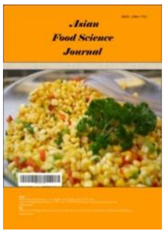

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Nutritional Composition, Antioxidant and Sensory Properties of a Maize-based Snack (Kokoro) Enriched with Defatted Sesame and Moringa Seed Flour

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Kokoro, a maize-based snack was made from maize flour and supplemented with *Moringa* seed flour (MSS) and defatted sesame flour (DSF) flours with the aim of improving its nutritional quality. An experimental design was carried out using optimal mixture model of response surface methodology which yielded 16 formulations in which three blends in terms of the best proximate composition and the control sample (100% maize) were selected. The snacks were analyzed for proximate, mineral, amino acid composition, sensory and antioxidant properties. Proximate analysis results showed significant (p<0.05) increase in protein (9.25–24.23%), fat (15.07–35.25%), ash (2.25–4.25%) content, and energy value (508.43–607.71 KJ/ g), while crude fiber (7.58–5.80%), moisture (4.58-3.64%) and carbohydrate (61.27–26.83%) content decreased with inclusion of MSF and DSF. Potassium (4.02-5.03mg/100 g) was the predominant mineral, followed by calcium (3.31-5.41mg/100 g) and potassium (1.67-3.75mg/100 g). Glutamic acid was the most

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abundant non–essential amino acids while leucine was the predominant essential amino acid in the enriched "kokoro". There was an increase in the amino acid content (except for aspartic acid, arginine and histidine) of the kokoro samples as the proportions of MSF and DSF increased. The result also showed that the essential amino acid index, predicted biological value, protein efficiency ratio and nutritional index of the enriched kokoro were higher than the control sample with values ranging from 0.6108-0.8944, 54.88-85.79%, 1.63-3.49g/100g and 5.65-21.67%, respectively. The result also showed that there was a significant ($p<0.05$) increase in the flavonoid, phenolic content and DPPH of the kokoro as supplementation with MSF and DSF increased. The control sample compared favourably with kokoro supplemented with 6.25% and 17.5% MSF and DSF, respectively, in terms of sensory evaluation. Hence, acceptable and nutritious kokoro snacks from this blend can be formulated which could enhance the nutritional wellness of consumers.

Keywords: Kokoro; moringa oliefera seed; defatted sesame seed; nutrition; enrichment.

1. INTRODUCTION

Snack refers to a light meal or food eaten between meals [1]. Snacks have gained importance and acceptability worldwide in recent years and are now part of the contemporary culture [2]. Typically, snacks are dense calorie foods consisting of high carbohydrate and fat content. They have low nutritional value because they provide less than 2% of the protein requirement; hence they are referred to as foods that provide "empty calories". Snack foods appeal to consumers on a number of levels such as taste, appearance, texture etc [1]. Globally, snacking is on the rise owing to an increasingly hectic lifestyle with more time spent at work. In the last ten years, changes in life-style and eating patterns have led to a gradual increase in demand for snack foods. Incorporating nutrients directly into snacks is an important means of ensuring consumers have healthy diet choices.

Maize (*Zea mays* subsp. *May* L.) is widely consumed cereal crop grown globally. It contributes between 12-15% of the total food requirement by Nigerian [3]. It is the third leading crop of the world after rice and wheat and the most important cereal crop in Nigeria next to sorghum [4] with an annual production of about 5.6 million tones [5]. They are good sources of carbohydrates, vitamins and minerals. Shah *et al*. [6] reported that 100g of edible portion of maize contains 71.88g carbohydrate, 8.84g protein, 4.57g fat, 2.15g crude fibre and 2.33g ash. Maize grain has great nutritional value and can be used as raw material for manufacturing many industrial products like cornflakes, bread, pastries, and for brewing of both alcoholic and non-alcoholic drinks. In different cultures and societies, they are use as compliments for soups, gravies and stews and supply the basic energy requirement of the consumer [7]. Maize grains are predominantly used for the production of different snack foods some of which may be eaten mainly to prevent hunger before main meals or just as relishes.

Sesame (*Sesemum indicum* Linn) also known as "gingely", "beniseed", "sim sim" and "til" is an important annual seed crop belonging to the Pedaliaceae plant family [8]. It has its origin in Africa and spread early through West Asia, India, China and Japan [9]. The seeds are very small and have no endosperm with one thousand seeds weighing 2-4 g [8]. The seeds can be white, grey, brown, chocolate or black. The seed yields high quality edible and odourless oil that serve as a good source of protein and fat for humans and livestock [10]. The seed contains about 20-30% protein which is high in tryptophan and methionine [9]. It is consumed directly as sweetmeat and snack. The oil can be used in salads, for cooking, producing margarine, soap making, pharmaceuticals, paints and lubricants. The seed cake is high in protein and can be used as animal feed or ground in to sesame flour and incorporated to health foods [9].

