Qualities Evaluation of Extruded Ready to Eat Snack from Composite Non-Wheat Flours

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ABSTRACT

Ready-to-eat flakes are processed grain formulations suitable for human consumption without further cooking in the home. Ready-to-eat flakes was produced from the mixtures of yellow maize, defatted soybean, defatted groundnut, moringa seed, scent leaf, pepper, salt and gray fish using extrusion technology at five different proportions of the ingredients. The proximate, minerals, antioxidant, functional properties, cracking strength and sensory properties of the formulations were investigated using standard methods. The research established that the use of local cereal based for the production of flakes is possible and good when using extrusion technology. The extruded products provide good quality flakes when supplemented maize with soybean and groundnut. It was deduced from the chemical composition of the flakes, that blending of cereals and legumes cause a significant increase in protein and carbohydrate contents making it a suitable ingredient for controlling malnutrition in diets. With respect to the nutritional composition, the addition of moringa seed to the blend samples increased the potassium, calcium, iron and phosphorus content of the flakes; this makes the blends better source of micronutrients. Also, the incorporating of moringa seed increased the total phenolic compound, vitamin C and flavonoids content. The samples from composite flour had the ability to withstand cracking strength compare to 100% wheat flour.

Keywords: *Flakes, Nutritional characteristics, Maize, Defatted soybean, Defatted groundnut, Moringa seed.*

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Highlights of this paper

- Local blended flakes as ready to eat flakes.
- Local blended flakes with Cereals and Legumes are better source of micronutrients.
- Local blended flakes could be used as a means of preventing malnutrition among infants and aged people in rural communities.

1. INTRODUCTION

Ready-to-eat flakes are processed grain formulations suitable for human consumption without further cooking in the home. They are relatively shelf-stable, light weight, and convenient to ship and store. Flakes by definition are breakfast cereal that use coarsely ground flour to invent ready-to-eat chips such as graham cracker. Ready-to-eat cereals (RTEC) are defined as finished product cereals that can be taken without further preparation and are also known as cold cereals. RTEC are high in fibre foods with modified vitamins and minerals including vitamins B, iron and calcium. Moreover, consumption of RTEF has also been associated with a greater likelihood of having vitamin and mineral intakes above recommended daily requirements, especially for calcium [1]. Cereals have been used over the years as industrial raw material based on the fibre, carbohydrate, low fat and protein content. Cereals include maize and sorghum which are enriched in minerals such as sulphur containing essential amino acid such as methionine, cysteine and tryptophan. Legumes and oil seeds are relatively low in sulphur containing amino acids, but very high in another essential amino acid like, lysine as reported by Kanu, et al. [2]. In recent times food researchers and processors have integrated legumes into natural cereal formulations as nutrient diversification scheme as well as exploits to reduce the incidence of malnutrition among vulnerable groups. Cereals can be appended with most oil seeds and legumes that are rich in essential amino acids particularly the Sulphur enriched ones [3]. Thus, appended cereal food will improve the nutritional and chemical value of the resulting fortified food compared to the individual components. Moringa (Moringa oleifera) is one of the indigenous vegetables that is widely consumed and used for its health benefits. Through research, underutilized moringa seeds contain significant minerals (calcium, phosphorus and iron), vitamins (A, B and C) amino acids, vitamins and carotene. Moringa seeds has some high considerable medicinal uses with high nutritional value, minerals, and are a good source of protein, vitamins, beta-carotene, amino acids and various phenolic [4].

It was reported by Gopalakrishnan, et al. [5] that moringa seed has a significant higher content of protein, fat and mineral (especially magnesium) than moringa leaves. It was based on this fact that Moringa seed had been used for combatting malnutrition in infant and nursing mothers. There is a possibility of employing the starch components derived from cereal grains and the protein, functional property and dietary fibre components from legumes to create a healthy, nutritious and disease resistant food for consumers.

