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Physicochemical Properties and Nutritional Qualities of Kokoro Produced from Composite Flour of Maize, Kidney Bean and Alligator Pepper

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ABSTRACT
The physicochemical properties and nutritional qualities of kokoro produced from composite flour of maize, kidney bean and alligator pepper were investigated. Three varieties of maize grains (ART-98-SW06-W, Br 9943-DMR-SR-W and SUWAN-1-SR-Y) were obtained from the Institute of Agricultural Research and Training (IAR&T), Ibadan, Nigeria; while both the kidney beans and alligator pepper were obtained from a local market (Oja Oba market, Akure, Nigeria). The maize grains, kidney beans and alligator pepper were respectively processed into flour and appropriate flour blends were obtained from them using the response surface methodology(RSM). Kokoro was thereafter prepared from each of the blends. Results obtained shows that protein content increased as substitution of kidney bean flour and alligator pepper increased ranging from 9.46% to 20.87%, this may be an indication of the potentials of the kidney bean and alligator pepper in improving the nutritional status of the snack, while similar trends were observed with respect to ash and fat content but carbohydrate showed a reverse trend. The functional properties: water and oil absorption capacities decreases in value as substitution of kidney bean increases, Slight increases were recorded in the case of the vitamin B1,B2 and B3with kidney bean and alligator pepper from 0.51 to 0.87mg/100g,0.16 to 0.73mg/100g and 0.11 to 0.73mg/100g in Vitamin B1,B2 and B3 respectively. Vitamin A is high all samples of SUWAN, minerals contents of the kokoro increased as substitution of kidney bean and alligator pepper increased ranging from 66.12 to 146.79mg/100g,4.01 to 66.01mg/100g, 9.61 to 28.81mg/100g ,0.78 to 4.07mg/100g and 0.49 to 1.24mg/100g in Potassium, Calcium, Magnesium, Iron and Zinc respectively. While the antinutrients level (oxalate, tannin, trypsin inhibitor and phytate) were found to be within the acceptable levels. Kidney beans and alligator pepper could be used to improve the nutrient composition of Kokoro.

Keywords: Kidney bean, Maize alligator pepper, snacks, nutritional composition, kokoro

I. INTRODUCTION

Maize is a popular cereal in the tropical countries which can be prepared and consumed in diverse ways and these vary from region to region or from one ethnic group to other. It is used for the production of different convenience snacks which are eaten to prevent hunger before the main meals or just for the fun of eating them (Fasasi and Alokun, 2012). One of such snacks derivable from maize is kokoro. It is a popular traditional snack made from maize flour which is commonly consumed by all ages especially in Southwestern Nigeria comprising Ogun, Oyo, Ondo, Ekiti, Osun and Lagos states. The technology of kokoro production is largely traditional, involving mixing maize flour with boiled water to form a paste, seasoning with salt and sugar, moulding into ring-like shapes and finally deep-fried in vegetable oil. The snack is usually consumed during the day alone with roasted groundnuts by the people and it is a predominantly carbohydrate food lacking in some essential nutrients such as protein and mineral contents (Otunola et al., 2012).

Maize snacks do not provide adequate nutritional qualities needed by the body because they are deficient in some essential amino acids especially lysine (Adelakun et al., (2005). Some

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deficiencies may be due to their composition or in many instances due to losses during processing. Amino acids lacking can be supplied to the food by complimenting the maize with legumes such as peanuts, pulses which are better sources of the sulphur amino acids (Okaka, 2005). Several studies have been conducted to improve the protein quality of maize products by fortification with plant proteins such as soybean, which is less expensive, Wasiu et al., (2011) investigated the nutritional and sensory properties of a maize based snack food (kokoro) supplemented with treated distillers spent grain. Adelakun et al.,(2005) also suggested the effect of soybean substitution on some physical, compositional and sensory properties of kokoro. (Ayinde et al., 2012) investigated the functional properties and quality evaluation of "kokoro" blended with beniseed cake (Sesame indicum) which increased the protein content of the snack.

In order to enhance the nutritional value of the snack, addition of vegetable protein could be a way of doing so by introducing new protein into it (Rosa et al., 2003). Legume proteins are mainly used in food formulations to complement the protein in cereal grains because of their chemical and nutritional characteristics (Sathe, 2002). Consumer acceptance of snacks is mainly due to the convenience, value, attractive appearance and texture found to be peculiar to these foods, especially when it concerns traditional food products (Anton and Luciano, 2007). While maize starch or flour provides all the features for the production of highly acceptable snack foods, its nutritional value is far from satisfying the needs of health-conscious consumers (Rampersad et al., 2003). Among other materials, incorporation of leguminous flour has been shown to cause a positive impact on levels of proteins and dietary fibre of maize starch-based snacks (Berrios, 2006). On the other hand, addition of high-fibre, high-protein alternate ingredients to starch has been demonstrated to significantly affect the texture, expansion and overall acceptability of local snacks (Obatolu et al., 2006).

One of the leguminous materials that can be used to enhance the nutritional quality of kokoro is Kidney beans (Phaseolus vulgaris L.). It is the most widely produced and consumed food legume in Africa, India and Latin America (FAO, 1999). It usually contains 20-30% protein on a dry basis (Sathe, 2002). The storage protein of these beans has attracted much attention, due to their superior functionalities (Shimelis and Rakshit, 2007). The inclusion of kidney beans in the daily diets has many beneficial physiological effects in controlling and preventing various metabolic diseases such as diabetes mellitus, coronary heart disease and colon cancer (Tharanathan and Mahadevamma, 2003). Furthermore, kidney beans are regarded as important sources of protein and minerals for processing into human food (Shimelis and Rakshit, 2007). When the flour of leguminous materials was used in food formulation, a wide variation in chemical, thermal, pasting and textural properties had been observed especially the good expansion quality (Singh et al., 2004). Therefore, it has been suggested that the use of legume will be highly feasible in the development of high-nutritional, low-calorie snacks (Berrios, 2006). Alligator pepper is a spice used as worm expellants, it is a spice used sparingly because of its strong flavour, popular ingredient in the famous pepper soup which is a great delight in Africa, useful in the treatment of measles and controlling excessive bleeding after child birth (Inegbenebor, 2009). The presence of alkaloids, tannins, saponin and phenols in alligator pepper supports the use of this plant as antimicrobial agent (Doherty et al., 2010).