Moringa oleifera (Lam.) is one of the under-exploited crops with great potentials. *Moringa oleifera* seeds are promising resources for food and non-food applications due to their content of high monounsaturated/saturated fatty acids (MUFA/SFA) ratio, sterols and tocopherols, as well as proteins rich in sulfated amino acids [11]. *Moringa oleifera* seeds are globular, about 1 cm in diameter [12]. According to Leone *et al*. [11], the seed has high protein content (on average 31.4%). Thus, the defatted seeds of *M. oleifera* could provide an economical source of protein for use as a food supplement to traditional maize-based snack such as kokoro to increase protein intake.

The traditional maize snack (Kokoro) is a popular local snack in Southwestern Nigeria [13], which is produced from thick coarse corn paste for consumers. Kokoro is rich in carbohydrate, low in protein and deficient in some essential amino acids particularly lysine. Maize is predominantly starch (60-75%), the protein content is low constituting of about 9-12% when compared with other grains. Amino acids that are lacking in maize can be supplemented by complimenting maize with legumes, nuts and seeds such as sesame and moringa seed flours, which are better sources of the sulphur amino acids [14], thus improving the balance of amino acid in the product [15]. Several other studies have been carried out to improve the nutritional quality of kokoro by fortification with plant proteins such as soybean, African yam bean and defatted coconut paste and showed considerable improvement [16,17,18]. However, there are no published reports of utilizing blends of sesame and moringa seed flour in enriching kokoro. Since this snack is consumed among all levels of the populace including school-aged children as refreshment in Southern Nigeria, incorporation of moringa seed and sesame seed flour will make the snack a useful protein and energy sources for its consumers. This study thus seeks to evaluate the nutrient composition as well as the acceptability of a maize-based snack enriched with sesame and moringa seed flour.

2. MATERIALS AND METHODS

2.1 Sample Collection

Maize, sesame seed and moringa seed were purchased from Institute of Agricultural Research and Training, Ibadan while refined vegetable oil, onions and salt to be used for the production of kokoro were purchased, from a local market in Akure, Nigeria.

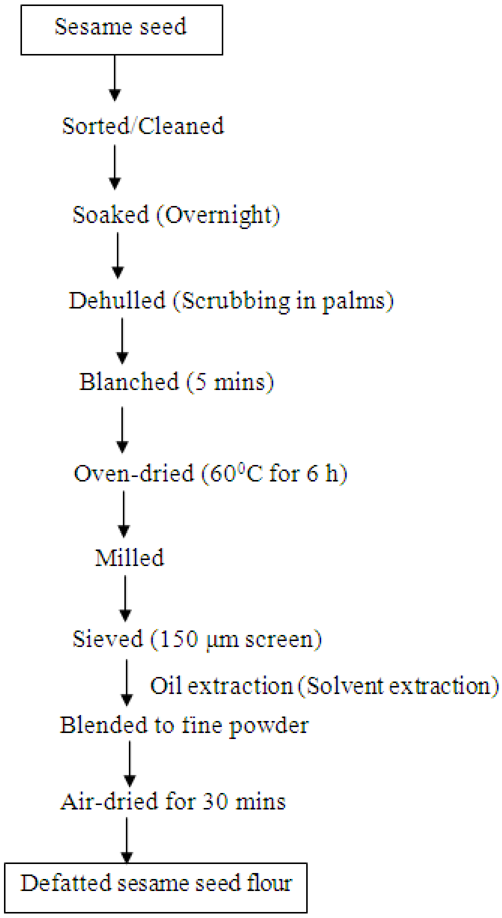

Fig. 1. Flow chart for the production of defatted sesame seed flour
Source: [9]

2.2 Production of Defatted Sesame Flour

Sesame seeds sorted to remove foreign materials were soaked overnight in cold tap water at ambient temperature. The hulls were removed by floatation technique after hand scrubbing between palms. The dehulled seeds were blanched in water for 5 minutes, washed in cold tap water and dried at 60ºC in hot air oven and then milled into flour using attrition mill to obtain the full-fat sesame flour. The full fat sesame flour was defatted using a solvent extraction apparatus, air dried in a hot air oven (Model QUB 305010G, Gallenkamp, UK) for 30 mins after which it was milled to powder using blender and stored in plastic container and covered with lid at 4ºC in a refrigerator from where the samples were drawn for analysis [9].

2.3 Production of Moringa Seed Flour

The moringa seeds were cleaned, dehusk and dried at 60 ± 2 ºC for 6 hrs in a hot air oven. Dried moringa seeds were milled and sieved using a 150µm sieve to obtain fine powder [16].

