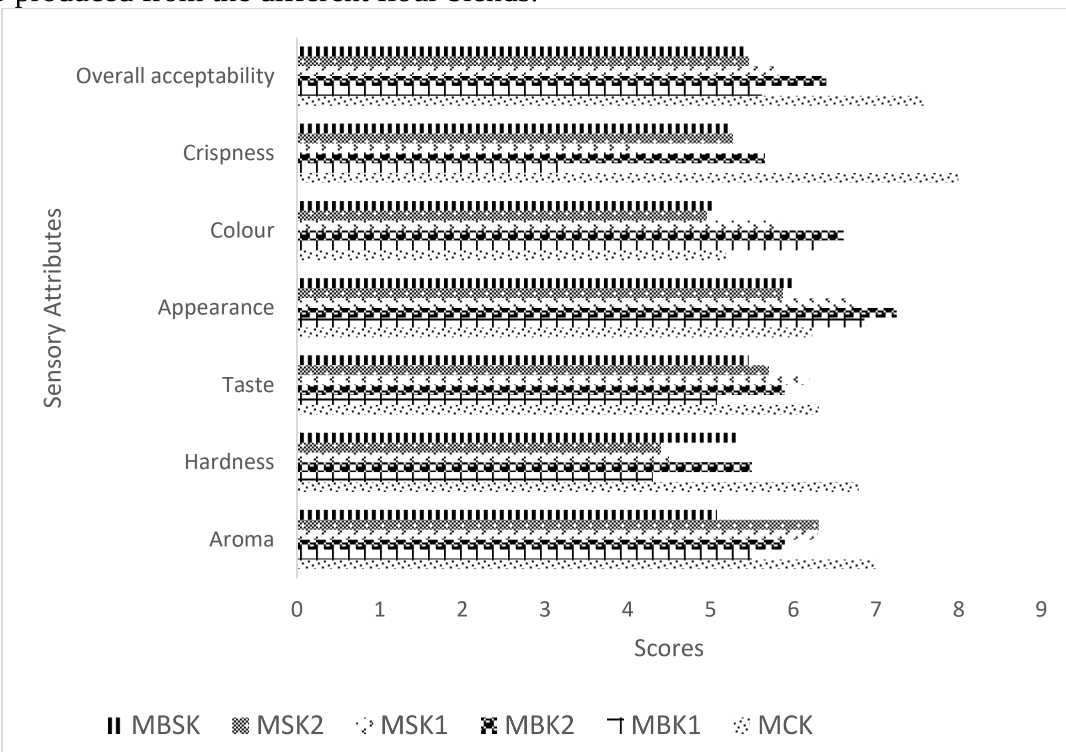

Figure 3: Mean sensory scores of the attributes for kokoro samples. Maize: Bambara: soybean flour; MFC (100:0), MBF1 (80:20), MBF2 (90: 10), MSF1(90: 10), MSF2 (80: 20), MBSF (80: 10: 10).

4. CONCLUSION

Increasing the level of either soybean or bambara groundnut substitution for maize in kokoro production resulted in an increase in fat, protein, and a decrease in carbohydrate contents of products. There was a decrease in sensory qualities of products, as substitution with either soybean or bambara groundnut increased. Notably, sensory acceptability, a crucial determinant of consumer preference, favored MCF (100 % maize) followed by MBF2 (90: 10 maize:bambara groundnut). Among the flour blends, the mixture of 90% maize and 10% bambara groundnut emerged as the most accepted by consumers due to its similarity in texture and crispness to the traditional 100% maize kokoro.

Conflict of interest.
The authors declare no
Authors' Declaration
The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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