Snacks provide an avenue for introducing plant proteins such as kidney beans to people who normally resist trying unfamiliar food. Supplementing maize with kidney bean and alligator pepper eliminates the problem of nutritive quality of the snack. Since kokoro is widely acceptable snack among all ages in Nigeria, it can serve as means of combating protein energy malnutrition among children because it is affordable among all the economic classes.

The possibility of producing acceptable kokoro, with better nutritional content, and sensory quality from maize flour mixed with kidney bean flour and alligator pepper flour was therefore investigated. This was hoped will increase the nutritional content of the snack as well as improve the sensory quality of the snack, which can serve as a vehicle for combating protein-energy malnutrition among the consumers particularly children.

II. MATERIALS AND METHODS

Materials

Three varieties of maize were used for this study. They are: 'ART-98-SW06-W'(Agricultural Research Training , South West, White), 'Br-W9943-DMR-SR-W'(Boral Resistance Downey Mildew Research Streak Resistance–White) and 'SUWAN-1-SR-Y'(Suwan-1-Streak Resistance, Yellow). They were obtained from the Institute of Agricultural Research & Training (IAR&T), Moor Plantation, Ibadan, Oyo state, Nigeria. Both the kidney bean (Phaseolus vulgaris) and alligator

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pepper (Aframomumdanielli) were obtained from a local market in Akure, Ondo State, Nigeria.

Methods

Preparation of maize flour: Maize grains were picked, sorted and cleaned manually; the grains were then rinsed in clean portable water, drained and then dried using a hot oven at 60°C for 7 hours. It was then cooled and milled using the hammer mill. The flour was sieved using 250um sieve. The flour was kept in a tight container for further analysis.

Preparation of kidney bean flour: The kidney bean flour which was free of dirt and stones was cleaned and soaked in 2 litres of water at room temperature of 30±2°C for 6 hours. The soaked seeds were drained rinsed and dehulled manually by rubbing between palms. The dehulled beans were drained, spread on the trays and dried in hot air oven at 60°C for 7 hours. The seeds were stirred occasionally during drying to obtain uniform drying .the dried seeds were milled using the local hammer mill. A 500 micron mesh was used to sieve the flour. The kidney bean flour was packed in an airtight container for subsequent use and analysis.

Preparation of alligator pepper flour: Alligator pepper was dehulled and cleaned, it was then dried at temperature of 60°C for 2 hours, it was milled and sieved with a 250µm sieve. The flour was then kept in an airtight container for subsequent use and analysis.

Optimisation of the maize flour, kidney bean flour and alligator pepper flour blends. Respond Surface Methodology (trial version 18.0) was used to obtain 16 blends of the three flour (maize flour, kidney bean flour and alligator pepper flour) at different ratios. The protein content and mineral content of the blend were determined. Three blends were selected based on the protein and mineral content obtained.

Preparation of kokoro: Kokoro was produced using three flour blends with the highest protein and mineral content. Maize flour was obtained from three varieties of maize(ART-98-SW06-W,Br 9943-DMR-SR-W and SUWAN-1-SR-Y), kidney beans and alligator pepper (Table 1). The process flow chart of kokoro is shown in figure 1.

Blends (Maize flour, Kidney bean flour and Alligator pepper)
↓
Mixing (stir in hot water 100°C)
↓
Kneading
↓
Cutting
↓
Shaping
↓
Frying
↓
Kokoro snacks

Figure 1: Flow Chart for the Production of Kokoro

Source: (Otunola et al., 2012)

Chemical analysis

The proximate composition of the samples was carried out using AOAC methods (AOAC, 2000). The carbohydrate content was determined by difference. The functional properties (emulsion capacity, water and oil absorption capacities) of the flour samples were determined using the method of Okezie and Bello (1988). Some mineral contents (iron, magnesium and calcium) of the samples were determined using Atomic Absorption Spectrophotometer (Bulk Scientific VGP 210) according to AOAC methods (AOAC, 2005). The sodium and potassium were determined using flame photometry. Vitamins A, B_1, B_2, and B_3 were determined using AOAC method (AOAC, 2000).

The antinutrients (oxalate, phytate, tannin and trypsin inhibitor) in the samples were also determined. Both oxalate and trypsin inhibitor were evaluated using AOAC (2005) while phytate and tannin were determined using the method of Latta and Eskin (1980).

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III. RESULTS AND DISCUSSION

Optimisation of the maize flour, kidney bean flour and alligator pepper flour blends.

The result of the optimization obtain were as presented in Table 1.

Table 1: Selected optimal flour blends (in ratio) from three varieties of maize, Kidney beans and Alligator pepper

Sample codes	Formulation name	Maize	Kidney beans	Alligator pepper
ART1	100%	100	0	0
ART2	ART (75.9:23.6:0.5)	75.9	23.6	0.5
ART3	ART (82.7:15.7:1.6)	82.7	15.7	1.6
ART4	ART (72.0:26.0:2.0)	72.0	26.0	2.0
BR1	BR 100%	100	0	0
BR2	BR (75.9:23.6:0.5)	75.9	23.6	0.5
BR3	BR (82.7:15.7:1.6)	82.7	15.7	1.6
BR4	BR (72.0:26.0:2.0)	72.0	26.0	2.0
SUWAN1	SUWAN 100%	100	0	0
SUWAN2	SUWAN (75.9:23.6:0.5)	75.9	23.6	0.5
SUWAN3	SUWAN (82.7:15.7:1.6)	82.7	15.7	1.6
SUWAN4	SUWAN (72.0:26.0:2.0)	72.0	26.0	2.0