2.4 Production of Enriched "kokoro"

Kokoro was produced using the method described by Fasasi and Aluko [2]. Maize grains were manually cleaned, cooked (boiled) till soft, cooled overnight and wet milled to obtain a paste. Dough was gently mixed in a stainless steel pot to obtain blends of maize, sesame and moringa flour. The three best blends were selected from the 16 runs from Response Surface Methodology were used as treatments while 100% maize was used as control. Twenty grams (20 g) of peeled onions, cut and wet milled and 6 g of salt were added to 400 g of each blends. The mixture was continuously mixed until a stiff dough was formed. The mixed dough was kneaded, rolled for 5 min on a chopping board. The kneaded dough was extruded into uniform sizes using cold extruder. The samples in form of ring shape were deep fried in hot vegetable oil at 150 ± 2ºC for 10 min. It was kept overnight to cool and fried again the next day at 150 ± 2℃ for 3 min till a crispy texture with white color was obtained [2]. It was cooled and packed into a sealed polyethylene bags and refrigerated at 4ºC for further analysis.

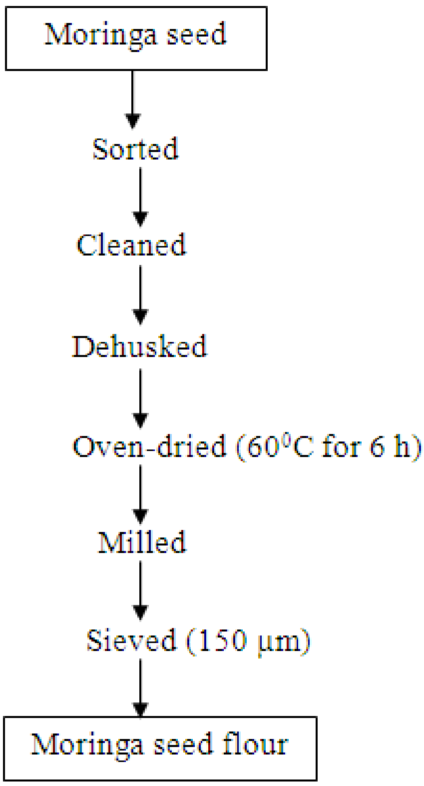

Fig. 2. Flowchart of the production of Moringa seed flour
Source: [16]

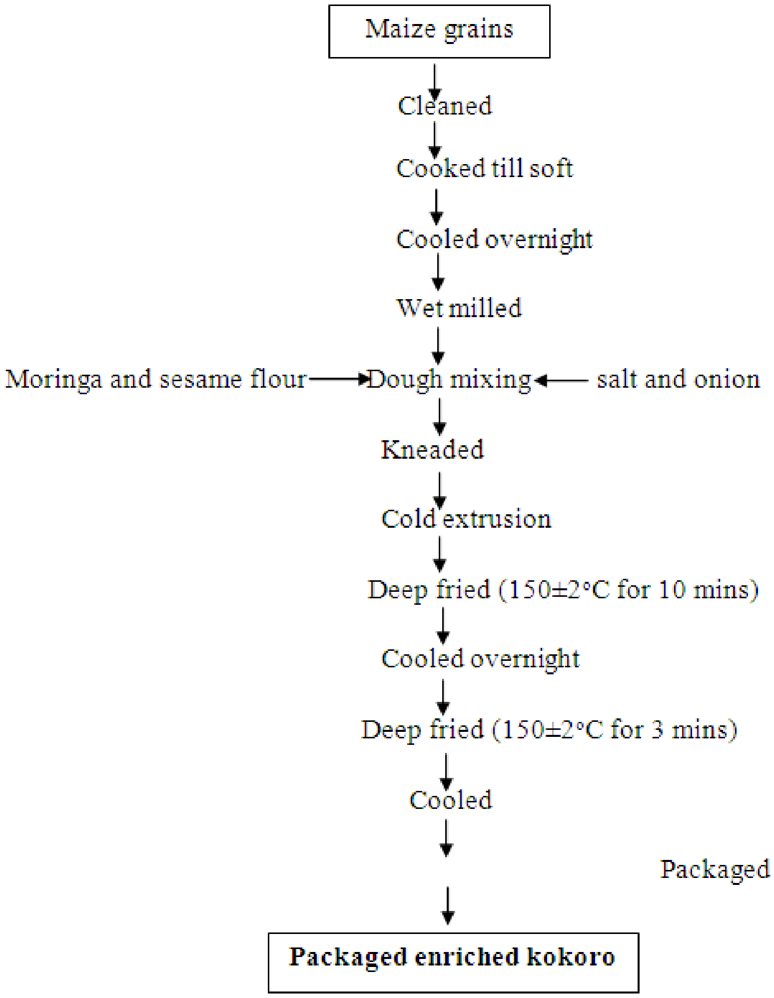

Fig. 3. Flowchart of the production of Enriched "kokoro" production
Source: [2]