In Nigeria, the high cost of commercial industrially produced high protein energy rich breakfast products make them out of reach to low income earners, consequently people in this wage category who constitute an appreciable percentage of the population depend for their breakfast on left over super or at best on sole cereal porridge that is of low nutritional value. There is therefore the need to develop affordable low cost high protein energy breakfast product whose production would not require high technology [6]. Hence, the need for immingling legumes with cereals in finished food development [7]. The presence of legumes and grains provide more valuable and cheaper protein that contains all essential amino acids in right proportion because their amino acid complements each other [8-11]. However, the practice of producing a ready to eat flakes from blends of maize, soybean and groundnut is an efficient means of meliorating the nutritional composition of ready to eat flakes. Enhancing the use of underutilized seed for food and snacks production is one of the meliorate ways to reduce malnutrition, environmental and financial vulnerability [12]. Therefore, it is of interest to process moringa seeds into acceptable, ready-to-eat and safe products together with other locally available materials including maize, defatted soybean and defatted groundnut flour.

2. MATERIALS AND METHODS

2.1. Materials

Defatted ground nut, maize, soybeans, moringa seed, and other ingredients to be used for this study will be purchased from Sabo market in Ilesha. The flaking will be carried out with a table top extruder machine available at Famex Zero Waste Farm, Ilesha, Osun State. Analyses of the raw materials and the produced flakes will be carried out at Federal university of Technology Food Science Laboratory, Akure, Ondo State, Nigeria.

2.2. Sample Preparation and Storage

Soybeans, groundnut, maize and moringa seeds used was properly cleaned and sorted to remove stones, dirt, chaff, weevil seeds and other extraneous matters. The modification method described by Ndife, et al. [13] was used to processing of maize grains into flour. Matured moringa seeds were manually removed from the seed kernels and dried using cabinet drier at 60°C for 5 days. The dried moringa seeds were milled in a clean Marlex blender and sieved using a sieve of 500 mm mesh size, to obtain a fine powder. Groundnut seed was roasted at the temperature of 120°C for 30 minutes, dehulled to remove the shell, dry milled, screw pressed, pulverized and sundry for 72 hours. Soy flour was prepared according to the method described by AOAC [14]. Soybeans were roasted, decorticated, winnowed and milled into fie flour using hammer mill (model EU 5000 D) and sieved through 250 µm aperture sieve. The four prepared flours were mixed with other spices and condiment in varying proportions to obtain four different samples Table 1. The samples were stored in an air tight environment and kept away from moisture.

Table-1. Composite Flour Formulations for ready-to-eat flakes made from Blends sample.

Sample code	**425**	**522**	**711**	**821**
Ingredient	A (%)	B (%)	C (%)	D (%)
Maize	35	35	35	35
Defatted soybean	30	25	20	10
Defatted Groundnut	10	15	20	30
Moringa seed	5	5	5	5
Scent leaf	5	5	5	5
Blended cray fish	5	5	5	5
Blended ginger	5	5	5	5
Pepper	3	3	3	3
Salt	2	2	2	2

2.3. Determination of Nutritional Composition and Ascorbic acid (Vitamin C)

The nutrient compositions and Ascorbic acid of the samples was analyzed using standard method of AOAC [14]. The Proximate parameters analyzed were; moisture content, ash, crude fiber, crude protein crude fat, carbohydrate and Ascorbic acid. The experiment was carried out in quadruplicate on each of mixes using standard methods.

2.4. Antioxidants

a. Determination of Flavonoid

The flavonoid content of the sample was determined according to the procedure of Boham and Kocipai [15]. The filtrate was later transferred into crucible and evaporated into dryness in a water bath and weighted to a constant weight and determined using Equation 1.

$$\text{Percentage flavonoid } (\%) = \frac{intial\ weight - final\ weight\ of\ the\ sample}{intial\ weight} \times \frac{100}{1} \qquad (1)$$

b. Determination of Total Phenol

The total phenolic content of the sample was analyzed using Folin-ciocalteu assay [16] using gallic acid as the standard. The mixture of the sample was mixed with distilled water to make a solution, 3ml of Folin-ciocalteu reagents solution, and 7% of the mixture was vortexed and incubated for 8 minutes at room temperature. The mixture was allowed to stand for 2 hours at room temperature. The absorbance was measured at 765 mm against distilled water as blank. The total phenolic content was expressed as mg/L gallic acid equivalent (GAE).