Key:
ART-1= Sample prepared from 100% 'ART-98-SW06-W' maize;
ART-2= Sample prepared from 75.9% 'ART-98-SW06-W' maize, 23.6% kidney bean and 0.5% alligator pepper;
ART-3= Sample prepared from 82.7% 'ART-98-SW06-W' maize, 15.7% kidney bean and 1.6% alligator pepper;
ART-4= Sample prepared from 72% 'ART-98-SW06-W' maize, 26% kidney bean and 2% alligator pepper;
BR-1= Sample prepared from 100% 'Br-W9943-DMR-SR-W' maize;
BR-2= Sample prepared from 75.9% 'Br-W9943-DMR-SR-W' maize, 23.6% kidney bean and 0.5% alligator pepper;
BR-3= Sample prepared from 82.7% 'Br-W9943-DMR-SR-W' maize, 15.7% kidney bean and 1.6% alligator pepper;
BR-4= Sample prepared from 72% 'Br-W9943-DMR-SR-W' maize, 26% kidney bean and 2% alligator pepper;
SUWAN-1= Sample prepared from 100% 'SUWAN-1-SR-Y' maize;
SUWAN-2= Sample prepared from 75.9% 'SUWAN-1-SR-Y' maize, 23.6% kidney bean and 0.5% alligator pepper;
SUWAN-3= Sample prepared from 82.7% 'SUWAN-1-SR-Y' maize, 15.7% kidney bean and 1.6% alligator pepper; and
SUWAN-4= Sample prepared from 72% 'SUWAN-1-SR-Y' maize, 26% kidney bean and 2% alligator pepper.

Proximate Composition and physicochemical **properties of composite flour meant for kokoro production**

The results for the proximate composition and physicochemical properties of maize-based blends for kokoro were shown in Table 2 and 3. There were significant differences ($p \leq 0.05$) among the samples. The high protein content of food legumes generally constitute the natural protein supplements to staple diet and kidney bean in Africa at least represent the legume of choice for such population (Nwosu, 2013). The crude protein content of the flour samples ranged from

Table 2: Proximate composition of composite flour for kokoro production (g/100g).

Samples	Protein	Moisture	Fat	Ash	Crude fiber	Carbohydrate
ART 1	9.46 ± 0.06^{k}	7.97 ± 0.02^{de}	4.34 ± 0.02^{b}	1.31 ± 0.03^{h}	2.91 ± 0.02^{a}	74.02 ± 0.09^{a}
ART2	17.69 ± 0.02^{e}	7.08 ± 0.06^{f}	5.22 ± 0.01^{a}	1.82 ± 0.01^{b}	1.17 ± 0.01^{e}	67.02 ± 0.09^{d}
ART3	17.36 ± 0.06^{f}	7.77 ± 0.58^{e}	4.34 ± 0.02^{b}	1.42 ± 0.02^{g}	1.05 ± 0.04^{fg}	68.06 ± 0.58^{c}
ART4	17.10 ± 0.11^{gh}	8.93 ± 0.09^{c}	3.45 ± 0.01^{e}	1.53 ± 0.02^{e}	1.02 ± 0.02^{g}	67.96 ± 0.19^{c}
BR1	11.33 ± 0.09^{j}	8.64 ± 0.37^{c}	4.39 ± 0.02^{b}	1.08 ± 0.02^{i}	1.31 ± 0.01^{d}	73.25 ± 0.33^{a}
BR2	19.85 ± 0.03^{b}	9.83 ± 0.03^{b}	4.32 ± 0.01^{b}	1.53 ± 0.02^{e}	1.06 ± 0.01^{fg}	63.39 ± 0.03^{g}
BR3	17.28 ± 0.02^{fg}	9.50 ± 0.01^{b}	4.07 ± 0.01^{c}	1.71 ± 0.01^{d}	1.39 ± 0.01^{c}	66.05 ± 0.03^{e}
BR4	19.04 ± 0.02^{c}	9.54 ± 0.01^{b}	4.42 ± 0.02^{b}	1.45 ± 0.03^{f}	1.09 ± 0.02^{f}	64.45 ± 0.03^{f}
SUWAN1	12.47 ± 0.34^{i}	10.38 ± 0.07^{a}	4.43 ± 0.38^{b}	1.76 ± 0.02^{c}	1.64 ± 0.07^{b}	69.30 ± 0.51^{b}
SUWAN2	18.76 ± 0.03^{d}	8.17 ± 0.01^{d}	3.09 ± 0.01^{f}	1.52 ± 0.02^{e}	0.95 ± 0.01^{h}	67.52 ± 0.02^{cd}
SUWAN3	17.07 ± 0.03^{h}	8.03 ± 0.01^{de}	3.80 ± 0.02^{d}	1.33 ± 0.02^{h}	0.93 ± 0.02^{h}	68.16 ± 1.18^{c}
SUWAN4	20.87 ± 0.04^{a}	8.12 ± 0.02^{de}	3.71 ± 0.09^{d}	1.86 ± 0.02^{a}	0.93 ± 0.02^{h}	65.83 ± 1.11^{e}

Values are means of triplicates samples. Values followed by different alphabets along the same column are significantly different at ($p \leq 0.05$)