Table 1. Selected optimal flour blends (%)

Samples	Maize flour	DSF	MSF
A	100	0	0
B	75.25	17.50	6.25
C	65.00	25.00	10.00
D	52.50	40.00	7.50

DSF= Defatted sesame seed flour
MSF= Moringa seed flour

2.5 Experimental Design and Development of Flour Combination

The experimental design was carried out using optimal mixture model of response surface methodology (Design Expert 8.0.3 software). There were three (3) variables namely maize, defatted sesame and moringa seed flour. The design yielded 16 possible formulations in which three blends (best blend) in terms of proximate composition were selected (Table 1).

2.6 Sensory Evaluation of the Enriched "kokoro"

Twenty semi-trained panelists were selected from staff and students of Federal University of Technology Akure Nigeria. The panelists were screened with respect to their interest and ability to differentiate food sensory properties. The study was carried out in a well illuminated sensory evaluation room of the Department of Food Science and Technology in the mid-morning hours (10.00 am). The exercise was monitored to avoid interference of other panelists. Each panelist was provided with a glass of clean water to rinse their mouths between the four evaluation sessions of 3 min interval. The four samples were presented in two digit coded plates and evaluated for taste, crispness, colour, aroma, sourness and overall acceptability using a nine point hedonic scale in which 1 represents the least score (dislike extremely) and 9 the most desirable score (like extremely) for all attributes [19].

2.7 Proximate Analysis

Moisture, ash, fat, crude protein and crude fiber contents of the 'kokoro' samples were carried out according to AOAC [20] methods of analysis while carbohydrate content was evaluated using the formula below;

Total carbohydrate (%) = 100 – (Fat % + Protein % + Moisture % + Ash % + Crude Fiber)

2.8 Estimation of Energy Value

The energy value (kcal/100g) was calculated using Atwater factor method described by Obiegbuna and Baba [21].

2.9 Mineral Analysis

The mineral concentration of the samples was determined using the official methods of AOAC [20]. Sodium and potassium were determined using flame photometer, calcium, magnesium, and iron were determined using atomic absorption spectrophotometer (Thermo scientific series Model GE Model No. 712354), while phosphorus was determined colorimetrically using Spectrophotometer (Model CE 2021 2000 Series, serial 923-41).

2.10 Determination of Amino Acid Composition

The amino acid composition of the samples was determined using the method described by Benitez [22]. The sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Technicon Sequential Multi-sample Amino Acid Analyzer (Hitachi, Model L-8900).

2.11 Calculated Nutritional Quality Determinations

Nutritional qualities were determined on the basis of the amino acid profiles. The Essential Amino Acid Index (EAAI) was calculated using the method of Labuda et al. [23] using the equation below:

$$EAAI = \sqrt[9]{\frac{[Lys + Threo + Val + Meth + Isoleu + leu + Phynylal + Histi + Trypt]_a}{[Lys + Threo + Val + Meth + Isoleu + leu + Phynylal + Histi + Trypt]_b}}$$

Where: [lysine, tryptophan, isoleucine, valine, threonine, leucine, phenylalanine, histidine and methionine] $_a$ in test sample and [lysine, tryptophan, isoleucine, valine, threonine, leucine, phenylalanine, histidine and the sum of methionine and cystine] $_b$ content of the same amino acids in standard protein (%) (egg or casein), respectively.

The nutritional index of the food samples was calculated using the formula below:

$$NI\ (\%) = \frac{EAAI\ X\ \%\ protein}{100}$$

The Protein Efficiency Ratio [PER] was estimated according to the regression equations as described by Mune-Mune et al. [24] as given below:

PER = -0.468 + 0.454(LEU) – 0.105(TYR)

The biological value was calculated as described by Mune-Mune et al. [24] using the following equation:

BV = 1.09 x Essential amino acid index [EAAI]

2.12 Statistical Analysis

Data obtained was subjected to statistical analysis. Means, Analysis of variance was determined using SPSS version 17.0 and the differences between the mean values was evaluated at p< 0.05 using Duncan's multiple range test .