2.5. Functional Properties Determination

a. Bulk Density Determination

Bulk density was analyzed for each of the formulated samples using the method described by Onwuka [17]. Bulk density was estimated as mass per unit volume of the sample (g/ml).

b. Determination of Water Holding Capacity

The Water and Fat absorption capacities of the formulated samples were analyzed using the method described by Onwuka [17]. The absorption capacity was expressed as gram of oil or water absorbed (or retained) per gram of sample.

c. Determination of Swelling Capacity

The swelling capacity was analyzed by the method described by Sanni, et al. [18] for 10mins,30mins, 60mins and 240mins.

d. Determination of Gelation Concentration

The least gelation concentration (LGC) was evaluated using of Coffmann and Garciaj [19] as modified by Adeleke and Odedeji [20]. The flour dispersions of 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 30% (w/v) prepared in 5 ml distilled water and heated at 90 °C for 1 h in water bath. The contents were cooled under tap water and kept for 2 h at 10 ± 2 °C. The least gelation concentration was determined as that concentration when the sample from inverted tube did not slip.

e. Determination of Mineral Content

The mineral contents of the formulated samples were analysed using [14]. Using dry ashing, the sample was ashed at 550°C for 3 h. 5 ml of 6N hydrochloric acid (HCl) was mixed with the ash and made up to 50 ml with distilled water. Selected minerals analyzed were; iron (Fe), calcium (Ca), magnesium (Mg), sodium (Na), manganese, copper (Cu), phosphorus (P) and zinc (Zn) were determined by atomic absorption spectrophotometer. (Buck Scientific Atomic Absorption Emission Spectrophotometer model 205, manufactured by Nowalk, Connecticut, USA) using standard wavelengths.

2.6. Sensory Evaluation

The four formulated samples were served to 20 semi-trained panelists consisting of students of the Department of Food Science and Technology, Federal University of Technology, Akure. Panelist were chosen on the basis of their willingness and commitment to partake in the sensory evaluation, using a 9-point Hedonic scale (1- dislike extremely, 9- like extremely). The samples were served to assessed for appearance, consistency, flavor, taste, aftertaste, mouth feel, and overall acceptability.

2.7. Statistical Analysis

The sensory scores obtained were further subjected to a one-way Analysis of Variance (ANOVA). The Least Significant Difference (LSD) test and Duncan Multiple Range Tests were used to determine significant differences between means and separate means respectively at $p<0.05$ levels using SPSS package version 21.0.

3. RESULTS AND DISCUSSION

3.1. Proximate Composition of the Blends Samples

The protein content of the flakes from composite flour decrease with decrease soybean flour substitution in the mixes. Protein content of the flakes ranged from 18.44% to 21.69% Table 2. The protein content of the four formulations were significantly different ($p < 0.05$) from each other. Among the composite flours, composite flour with 10% soybean and 30% groundnut flour substitution had the highest protein content (21.69%) while the lowest value (18.44%) was observed in sample 711 (20% soybean and 20% groundnut). These values are higher than other related previous studies; lower values were recorded for the commercial control sample, Weetabix Original (11.50%), a breakfast meal containing African yam bean, maize, sorghum and soybean (13.53-15.02%) by Agunbiade and Ojezele [21] as well as breakfast cereal made from treated pigeon pea and sorghum (17.22 %) by Mbaeyi [22] respectively. The high protein content of the products may be assigned to the presence of defatted groundnut flour used in the formulations. Raw groundnut has been reported to contain about 48% protein [23]. The progressive solubilization and leaching out of the nitrogenous substances during soaking and boiling of the legume may be responsible for the slight protein reduction in the samples [24] other than these. The generally high level of protein, however demonstrates the effect of supplementing legumes in ready-to-eat flakes. High crude protein of the soy-maize-groundnut.