Key:
ART-1= Sample prepared from 100% ‘ART-98-SW06-W’ maize;
ART-2= Sample prepared from 75.9% ‘ART-98-SW06-W’ maize, 23.6% kidney bean and 0.5% alligator pepper;
ART-3= Sample prepared from 82.7% ‘ART-98-SW06-W’ maize, 15.7% kidney bean and 1.6% alligator pepper;
ART-4= Sample prepared from 72% ‘ART-98-SW06-W’ maize, 26% kidney bean and 2% alligator pepper;
BR-1= Sample prepared from 100% ‘Br-W9943-DMR-SR-W’ maize;
BR-2= Sample prepared from 75.9% ‘Br-W9943-DMR-SR-W’ maize, 23.6% kidney bean and 0.5% alligator pepper;
BR-3= Sample prepared from 82.7% ‘Br-W9943-DMR-SR-W’ maize, 15.7% kidney bean and 1.6% alligator pepper;
BR-4= Sample prepared from 72% ‘Br-W9943-DMR-SR-W’ maize, 26% kidney bean and 2% alligator pepper;
SUWAN-1= Sample prepared from 100% ‘SUWAN-1-SR-Y’ maize;
SUWAN-2= Sample prepared from 75.9% ‘SUWAN-1-SR-Y’ maize, 23.6% kidney bean and 0.5% alligator pepper;
SUWAN-3= Sample prepared from 82.7% ‘SUWAN-1-SR-Y’ maize, 15.7% kidney bean and 1.6% alligator pepper; and
SUWAN-4= Sample prepared from 72% ‘SUWAN-1-SR-Y’ maize, 26% kidney bean and 2% alligator pepper.

9.46% to 20.87% with ART1 (100% maize flour control sample) having the lowest and SUWAN 4(made from 72% maize flour, 26% kidney bean flour and 2% alligator pepper) having the highest. The SUWAN sample varieties had the highest values in their protein contents. Protein content increased as kidney bean was added in the composite mixture. The higher the protein content of the kidney bean and alligator pepper flour accounted for greater increase in the protein content of the maize, kidney bean and alligator pepper sample. Protein content is one of the important qualities of any food. Moisture content which is one of the outstanding qualities and widely used parameter in the processing and testing of food qualities was found to range from 7.08% to 10.38%, with sample SUWAN1 (100% maize)had the highest value of 10.83% while sample ART3 had the least moisture content of 7.08%.The moisture content of the composite flour of the maize variety ART2 was lower than that of its100% flour except for sample ART4.There was also a noticeable reduction in the moisture content of the composite flours of the SUWAN varieties as compared to the 100% SUWAN flour , but an increase was observed in the moisture content of the composite flours of BR varieties. High moisture content may affect the storability and the quality of the product. This implies that the maize-kidney blends may have a short shelf- life due to their high moisture content. Ash is a non- organic compound

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containing mineral content of food and nutritionally it aids in the metabolism of other organic compounds such as fat and carbohydrate (Mcwilliam, 1978). The results for the ash content of the flour were significantly different from one another which ranged from 1.08 to 1.86%. When compared to the 100% maize flour (ART 1 and BR 1) there was an increase in the ash content of the flours ART2, ART3 ART4, BR2, BR3, BR4, SUWAN2, SUWAN3 and SUWAN4 as kidney bean was added to the maize variety The crude fibre content of 100% maize was 2.91% and it reduced with substitution of kidney bean and alligator pepper blends, SUWAN4 had the least crude fibre content of (0.93%). Crude fibre is an important content in human diet as it is known to aid the digestive system of the human (Ayinde et al., 2012). Fats were in the range of 3.09% to 5.22% for the flour samples. The maize variety ART 4 (72% maize, 26% kidney bean and 2% alligator pepper) had the highest fat content of 5.22% and SUWAN1 (75.6% maize, 23.6% kidney bean and 5% alligator pepper) had the least fat content. Fat plays a significant role in determining the shelf life of food products and as such relatively high fat content could be undesirable in baked food products. The carbohydrate content ranged from 63.38 to 74.90% for the flour samples. The carbohydrate content was higher in the 100% maize than the enriched blends. This was due to the relatively low carbohydrate content of kidney bean of the samples. Also, the carbohydrate composition of the 100% flours i.e. ART(74.90%), BR2(73.49%) and SUWAN 3(71.09%) were higher than that of the composite (flours containing kidney bean and alligator pepper).The high carbohydrate makes it ideal for rapid growth.

The physicochemical properties of the flour obtained from different varities of maize with kidney bean and alligator pepper are presented in Table 3.

Table 3: physicochemical **properties of kokoro flour**

Samples	Water absorption capacity(ml/mg)	Oil absorption capacity(ml/mg)	Foaming capacity(ml/mg)	Least gelation capacity(ml/mg)	Emulsifying capacity(ml/mg)
ART1	142.17 ± 1.26^{c}	115.75 ± 0.25^{e}	12.12 ± 0.10^{de}	2.00 ± 0.00^{e}	45.55 ± 0.16^{c}
ART2	109.07 ± 0.0^{6j}	108.52 ± 0.15^{g}	14.33 ± 0.58^{c}	5.67 ± 0.58^{a}	40.00 ± 0.00^{d}
ART3	127.18 ± 0.16^{g}	112.03 ± 0.73^{f}	8.67 ± 0.58^{fg}	2.00 ± 0.00^{e}	40.00 ± 0.00^{d}
ART4	129.10 ± 0.01^{f}	114.40 ± 0.35^{e}	11.33 ± 0.58^{e}	2.00 ± 0.00^{e}	45.00 ± 0.00^{c}
BR1	136.90 ± 0.10^{e}	120.70 ± 0.70^{c}	14.30 ± 0.30^{c}	2.67 ± 0.58^{cd}	47.40 ± 0.55^{a}
BR2	140.34 ± 0.58^{d}	123.28 ± 3.10^{b}	17.33 ± 0.58^{b}	3.33 ± 0.58^{bc}	40.00 ± 0.00^{d}
BR3	156.11 ± 0.84^{a}	120.02 ± 1.48^{cd}	8.00 ± 0.00^{g}	2.00 ± 0.00^{e}	34.67 ± 0.58^{e}
BR4	125.33 ± 1.53^{h}	110.68 ± 0.83^{f}	19.33 ± 0.58^{a}	5.67 ± 0.58^{a}	40.00 ± 0.00^{d}
SUWAN1	152.67 ± 0.58^{b}	136.67 ± 0.58^{a}	13.67 ± 0.58^{c}	6.33 ± 0.58^{a}	46.67 ± 0.58^{b}
SUWAN2	132.33 ± 1.53^{e}	118.34 ± 0.12^{d}	8.00 ± 0.00^{g}	4.00 ± 0.00^{b}	40.33 ± 0.58^{d}
SUWAN3	142.26 ± 1.18^{c}	135.76 ± 0.43^{a}	9.33 ± 0.58^{f}	3.67 ± 0.58^{b}	45.00 ± 0.00^{c}
SUWAN4	123.41 ± 0.09^{i}	118.40 ± 0.04^{d}	12.33 ± 0.58^{d}	3.67 ± 0.58^{b}	40.00 ± 0.00^{d}