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Kokoro Enriched with Sesame and Moringa Seed Flour

Table 2 shows the proximate composition of the three optimized samples and the control. The protein, fat, ash and energy content of enriched "kokoro" samples increased with increasing level of DSF and MSF substitution. On the other hand, moisture and crude fiber content decreased. These trends indicate nutrients enhancement of the food product with DSF and MSF in varying proportion which could be as a result of high nutrient content (protein and fat) in both sesame and moringa seeds [25]. Low moisture content is desirable in snacks as high moisture content could result in low crispiness of the snack and accelerate other biochemical changes such as oxidative rancidity [26]. The control sample (sample A) had the highest moisture content (4.58%) while sample D had the lowest moisture content (3.64%). The low moisture content of the enriched kokoro gave the product a longer shelf life. High-moisture products (>12%) have shorter shelf stability compared with lower-moisture products (≤12%) [27]. The moisture content of the enriched "kokoro" was very low to the range of (5.06-7.29%) reported by Ayinde et al. [28] for "kokoro" made from maize-benniseed flour blends. Therefore, the low moisture content of enriched "kokoro" makes it less liable to microbial attack and would have longer shelf stability.

Ash content is an indicator of mineral content; hence sample with higher ash content are expected to have a relatively higher mineral content. The total ash content obtained in this study ranged from 2.25 to 4.25% and was found to be higher than the values of 2.20 to 2.60% reported by Ayinde et al. [28] on "kokoro" made from maize-benniseed blends. These differrences could be attributed to the inclusion of MSF and sesame in the sample and also the differrent location where the sample was cultivated since it has been reported that gene and enviroment interactions affects nutritional composition of plant materials [29]. The incorporation of defatted sesame and MSF enhance the amount of minerals in food products [30].

The fat content of the sample ranged between 15.07 to 35.25% with the control sample having the lowest value while sample D had the highest. There was a significant (p<0.05) increase in the fat content of the samples as the proportion of DSF and MSF increased. The fat content results followed the same trend for fat content obtained by Fasasi and Aluko [2] in "kokoro" enriched with soy flour. The increase in the fat content might be attributed to the fact that MSF is rich in oil and also the defatted sesame flour was not 100% defatted. Fat plays a role in determining the shelf life of foods. They are also sources of essential fatty acids for the body's fat synthesis, and serve as vehicles for the absorption of fat–soluble vitamins and other precursors. The crude fat content of the enriched kokoro samples contributed to making these samples in meeting the daily lipid requirement of consumers. However, a high amount of fat can accelerate spoilage by promoting rancidity leading to the production of off flavours and odours [31].

The value of protein ranged from 9.25-24.23% with the control sample having the lowest value, while and sample D had the highest value. There was a significant (p<0.05) increase in the protein content of the samples as the proportion of DSF and MSF increased. Values obtained for the protein content were fairly comparable to the recommended protein level of 18-20% for foods [32]. This is however obviously due to increase in the proportion of the DSF and MSF added. Therefore, the protein content of the enriched kokoro would be useful as food supplements in combating protein-energy malnutrition in children in developed countries. The values obtained were higher than that obtained by Ayinde *et al.* [28]. This may due to the defatting of the sesame flour to about 5% as defatting has been shown to improve protein content of flours [33] and also the addition of MSF which is also rich in protein.

The crude fiber content of the samples ranged from 5.80-7.58%; sample D had the lowest value while the control sample had the highest value. There was a decrease in the crude fiber content of the samples as the proportion of DSF and MSF increased. Sample B, C and the control sample did not show any significant differences (p>0.05). Crude fiber is the amount of indigestible sugars present in a food sample which has the physiological role of adding bulk to stool, and thus contribute to the maintenance of internal distensions for a normal peristaltic movement [34]. National Soyabean Research Laboratory [35] reported that a diet low in fiber is undesirable as it could cause constipation and associated diseases like piles, appendicitis, colon cancer and several other digestive disorders. Crude fiber content from this study is higher when compared with the values (2.56-1.74%) obtained by Otunola et al. [36] for kokoro enriched with defatted groundnut paste. The high fiber content of the kokoro samples suggests that these products will aid digestion thereby preventing constipation.

The results also showed that there was a significant decrease ($p<0.05$) in the carbohydrate content of the samples as the proportion of DSF and MSF increased with values (26.23-61.91%). This might be due to higher protein content of the DSF and MSF. Maize is predominantly starch (60-75%) which accounted for the high carbohydrate content in the control sample [6].

The calorific values showed that there was a significant difference ($p<0.05$) between the samples with sample D (52.5:40:7.5) having the highest value (607.71 kcal/100 g) while the control sample had the least values (508.43 kcal/100 g). There was a progressive increase in the energy content of the enriched "kokoro" as the substitution of DSF and MSF increased. This could be probably due to increase in fat and protein content of the samples. The increase in the energy content of the enriched "kokoro" implies that it would be a source of high energy and nutrients dense food for consumers [37]. Energy is very important in the human body as it is required for every physical activity. Deficiency in calorie is as much a cause of malnutrition as protein deficiency [38], hence the need for energy.