Table-2. Proximate analysis of ready-to-eat flakes from blends (Dry Basis).

Samples	Fibre (%)	Fat (%)	Ash (%)	Protein (%)	Carbohydrate (%)
425	7.43±0.12^{d}	9.95±0.20^{d}	7.47±0.45^{d}	20.38±0.06^{b}	54.25±0.29^{a}
522	12.36±0.12^{a}	13.89±0.32^{b}	7.35±0.06^{a}	18.68±0.07^{d}	46.49±0.42^{b}
711	8.79±0.25^{c}	14.58±0.00^{a}	6.14±0.06^{c}	18.44±0.02^{c}	52.02±0.22^{c}
821	10.18±0.12^{b}	11.90±0.00^{c}	6.01±0.12b^{c}	21.69±0.00^{a}	46.42±0.31^{d}

Note: Values are means +SD of triplicate determinations Means differently superscripted along the vertical columns are significantly different ($p<0.05$).

Composite flour signifies that the composite flour can serve as cheap source of protein to African Populace Fat content of the flakes from composite flour ranged from 9.95% to 14.58%. Among the five samples, flakes with 20% soybean and 20%groundnut flour blend had the highest fat content (14.58%) while the lowest value (9.95%) was observed in soybean: groundnut blend flour with 30:10 respectively. Fat content ware significantly different ($p < 0.05$) for all the formulations. The fat content of the flour was relatively high because it was reported that raw soybean and raw groundnut has a fat content of 40% and 36-54% respectively [23] which was used for the mixtures. The fat content of the biscuit made from Sorghum and Pigeon pea composite flour range from 8.70-14.2% [19] which is in line with this study. Most of the legumes, with the exception of groundnuts and soybeans contain less than 3% fat [25]. Higher fat values were recorded for fortified breakfast cereals made from African yam beans, maize, sorghum and soybean as 3.7% [21]. The results of the ash content analysis of the formulated samples showed significant differences ($p<0.05$) with values ranging from 2.37 to 7.47%. Malted soy-sorghum biscuit was recorded to have 3.14% by Bolarinwa, et al. [26] Lower values, 1.36% [21] and 1.50% [20] were recorded by other researchers. The high ash values recorded in this study may be attributed to the presence of defatted soybean and whole maize grains used as part of the ingredients in this study.

The values obtained from the findings of crude fiber content of the formulated breakfast cereals ranged from 7.43% to 12.36%. Lower values, 3.1- 3.8% [18] and 1.54-4.0% [20] were previously recorded for other ready-to-eat cereals formulation. The control sample- Weetabix however contained a fiber value of 10%. Fiber is needed to aid in digestion and keep the gastrointestinal tract healthy and also keep the blood sugar stable. It slows down the release of glucose during digestion, so cells require less insulin to absorb that glucose. The American Diabetes Association recommends that people with diabetes should consume 25-50g of fiber per day [27]. The fecal bulking action of insoluble fiber makes it useful in the treatment of constipation and diverticular disease [28]. The values from the carbohydrate content analysis of the formulated samples ranged from 46.42 to 54.25% with all the samples showing significantly different ($p<0.05$). Flakes with formulation 30:10 (soybean: groundnut) respectively had the highest carbohydrate value of 54.25% and lowest value 46.42% for 10:30 soybean and groundnut blends respectively. Higher carbohydrate values were reported for breakfast cereals formulated from sorghum and pigeon pea [20] as well as the control- Weetabix (68.4%) [29]. The higher carbohydrate values recorded by other researchers may be assigned to the high content of the cereals and legumes used as the main ingredients in the formulations [2].