Values are means of triplicates samples. Values followed by different alphabets along the same column are significantly different at ($p \leq 0.05$)

Key:
ART-1= Sample prepared from 100% ‘ART-98-SW06-W’ maize;
ART-2= Sample prepared from 75.9% ‘ART-98-SW06-W’ maize, 23.6% kidney bean and 0.5% alligator pepper;
ART-3= Sample prepared from 82.7% ‘ART-98-SW06-W’ maize, 15.7% kidney bean and 1.6% alligator pepper;
ART-4= Sample prepared from 72% ‘ART-98-SW06-W’ maize, 26% kidney bean and 2% alligator pepper;
BR-1= Sample prepared from 100% ‘Br-W9943-DMR-SR-W’ maize;
BR-2= Sample prepared from 75.9% ‘Br-W9943-DMR-SR-W’ maize, 23.6% kidney bean and 0.5% alligator pepper;
BR-3= Sample prepared from 82.7% ‘Br-W9943-DMR-SR-W’ maize, 15.7% kidney bean and 1.6% alligator pepper;
BR-4= Sample prepared from 72% ‘Br-W9943-DMR-SR-W’ maize, 26% kidney bean and

2% alligator pepper;
SUWAN-1= Sample prepared from 100% ‘SUWAN-1-SR-Y’ maize;
SUWAN-2= Sample prepared from 75.9% ‘SUWAN-1-SR-Y’ maize, 23.6% kidney bean and 0.5% alligator pepper;
SUWAN-3= Sample prepared from 82.7% ‘SUWAN-1-SR-Y’ maize, 15.7% kidney bean and 1.6% alligator pepper; and
SUWAN-4= Sample prepared from 72% ‘SUWAN-1-SR-Y’ maize, 26% kidney bean and 2% alligator pepper.

Water absorption capacity is a useful indicator of whether flours or isolates can be incorporated into aqueous food formulations. The water absorption capacity of the flour samples ranged from 109.07 to 156.11ml/mg. The values are in correlation with 144 to 166ml/mg for maize and beniseed flour reported by Ayinde et al., (2012). The values of the 100% maize flour differs significantly ($p \leq 0.05$) from the composite flours. Sample ART3 had the lowest water absorption capacity. The reduction in the water absorption capacity of the composite flours is due to the added kidney bean which contain appreciable amount of protein. Water absorption behaviour cannot cannot be dissociated from the nature of starch of the maize and kidney bean in the product. The nature of starch has been found to have effect on the water absorption capacity (Finney, 1994). The oil absorption capacity of the blends differed significantly ($p \leq 0.05$) from each other. The results for oil absorption capacity for kokoro flour samples ranged from 108.52 to 136.67 ml/mg. The result showed that the samples might be useful in confectioneries where hydration to improve handling is desired, where oil absorption property is of prime importance. .Foaming capacity showsa significant ($p \leq 0.05$) difference among the samples of kokoro flour which ranged from 8.00 to 9.33ml/mg. Foaming capacity and stability is related to protein content because some proteins have surface active properties to entrap gas bubbles. Soluble protein can reduce surface tension at interface between air bubbles and surrounded liquid (Eltayebet al., 2011). Protein is also able to undergo rapid conformational change and rearrangement at the interface to form a cohesive viscoelastic film via intermolecular interactions to stabilize foam (Adebowale et al., 2005). The least gelation capacity ranges from 2.00 to 6.33 which are slightly significant ($p \leq 0.05$) with sample SUWAN 1 having the highest of 6.33 and ART 1, ART3, ART4 and BR3 having the lowest of 2.00 for each samples. The emulsion capacity ranged from 34.67 to 47.40%, this indicates that there was significant difference between all the entire samples in the emulsion capacity. Samples ART1, BR1 and SUWAN1 (100% maize) had the highest values of 45.55%, 47.40% and 46.67% which is an indication that the samples has the capacity or tendency to form emulsion more than other samples with the addition of kidney bean which may be due to the presence of amylose and amylopectin content in the maize flour (Mempha, et al., 2007).

Proximate composition Mineral content of kokoro obtained from composite flour of maize, kidney bean and alligator pepper

The proximate and mineral composition of the kokoro products are presented in Table 4 and 5 respectively. Addition of kidney bean and alligator pepper resulted in significant increase in the Ca, K, Mg, Na Fe and Zn. Kokoro samples differs significantly ($p \leq 0.05$). The mineral composition sodium, potassium, calcium, magnesium, iron and zinc ranged between 14.07 to 42.15, 66.13 to 146.79, 4.01 to 66.01, 9.61 to 26.35, 0.78 to 4.07 and 0.46 to 1.24. The results showed that, for all the maize varieties (i.e. ART, BR and SUWAN), kokoro made with composite flours (added kidney bean and alligator pepper) were higher in their mineral composition than kokoro made with 100% flour. The Na/K ratio in the body is important because it helps in controlling high blood pressure. The Na/K ratio values, when calculated was found less than one, which compares favourably with the recommended value of less than one.