3.2 Mineral Composition of Kokoro Enriched with Sesame and Moringa Seed Flour

Table 3 shows the mineral composition (mg/100g) of the three optimized samples and the control. The mineral content of the enriched "kokoro" was found to vary significantly ($p\leq0.05$) with increasing DSF and MSF in the flour blends. The mineral composition of the sample showed that phosphorus was the predominant mineral, followed by calcium, potassium and sodium. Other elements were found in comparatively low concentrations. There was a decrease in the phosphorus content of enriched "kokoro". However, the result obtained in this study was lower than the findings of Fasasi and Aluko [2] on ginger spiced maize snack "kokoro" enriched with soy flour. On the other hand, there was a significant ($p<0.05$) increase in the sodium, calcium, potassium, magnesium and iron contents of the samples as the proportion of DSF and MSF increased. This is similar to the findings of Idowu [17] who reported significant increases in the calcium, magnesium, iron and sodium contents of kokoro as the proportion of African yam bean flour increased.

The Na/K ratio in the body is important because it helps in controlling high blood pressure. Na/K ratio values compares favorably with the recommended value of less than one [39]. Nieman et al. [39] considered a food source good if the Ca/P ratio is above 1 and poor if the ratio is less than 0.5. The enriched maize snack "kokoro" happen to be a good food source for minerals used in bone formation as the Ca/p ratio ranged from 0.66 - 1.4. The results from mineral analysis therefore showed that the enriched "kokoro" would contribute substantially to the recommended dietary requirements for minerals to its consumers.

3.3 Amino acid Profile of Enriched "Kokoro" Samples

The amino acid profile (essential and non-essential amino acids) of the enriched "kokoro" and control sample is shown in Table 4. The result showed that sample D had the highest total amino acids. This could be as a result of DSF and MSF protein influence on the composite as sample D had the highest DSF and MSF composition. Glutamic acid was the most abundant non–essential amino acids in the enriched "kokoro" while leucine was the predominant essential amino acid in the enriched "kokoro". There was an increase in the amino acid content (except for aspartic acid, arginine and histidine) of the kokoro samples as the proportions of DSF and MSF increased. Kokoro which is a maize based snack is deficient in some essential amino acids particularly lysine [7]. However, enrichment of kokoro with DSF and MSF was found to increase the lysine content from 2.65 g/100g to 4.22 g/100g. Lysine is important in protein synthesis, thus it is essential for growth and maintenance of the body. Therefore complimenting kokoro snack with DSF and MSF improves the balance of amino acid in the product. Amino acids are important components for healing and protein synthesis;

any deficiency in these essential amino acids will hinder recovery process [40].

3.4 Predicted nutritional quality of "Kokoro" Samples

The predicted nutritional quality of the formulated snacks is presented in Table 5. The predicted protein efficiency ratio (PER) of the samples was observed to increase from 1.63 g/100g in the control sample to 3.49 g/100g in sample D. This shows that the enrichment with DSF and MSF increased the nutritional quality of the samples. The essential amino acid index (EAAI) and predicted biological value of the snack was also found to increase from 61.08% and 54.88% in the control snack to 89.44% and 85.79%, respectively. This is due to the supplementation with DSF and MSF. The total essential amino acid (TEAA) with histidine and arginine of formulated snacks were within the values recommended per day by the FAO/WHO for infants (39%), children (26%) and adults (11%) [32]. Nutritionally, a protein-based food material is said to be of good nutritional quality when its protein efficiency ratio is 2.7 and above, biological values is >70%, essential amino acid index (EAAI) is >0.70 [24]. As seen from this study, the protein efficiency of sample C and D (3.26 g/100g and 3.49 g/100g, respectively) were in line with the recommended value. Essential amino acid index and biological values of the enriched kokoro were also within the recommended values.

3.5 Antioxidant Properties of "kokoro" Samples

The antioxidant factors of the enriched "kokoro" and control samples are shown in Table 6.The total flavonoids, total phenol and DPPH (1, 1-Diphenyl-2-picrylhydrazyl) were used to evaluate the antioxidant capacity of the enriched "kokoro" produced from maize-defatted-seame- moringa blends. The result showed that there was a significant ($p<0.05$) increase in the flavonoid, phenolic content and DPPH of the kokoro as supplementation with DSF and MSF. Recent finding has shown that phenolic compounds are powerful antioxidants that can protect the human body from free radicals, the formation of which is associated with the normal metabolism of aerobic cells [41]. The extract of the enriched ""kokoro" showed a significant effect in inhibiting DPPH. Increase of 34.86-78.52 had been observed in DPPH scavenging activities of the enriched "kokoro" when compared to the control.