3.2. Functional Properties

The result of evaluation of the functional properties of the developed flakes is shown in Table 3. The highest bulk density was observed for samples 821(10% defatted soybean and 30% defatted groundnut flour) (0.80g/ml) and lowest for sample 522 (25% defatted soybean and 15%defatted groundnut flour) (0.58g/ml). The variation in bulk density could be as a result of the variation in starch content. Iwe and Onalope [30] reported that starch content increased bulk density. Bulk density mediates the relative volume of packaging material required for the product. The higher the bulk density, the denser the packaging material required. It also designates the porosity of a product which influences the package design and could be used in determining the type of packaging material required [30] Swelling capacity of flours is a function of the size of particles, varieties and processing methods or unit operations. High swelling capacity was reported as one of the main criteria of a good product [31]. The value of swelling capacity recorded for composite flour for sample 711 (109.69 ml) had the highest and lowest for sample 100 (65.96 ml). The results of swelling capacity for all the samples was above average this implied the samples were of good quality. There was significant difference ($P< 0.05$) in the swelling capacity of all the samples studied.

Water absorption capacity (WAC) denotes the extent to which protein can be incorporated into food formulation. High water absorption capacity value implies increase in digestibility of the starch. The water absorption capacity values of the composite flour ranged from 668.31% to 87.97%. Sample 425 recorded the highest water absorption capacity (668.31%) and sample 100 recorded the lowest water absorption capacity (87.97%).

Table-3. Functional analysis of composite flour.

Samples	Bulk Density(g/ml)	Water Absorption(g/ml)	Swelling Capacity(ml)	Disperse Capacity (%)	Gelation Cont(g/ml)
425	0.72 ±0.20[a]	659.49 ±6.52[a]	89.71 ±0.20[c]	89.91 ± 0.20[c]	14
522	0.58 ±0.15[a]	658.51 ±10.00[a]	90.20 ±0.20[b]	93.53 ± 2.89[b]	16
711	0.78 ±0.20[a]	656.96 ±3.82[a]	109.69 ±0.20[a]	119.68 ±0.20[a]	18
821	0.80 ±0.15[a]	640.15 ±2.57[b]	79.92 ±0.20[d]	89.91 ± 0.20[c]	20
100	0.76±0.00[a]	87.97 ±0.00[c]	65.96±0.46[e]	59.22±0.15[c]	8

Note: Values are means +SD of triplicate determinations Means differently superscripted along the vertical columns are significantly different (p<0.05).

There was significant difference (P< 0.05) in only sample code 100 which is 100% wheat sample in the water absorption capacity of the samples studied. The highest WAC of the composite flour could be ascribed to the presence of amount of carbohydrates (starch) and fibre in sample flour. Water absorption capacity is a vital function of protein in various food products like soups, dough and baked products [32]. The results showed increase in WAC with increase in defatted soybean flour inclusion. This may be connected to soybean fiber hygroscopic properties, thus, on exposure to moisture it swells [33]. Similar values were obtained from Mbaeyi [22] for treated and untreated sorghum and pigeon pea breakfast cereals.

A gel represents a transitional phase between solid and liquid states. In food systems, the solid consists of proteins, polysaccharides or a mixture of both, while the liquid is usually water. The gelation properties can be influenced by the ionic strength, pH and the presence of non-protein components as reported by Sridaran, et al. [34]. Sample 821 (Soy-groundnut at ratio 10:30) formed a gel at a significantly higher concentration (20 g/ 100 ml). Sample 100 (wheat flour) formed gel quickly at very lowest concentration (8 g/100 ml). The gradual reduction in the gelation capacity with decreasing defatted soybean ratio may be as a result of high fiber content with high water absorption capacity and thus does not thicken or gel on heating [33]. Sample 711 recorded the highest value (119.68%) and lowest value (59.22) with sample 100.