Table 4: Proximate composition Kokoro

Samples	Protein	Moisture	Fat	Ash	Crude fiber	CHO
ART1	4.87 ± 0.66^{h}	10.69 ± 0.11^{g}	23.08 ± 0.02^{g}	1.27 ± 0.03^{b}	5.22 ± 0.01^{a}	54.87 ± 0.65^{a}
ART2	12.00 ± 0.01^{c}	10.40 ± 0.01^{h}	28.67 ± 0.01^{c}	1.09 ± 0.00^{d}	1.52 ± 0.01^{gh}	46.32 ± 0.02^{de}
ART3	12.00 ± 0.57^{c}	11.48 ± 0.01^{e}	27.74 ± 0.00^{d}	0.96 ± 0.00^{g}	1.75 ± 0.01^{f}	46.07 ± 0.55^{e}

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ART4	9.61±0.01^{e}	10.23±0.06^{i}	27.72±0.01^{d}	0.69±0.01^{h}	1.85±0.00^{e}	49.91±0.06^{b}
BR1	5.48±0.34^{g}	12.54±0.22^{c}	28.39±0.02^{cd}	0.99±0.03^{f}	4.31±0.01^{b}	48.28±0.25^{c}
BR2	10.81±0.01^{d}	10.72±0.00^{g}	31.95±0.96^{b}	0.43±0.01^{j}	1.54±0.01^{g}	44.55±0.97^{fg}
BR3	9.61±0.01^{e}	11.13±0.01^{f}	32.53±0.04^{a}	0.40±0.01^{k}	1.48±0.00^{gh}	44.86±0.04^{f}
BR4	12.59±0.02^{b}	11.35±0.11^{e}	27.97±0.05^{d}	0.49±0.00^{i}	1.36±0.17^{i}	46.24±0.22^{de}
SUWAN1	8.56±0.22^{f}	13.77±0.11^{a}	26.46±0.16^{e}	1.36±0.01^{a}	3.80±0.02^{c}	46.06±0.07^{e}
SUWAN2	12.57±0.05^{b}	12.39±0.01^{d}	26.79±0.02^{e}	1.17±0.01^{c}	2.97±0.02^{d}	44.15±0.01^{gh}
SUWAN3	10.80±0.04^{d}	12.33±0.01^{d}	27.46±0.03^{d}	1.04±0.02^{e}	1.54±0.01^{g}	46.83±0.04^{d}
SUWAN4	14.67±0.31^{a}	13.48±0.01^{b}	25.67±0.02^{f}	1.25±0.01^{b}	1.43±0.00^{i}	43.50±0.30^{h}

Values are means of triplicates samples. Values followed by different alphabets along the same column are significantly different at ($p \leq 0.05$)

Key:
ART-1= Sample prepared from 100% 'ART-98-SW06-W' maize;
ART-2= Sample prepared from 75.9% 'ART-98-SW06-W' maize, 23.6% kidney bean and 0.5% alligator pepper;
ART-3= Sample prepared from 82.7% 'ART-98-SW06-W' maize, 15.7% kidney bean and 1.6% alligator pepper;
ART-4= Sample prepared from 72% 'ART-98-SW06-W' maize, 26% kidney bean and 2% alligator pepper;
BR-1= Sample prepared from 100% 'Br-W9943-DMR-SR-W' maize;
BR-2= Sample prepared from 75.9% 'Br-W9943-DMR-SR-W' maize, 23.6% kidney bean and 0.5% alligator pepper;
BR-3= Sample prepared from 82.7% 'Br-W9943-DMR-SR-W' maize, 15.7% kidney bean and 1.6% alligator pepper;
BR-4= Sample prepared from 72% 'Br-W9943-DMR-SR-W' maize, 26% kidney bean and 2% alligator pepper;
SUWAN-1= Sample prepared from 100% 'SUWAN-1-SR-Y' maize;
SUWAN-2= Sample prepared from 75.9% 'SUWAN-1-SR-Y' maize, 23.6% kidney bean and 0.5% alligator pepper;
SUWAN-3= Sample prepared from 82.7% 'SUWAN-1-SR-Y' maize, 15.7% kidney bean and 1.6% alligator pepper; and
SUWAN-4= Sample prepared from 72% 'SUWAN-1-SR-Y' maize, 26% kidney bean and 2% alligator pepper.

Table 5: Mineral composition of kokoro

Samples	Sodium	Potassium	Calcium	magnesium	Iron	Zinc
ART1	34.87±0.30^{l}	66.13±0.23^{k}	4.01±0.01^{k}	16.07±0.12^{f}	0.78±0.01^{k}	0.49±0.00^{i}
ART2	34.63±0.03^{d}	146.79±0.21^{a}	60.06±0.06^{b}	28.81±0.02^{a}	3.59±0.02^{c}	1.03±0.01^{cd}
ART3	42.15±0.05^{a}	120.10±0.10^{c}	40.08±0.01^{h}	18.02±0.02^{d}	3.90±0.02^{b}	1.24±0.05^{a}
ART4	27.10±0.10^{e}	118.01±0.02^{e}	34.13±0.13^{i}	26.35±0.05^{b}	2.61±0.02^{f}	0.98±0.01^{ef}
BR1	14.13±0.12^{k}	48.31±0.01^{l}	6.02±0.02^{j}	9.61±0.01^{j}	1.00±0.02^{i}	0.46±0.01^{i}
BR2	16.81±0.01^{i}	96.85±0.15^{f}	58.15±0.02^{c}	10.70±0.10^{i}	2.53±0.03^{g}	1.13±0.03^{b}
BR3	26.36±0.03^{f}	88.41±0.02^{h}	48.16±0.05^{f}	9.61±0.02^{j}	2.48±0.03^{h}	1.05±0.02^{c}
BR4	24.08±0.03^{g}	85.90±0.00^{i}	52.05±0.05^{e}	16.82±0.02^{e}	2.68±0.01^{e}	0.90±0.03^{g}