The antioxidant activity of plant extracts containing polyphenol components is due to their capacity to be donors of hydrogen atoms or electrons and to capture the free radicals. DPPH analysis is one of the tests used to prove the ability of the components of the enriched ""kokoro" extract to act as donors of hydrogen atoms and to capture free radicals. DPPH is often used as a substrate to evaluate the anti-oxidative activity of antioxidants [42]. The increase in the total flavonoids, total phenol and DPPH could be as a result of the high antioxidant property of sesame oil and moringa oil which where the constituent of the enriched "kokoro". High phenolic content of the enriched kokoro samples therefore implies high antioxidant activity. The high DPPH activity exhibited by the enriched "kokoro" samples also suggests that the product may not only provide the basic food nutrients but may also serve as functional food that can promote health. This is because high antioxidant activity helps to reduce oxidative stress that has been implicated in the etiology of a number of chronic diseases.

3.6 Sensory Qualities of "Kokoro" Samples

Table 7 shows the sensory scores of enriched "kokoro" and control sample. The result showed a decrease in the mean scores for colour, taste, crispiness, sourness and overall acceptability. Differences in the mean sensory scores may be due to the proportion of the DSF and MSF added to the product. Similar findings were also reported by Ayinde *et al*. [28] for kokoro produced from maize-benniseed blends. The decrease in the taste and colour of the kokoro samples could also be attributed to the influence of moringa seed which might have impacted some bitter taste to the product. A similar result was reported for noodles supplemented with moringa, where colour and taste of the noodles decreased with higher proportions of moringa flour [43]. The generally lower scores for the enriched "kokoro" in comparison to the control sample was expected due to the fact that the panelists were used to kokoro made from 100% maize, as DSF and MSF have not been traditionally used in production of the common "kokoro". Despite the decrease in the mean scores of the samples, the result showed that the control sample was not significantly ($p<0.05$) different from sample B indicating a high level of acceptance of the sample B.

Table 2. Proximate composition of "kokoro" enriched with sesame and moringa seed flours

Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude fibre (%)	CHO (%)	Energy (KJ/g)
A	4.58±0.19[a]	2.25±0.56[a]	15.07±0.00[d]	9.25±0.06[d]	7.58±0.09[a]	61.27±0.72[a]	508.43±3.04[d]
B	3.84±0.42[a]	3.26±0.55[a]	28.15±0.19[c]	15.10±0.28[c]	6.29±0.09[a]	43.36±1.08[b]	571.823.92[c]
C	3.77±0.39[a]	3.95±0.55[a]	31.47±0.28[b]	18.48±0.36[b]	6.09±0.19[a]	36.24±0.72[c]	588.95±4.02[b]
D	3.64±0.12[a]	4.25±0.57[a]	35.25±0.23[a]	24.23±0.18[a]	5.80±0.20[b]	26.83±0.19[d]	607.71±2.32[a]

Values represent means of triplicates. abc= Mean ± Standard deviation with the same superscript in the same column show no significant difference (p≤0.05)
KEYS: A = Maize (100%)
B = Maize (75.25%): DSF (17.5%): MSF (6.25%)
C = Maize (65%): DSF (25%): MSF (10%)
D = Maize (52.5%): DSF (40%): MSF (7.5%)

Table 3. Mineral composition (mg/100g) of "kokoro" enriched with sesame and moringa seed flours

Samples	Na	Ca	K	Mg	Fe	P	Na/K	Ca/p
A	0.98±0.03[d]	3.31±0.34[d]	1.67±0.76[a]	0.25±0.05[d]	0.07±0.09[c]	5.03±0.10[a]	0.59	0.66
B	2.17±0.09[a]	5.93±0.34[a]	3.26±0.05[b]	0.36±0.03[c]	0.16±0.09[a]	4.23±0.10[c]	0.67	1.40
C	1.86±0.04[a]	5.03±0.57[c]	3.75±0.05[a]	0.31±0.05[b]	0.15±0.19[b]	4.55±0.20[b]	0.49	1.11
D	1.91±0.10[a]	5.41±0.23[b]	2.55±0.50[c]	0.32±0.01[a]	0.15±0.20[b]	4.02±0.30[d]	0.75	1.35

Values represent means of triplicates. abc= Mean ± Standard deviation with the same superscript in the same column show no significant difference (p≤0.05)
KEYS: A = Maize (100%)
B = Maize (75.25%): DSF (17.5%): MSF (6.25%)
C = Maize (65%): DSF (25%): MSF (10%)
D = Maize (52.5%): DSF (40%): MSF (7.5%)