3.3. Mineral Analysis

The results of the mineral composition of flakes as shown in Table 4, the sodium (Na) values of the formulated flakes blends ranged between 19.97-25.65PPM. Sample 425 has the highest sodium value while sample 821 has the lowest value. Also, the value of defatted soybean in the flakes is directly proportional to the amount of sodium in the blends. All the values were significantly different (P<0.05). Although sodium helps in maintaining the water balance in the body, absorption and transmission of some nutrients and nerve impulses. Health practitioners have encouraged reduction in the intake of sodium because it has been found out to increase the rate of blood pressure in salt sensitive individuals. The potassium (K) content of flakes samples was relatively high than other minerals analyzed. The value range from 52.78-84.43PPM. sample 711 had the highest value of K content while sample 425 has the lowest value. Due to the fact that moringa is rich in potassium [35] it can be inferred that moringa contributed more to the potassium content of the formulated samples. All the values were significantly different (P<0.05).

The calcium (Ca) content of the flakes sample range from 15.44 - 26.39PPM. Sample 425 had the highest calcium value while sample 821 had the lowest value. Calcium is vital in maintaining total body health and it also help both the bones and teeth to be strong. It ascertains proper performance of muscles and nerves. The results indicate that high amount of defatted soybean yields high calcium value of the flakes. Sample 522 and 711, sample 821 and 100 values were not significantly different (P<0.05), only sample 425 was significantly different (P<0.05).

Table-4. Mineral analysis of flakes prepared from blend samples.

Samples	Sodium(g/ml)	Potassium(g/ml)	Calcium(g/ml)	Iron(g/ml)	Phosphorus(g/ml)
425	25.65±0.70 [b]	52.78±0.12 [d]	26.39±0.02 [b]	1.46±0.07 [a]	19.79±0.01 [a]
522	22.42±0.18 [a]	63.100±0.00 [c]	23.43±0.28 [a]	0.30±0.02 [b]	14.66±0.03 [c]
711	21.76±0.08 [d]	84.43±0.80 [a]	20.66±0.64 [a]	0.17±0.14 [c]	10.95±0.01 [d]
821	19.97±0.09 [c]	70.50±0.14 [c]	15.44±0.04 [c]	0.07±0.00 [d]	17.26±0.02 [b]

Note: Values are means +SD of triplicate determinations Means differently superscripted along the vertical columns are significantly different ($p<0.05$).

The iron (Fe) content of the Flakes range from 0.07 – 1.46 PPM. Sample 425 had the highest iron content while sample 821 had the lowest value. From the results, it indicates that defatted soybean contribute to the iron content in the flakes. The content of calcium and iron of the composite flour 425 shows that products from the flour would be nutritionally beneficial for children for strong bone, blood formation and body development. The mineral content of flakes obtained in this study is in agreement with the values reported by Oboh [36] for wheat-sunflower barley cookies.

3.4. Antioxidants

The result of antioxidant properties of flakes from the composite blends is presented in Table 5. The flavonoids content value range from 1.50 – 1.68g/mg. There is no significant difference ($P<0.05$) between the samples. from the results, it was observed that the samples with highest flavonoid had a flour combination of 20% soybean and 20% groundnut, which implies that both the soybean and groundnut contribute to the flavonoid content. The TPC values reported varied among the different composite

Table-5. Antioxidant analysis of flakes from a blend samples.

Flakes	Phenol(mg/g)	Flavonoids(mg/g)	Ascorbic acid (mg/g)
425	2.59 ± 0.23 [ab]	1.50 ±0.06 [b]	30.86±0.68 [b]
522	2.62 ±0.52 [ab]	1.70 ±0.20 [ab]	25.30 ±2.60 [c]
711	2.74 ±0.37 [ab]	1.81 ±0.06 [a]	21.38 ±0.37 [d]
821	3.03 ±0.08 [a]	1.68 ±0.08 [ab]	20.05 ±1.03 [a]

Note: Values are means +SD of triplicate determinations Means differently superscripted along the vertical columns are significantly different ($p<0.05$).