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SUWAN1	14.07±0.07^{k}	68.65±0.05^{j}	4.02±0.02^{k}	20.37±0.03^{c}	0.90±0.02^{j}	0.71±0.02^{h}
SUWAN2	23.25±0.06^{h}	119.07±0.07^{d}	40.32±0.01^{g}	17.95±0.05^{d}	3.32±0.02^{d}	0.95±0.02^{f}
SUWAN3	14.71±0.01^{j}	96.26±0.0^{g}	66.01±0.01^{a}	14.42±0.02^{h}	3.35±0.02^{d}	1.02±0.01^{cde}
SUWAN4	38.39±0.01^{b}	130.04±0.04^{a}	52.17±0.05^{d}	14.67±0.03^{g}	4.07±0.05^{a}	0.99±0.04^{def}

Values are means of triplicates samples. Values followed by different alphabets along the same column are significantly different at ($p \leq 0.05$)

Key:
ART-1= Sample prepared from 100% ‘ART-98-SW06-W’ maize;
ART-2= Sample prepared from 75.9% ‘ART-98-SW06-W’ maize, 23.6% kidney bean and 0.5% alligator pepper;
ART-3= Sample prepared from 82.7% ‘ART-98-SW06-W’ maize, 15.7% kidney bean and 1.6% alligator pepper;
ART-4= Sample prepared from 72% ‘ART-98-SW06-W’ maize, 26% kidney bean and 2% alligator pepper;
BR-1= Sample prepared from 100% ‘Br-W9943-DMR-SR-W’ maize;
BR-2= Sample prepared from 75.9% ‘Br-W9943-DMR-SR-W’ maize, 23.6% kidney bean and 0.5% alligator pepper;
BR-3= Sample prepared from 82.7% ‘Br-W9943-DMR-SR-W’ maize, 15.7% kidney bean and 1.6% alligator pepper;
BR-4= Sample prepared from 72% ‘Br-W9943-DMR-SR-W’ maize, 26% kidney bean and 2% alligator pepper;
SUWAN-1= Sample prepared from 100% ‘SUWAN-1-SR-Y’ maize;
SUWAN-2= Sample prepared from 75.9% ‘SUWAN-1-SR-Y’ maize, 23.6% kidney bean and 0.5% alligator pepper;
SUWAN-3= Sample prepared from 82.7% ‘SUWAN-1-SR-Y’ maize, 15.7% kidney bean and 1.6% alligator pepper; and
SUWAN-4= Sample prepared from 72% ‘SUWAN-1-SR-Y’ maize, 26% kidney bean and 2% alligator pepper.

Selected vitamin content and residual antinutrients in kokoro obtained from composite flour of maize, kidney bean and alligator pepper.

The results of the vitamin content in kokoro samples differ significantly ($p \leq 0.05$) as shown in Table 6 which indicates that vitamin B1 ranges from 0.51 to 0.87, vitamin B2 ranged from 0.16 to 0.73, vitamin B3 ranged from 0.11 to 0.73 and vitamin A ranged from 96.17 to 122.21.The results of the products indicate that there was a significant increase in the vitamin composition of kokoro samples with added kidney bean and alligator pepper than the kokoro samples with 100% maize. SUWAN variety was observed to have the highest vitamin A among all the samples.

Table 6.Vitamin composition of kokoro

Samples	Vitamin B_1	Vitamin B_2	Vitamin B_3	Vitamin A
ART 1	0.69±0.00^{h}	0.16±0.00^{i}	0.21±0.00^{k}	106.38±1.48^{e}
ART2	0.87±0.01^{a}	0.69±0.01^{b}	0.72±0.01^{b}	103.00±0.00^{fg}
ART3	0.80±0.01^{e}	0.63±0.01^{e}	0.66±0.00^{e}	102.67±0.83^{fg}
ART4	0.70±0.02^{h}	0.57±0.01^{g}	0.57±0.01^{h}	103.58±0.13^{f}
BR1	0.51±0.01^{j}	0.17±0.00^{i}	0.53±0.00^{i}	102.18±0.11^{g}
BR2	0.81±0.01^{d}	0.62±0.01^{e}	0.67±0.00^{d}	98.57±0.02^{h}
BR3	0.76±0.01^{g}	0.60±0.01^{f}	0.62±0.01^{f}	102.38±0.33^{g}
BR4	0.67±0.01^{i}	0.54±0.01^{h}	0.50±0.01^{j}	96.17±0.29^{i}
SUWAN1	0.85±0.00^{b}	0.66±0.02^{c}	0.11±0.00^{l}	122.21±0.01^{a}
SUWAN2	0.84±0.01^{b}	0.73±0.01^{a}	0.73±0.01^{a}	116.15±0.29^{c}
SUWAN3	0.83±0.01^{c}	0.65±0.01^{d}	0.68±0.01^{c}	120.42±0.44^{b}
SUWAN4	0.77±0.01^{f}	0.58±0.01^{fg}	0.60±0.00^{g}	113.37±0.07^{d}

Values are means of triplicates samples. Values followed by different alphabets along the same column are significantly different at ($p \leq 0.05$)

Key:
ART-1= Sample prepared from 100% ‘ART-98-SW06-W’ maize;

ART-2= Sample prepared from 75.9% 'ART-98-SW06-W' maize, 23.6% kidney bean and 0.5% alligator pepper;
ART-3= Sample prepared from 82.7% 'ART-98-SW06-W' maize, 15.7% kidney bean and 1.6% alligator pepper;
ART-4= Sample prepared from 72% 'ART-98-SW06-W' maize, 26% kidney bean and 2% alligator pepper;
BR-1= Sample prepared from 100% 'Br-W9943-DMR-SR-W' maize;
BR-2= Sample prepared from 75.9% 'Br-W9943-DMR-SR-W' maize, 23.6% kidney bean and 0.5% alligator pepper;
BR-3= Sample prepared from 82.7% 'Br-W9943-DMR-SR-W' maize, 15.7% kidney bean and 1.6% alligator pepper;
BR-4= Sample prepared from 72% 'Br-W9943-DMR-SR-W' maize, 26% kidney bean and 2% alligator pepper;
SUWAN-1= Sample prepared from 100% 'SUWAN-1-SR-Y' maize;
SUWAN-2= Sample prepared from 75.9% 'SUWAN-1-SR-Y' maize, 23.6% kidney bean and 0.5% alligator pepper;
SUWAN-3= Sample prepared from 82.7% 'SUWAN-1-SR-Y' maize, 15.7% kidney bean and 1.6% alligator pepper; and
SUWAN-4= Sample prepared from 72% 'SUWAN-1-SR-Y' maize, 26% kidney bean and 2% alligator pepper.