Table 4. Amino acid profile of "kokoro" samples

Amino acids	A	B	C	D
Cysteine	1.12	2.00	2.22	2.26
Methionine	1.20	2.00	2.02	2.12
Tyrosine	2.07	1.47	1.50	1.45
Isoleucine	2.54	2.94	3.15	3.26
Leucine	3.20	7.20	8.35	9.15
Lysine	2.65	4.22	3.80	3.95
Threonine	2.10	2.35	2.40	2.20
Valine	3.20	3.55	3.60	3.75
Tryptophan	0.70	0.79	0.83	0.81
Phenylalanine	1.21	3.66	3.50	3.25
(TEAA)	21.99	30.48	31.67	32.22
Aspartic acid	6.11	4.20	4.00	4.35
Glutamic acid	7.50	21.77	22.63	23.44
Proline	1.12	8.12	8.20	8.26
Serine	1.75	3.58	3.74	3.60
Glycine	2.25	3.30	3.14	3.20
Alanine	1.65	2.80	2.75	2.70
Arginine	3.84	3.30	3.15	3.20
Histidine	1.80	1.55	1.58	1.60
(TNEAA)	26.02	48.62	49.19	50.32

KEYS: (TEAA) = Total essential amino acid
(TNEAA)= Total non-essential amino acid

Table 5. Calculated nutritional quality of the "kokoro" samples

Calculated Nutritional Quality				
Parameters	**A**	**B**	**C**	**D**
TEAA+ HIS+Arg/TAA %	27.08	33.03	33.79	34.48
TEAA/TAA ~~%~~	46.13	36.37	36.56	36.53
TNEAA/TAA %	53.87	63.63	63.44	63.47
TSAA (Meth + Cys)	2.32	4.00	4.22	4.38
ArEAA (Phe + Tyr)	5.57	4.72	5.00	5.11
TEAA/TNEAA	0.86	0.57	0.58	0.58
PER(g/100g)	1.63	2.35	3.26	3.49
EAAI	0.6108	0.8467	0.8797	0.8944
EAAI%	61.08	84.67	87.97	89.44
BV (%)	54.88	80.58	84.19	85.79
Nutritional index (%)	5.65	12.78	16.25	21.67

Keys: A = Maize (100%)
B = Maize (75.25%): DSF (17.5%): MSF (6.25%)
C = Maize (65%): DSF (25%): MSF (10%)
D = Maize (52.5%): DSF (40%): MSF (7.5%)

Table 6. Antioxidant Factors of *"kokoro"* samples

Samples	**Flavonoid(mg/g)**	**Phenol (mg/g)**	**DPPH (%)**
A	0.11 ± 0.00^{d}	1.69 ± 0.00^{d}	27.89 ± 0.11^{d}
B	0.15 ± 0.00^{c}	2.54 ± 0.00^{c}	34.86 ± 0.14^{c}
C	0.19 ± 0.00^{b}	3.39 ± 0.02^{b}	43.41 ± 0.62^{b}
D	0.29 ± 0.01^{a}	3.75 ± 0.01^{a}	78.52 ± 0.06^{a}

Values represent means of triplicates. abc= Mean ± Standard deviation with the same superscript in the same column show no significant difference (p≤0.05)
KEYS: A = Maize (100%)
B = Maize (75.25%): DSF (17.5%): MSF (6.25%)
C = Maize (65%): DSF (25%): MSF (10%)
D = Maize (52.5%): DSF (40%): MSF (7.5%)

Table 7. Mean sensory scores of "kokoro" samples

Samples	Colour	Taste	Crispiness	Flavour	Sourness	Overall Acceptability
A	7.70[a]	7.50[a]	7.90[a]	5.30[a]	5.20[a]	7.30[a]
B	7.60[a]	7.50[a]	7.60[a]	5.60[a]	4.30[b]	7.30[a]
C	5.60[b]	6.00[b]	5.00[b]	6.60[b]	3.10[c]	5.30[b]
D	4.50[c]	5.30[b]	4.10[b]	6.60[c]	2.70[c]	4.20[c]

Mean with the same superscript in the same column show no significant difference (p≤0.05)
KEYS: A = Maize (100%)
B = Maize (75.25%): DSF (17.5%): MSF (6.25%)
C = Maize (65%): DSF (25%): MSF (10%)
D = Maize (52.5%): DSF (40%): MSF (7.5%)

4. CONCLUSION

The supplementation of DSF and MSF to maize flour in the production of kokoro enhanced the protein, ash, fat and energy contents of the product. In addition, mineral elements such as sodium, calcium, potassium and magnesium were improved by the enrichment with DSF and MSF. Kokoro enriched with DSF and MSF were found have better nutritional quality and antioxidant properties than those without DSF and MSF supplementation. On the other hand, DSF and MSF supplementation had a negative effect on the acceptability of the snacks, however sensory scores of the control sample was not significantly different from the sample supplemented with 6.25% MSF and 17.5% DSF. This therefore shows that kokoro with a higher nutritional quality can be made with composite blends of maize flour, DSF and MSF. The maximum level of replacement which is acceptable is 6.25% MSF and 17.5% DSF.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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