Flour containing flakes as shown in Table 5. The phenol content of the composite flour range from 2.59 - 3.03g/mg. There were no significant different between all the samples. The highest value is found in sample 821 (10% soybean: 30% groundnut) while the lowest value is found in sample 425 (30% soybean: 10% groundnut). Groundnut had a contribution in phenolic content of the flour. Total phenolic compounds TPC were quantified by the Folin–Ciocalteu method which is an electron transfer based assay and measures reducing capacity. Phenol phytochemicals inhibit auto oxidation of unsaturated lipids, thus preventing the formation of oxidized low-density lipoprotein (LDL) which is considered to induce cardiovascular disease [37]. These values were generally higher than those reported by Kaushal, et al. [37] on some tropical cereals and legumes. The vitamin C content ranged from 20.05mg/100g to 30.86mg/100g. sample 425 had the highest value while sample 821 had the lowest value. It was observed that the value of vitamin C decrease with decrease in defatted soybean and increased in defatted groundnut. It can be due to the soybeans in the composite flour which contribute to the vitamin content of the flakes. Ascorbic acid plays a key nutritional role in foods. It is an essential nutrient for human, a deficiency of which causes scury. It is also a potent antioxidant, protecting the body from oxidative stress.

3.5. Sensory Analysis

The sensory evaluation results performed on different flakes produced are shown in Table 6 panelist rated the flakes prepared from 100% wheat flour as the best in terms of appearance, taste, aroma and overall acceptability. Sample 100 (100% wheat) scaled like moderately with respect to aroma (7.52), followed by sample 711 (6.45), 425 (5.90), 821 (5.10) and 522 (4.75). From the results, the three most preferred product after control (711, 425 and 821) and the least preferred in term of aroma is sample 522 which had high defatted soybean and low defatted groundnut content. The sensory analysis in term of appearance, texture, taste and overall acceptability, sample 100 (100% wheat) which was the control had the best value followed by sample 711 (6.45%) with a balanced ratio of defatted soybean and defatted groundnut (20:20%) then followed by sample 425 (5.90%) ratio 30:10, sample 821 (5.10) containing 10 % defatted soybean with 30% defatted groundnut, followed by the least acceptable sample 522 (4.75%).

Table-6. Sensory analysis of flakes from blend samples.

Samples	Aroma	Appearance	Texture	Taste	Acceptability
425	5.90 ± 1.07^{ab}	5.35 ± 1.57^{b}	6.40 ± 1.14^{a}	5.85 ± 1.53^{a}	6.10 ± 1.52^{a}
522	4.75 ± 1.52^{c}	3.70 ± 1.42^{c}	5.30 ± 1.49^{b}	5.10 ± 1.21^{b}	5.05 ± 1.15^{b}
711	6.45 ± 1.50^{a}	6.40 ± 1.50^{d}	6.70 ± 1.26^{a}	6.40 ± 1.31^{ab}	6.60 ± 1.27^{a}
821	5.10 ± 1.37^{bc}	6.20 ± 1.28^{ab}	6.10 ± 0.85^{a}	5.30 ± 1.69^{b}	5.85 ± 1.42^{ab}
100	7.52 ± 1.05^{d}	7.53 ± 0.04^{a}	7.44 ± 1.19^{e}	7.40 ± 0.91^{c}	7.52 ± 1.05^{a}

Note: Values are means +SD of triplicate determinations Means differently superscripted along the vertical columns are significantly different ($p<0.05$).

4. CONCLUSION

In conclusion, using an extruder to be able to produce flakes of an improved protein and anti-oxidant is excellent. With this, it can be established that the use of local cereal base for the production of flakes is possible and good when using extrusion process and provides a good quality when supplement maize with soybean and groundnut. Based on the chemical composition of the flakes, blending of cereals and legumes cause a significant increase in protein content and carbohydrate content making it a suitable ingredient for malnutrition diets. With respect to the nutritional composition, the addition of moringa seed to the blend samples increased the potassium, calcium, iron and phosphorus content of the flakes, this makes the blends better source of micronutrients. Also, the incorporating of moringa seed increased the total phenolic compound, vitamin C and flavonoids content. The samples from composite flour had the ability to withstand cracking strength compare to 100% wheat flour.

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