The levels of antinutrients (phytate, oxalate, tannin and trypsin inhibitor) were shown in Tables 7. The phytate content of kokoro ranged from 6.18 to 11.95 mg/g, oxalate content from 0.14 to 1.49 mg/g, tannin from 0.82 to 3.13 mg/g and trypsin inhibitor 0.01 to 12.72 mg/g. There were significant ($p \leq 0.05$) difference among the samples. Phytate content was found higher than the rest of the parameters tested which may be due to the presence of both maize and kidney bean in the products. Onwuka, (2005) stated that tannins can provoke an astringent reaction in the mouth and make the food unpalatable and that they can complex with and thus precipitates proteins in the gut, reducing the digestibility or inhibiting digestive enzymes and microorganisms. The level of tannin recorded is very low compared to the critical level 7.3-7.9 mg/g reported by (Aletor, 1993) thus regarded safe. Also no taste panelist reported irritation of the mouth or throat during or after the organoleptic evaluation of the products. This indicates the very low level of oxalate in the kokoro samples.

Table 7: Antinutritional content of kokoro

Samples	Phytate (mg/g)	Oxalate (mg/g)	Tannin (mg/g)	Trypsin inhibitor (%)
ART1	9.48 ± 0.58^{bc}	0.99 ± 0.00^{c}	1.08 ± 0.01^{cd}	0.01 ± 0.06^{e}
ART2	6.18 ± 0.58^{e}	0.14 ± 0.06^{h}	0.82 ± 0.38^{d}	2.80 ± 0.07^{l}
ART3	8.65 ± 0.58^{cd}	0.32 ± 0.06^{g}	1.97 ± 0.38^{bc}	5.70 ± 0.07^{k}
ART4	8.65 ± 0.58^{cd}	0.77 ± 0.06^{de}	2.58 ± 0.38^{ab}	6.82 ± 0.07^{j}
BR1	10.71 ± 0.00^{b}	1.13 ± 0.06^{c}	1.18 ± 0.01^{cd}	0.07 ± 0.06^{a}
BR2	8.65 ± 0.58^{cd}	0.68 ± 0.06^{ef}	2.42 ± 0.38^{ab}	11.14 ± 0.07^{d}
BR3	8.65 ± 0.58^{cd}	1.04 ± 0.06^{c}	3.05 ± 0.38^{a}	12.72 ± 0.07^{b}
BR4	7.83 ± 0.58^{de}	0.59 ± 0.06^{f}	1.05 ± 0.38^{cd}	8.45 ± 0.07^{h}
SUWAN1	11.95 ± 0.59^{a}	1.49 ± 0.06^{a}	1.27 ± 0.71^{cd}	0.01 ± 0.03^{c}
SUWAN2	8.65 ± 0.58^{cd}	1.13 ± 0.06^{c}	2.46 ± 0.38^{ab}	9.08 ± 0.07^{g}
SUWAN3	9.47 ± 0.58^{bc}	1.31 ± 0.06^{b}	3.13 ± 0.38^{a}	9.90 ± 0.07^{f}
SUWAN4	7.00 ± 0.58^{de}	0.86 ± 0.06^{d}	1.36 ± 0.38^{cd}	7.24 ± 0.07^{i}

Values are means of triplicates samples. Values followed by different alphabets along the same column are significantly different at ($p \leq 0.05$)

Key:
ART-1= Sample prepared from 100% 'ART-98-SW06-W' maize;
ART-2= Sample prepared from 75.9% 'ART-98-SW06-W' maize, 23.6% kidney bean and 0.5% alligator pepper;
ART-3= Sample prepared from 82.7% 'ART-98-SW06-W' maize, 15.7% kidney bean and 1.6% alligator pepper;

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ART-4= Sample prepared from 72% 'ART-98-SW06-W' maize, 26% kidney bean and 2% alligator pepper;
BR-1= Sample prepared from 100% 'Br-W9943-DMR-SR-W' maize;
BR-2= Sample prepared from 75.9% 'Br-W9943-DMR-SR-W' maize, 23.6% kidney bean and 0.5% alligator pepper;
BR-3= Sample prepared from 82.7% 'Br-W9943-DMR-SR-W' maize, 15.7% kidney bean and 1.6% alligator pepper;
BR-4= Sample prepared from 72% 'Br-W9943-DMR-SR-W' maize, 26% kidney bean and 2% alligator pepper;
SUWAN-1= Sample prepared from 100% 'SUWAN-1-SR-Y' maize;
SUWAN-2= Sample prepared from 75.9% 'SUWAN-1-SR-Y' maize, 23.6% kidney bean and 0.5% alligator pepper;
SUWAN-3= Sample prepared from 82.7% 'SUWAN-1-SR-Y' maize, 15.7% kidney bean and 1.6% alligator pepper; and
SUWAN-4= Sample prepared from 72% 'SUWAN-1-SR-Y' maize, 26% kidney bean and 2% alligator pepper.

IV. CONCLUSION

Substitution of maize flour with kidney bean and alligator pepper increased the nutritive value of the snacks. The functional properties, vitamin and mineral contents were also improved as substitution of kidney bean flour and alligator pepper increased. Antinutrients level of the samples were at minimal level indicating that the snack obtained from the blend of maize , kidney bean and alligator pepper is safe for consumption.

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