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Development and Quality Evaluation of Extruded Breakfast Cereal from Blends of O*fada R*ice and Cowpea (*Vigna unguiculata*) with Date Palm Fruit

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Abstract

Development of food product is a global initiative focused on crops utilization for economic empowerment and service provider. Extruded breakfast cereal developed from unconventional grain, *ofada* rice blended with cowpea and date palm fruit as natural sweetener was designed and evaluated. Composite flour formulation was in ratio 55:45, 60:40, 65:35, 70:30 while date palm fruit was kept constant. Proximate, functional, pasting, shelf-life and sensory analyses were carried out. Protein and ash content in experimented samples, B1KK, B2KL, B3KM and B4KN increased significantly with increased proportion of cowpea. At 5% level of significance, there was significant difference in water absorption index in all experimented sample while bulk density and swelling power showed no significant difference in most samples. Final viscosity of the samples increased as the proportion of *ofada* rice decreased while setback viscosity increased as the proportion of cowpea increased. Moisture content, free fatty acid and peroxide value of the samples increased slightly as approaches six weeks storage, however, the result was within internationally acceptable quality limits. Sensory attributes of the designed products are significantly related to the control sample, apparently, consumer perception of the breakfast cereal based products indicated that B2KL was most preferred and thus recommended for commercialization.

Keywords: Breakfast; Cereal; Extrusion; Analysis; Composite flour.

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1. Introduction

Breakfast is believed to be the nutritional foundation or the main and important food that are consumed daily [1]. A food specialist sees breakfast as the essential meal that should not be skipped under any circumstance. Research findings revealed that skipping of the breakfast has led to health challenges such as constipation, metabolism disorder and weight issues [2]. Breakfast has been viewed and understands to be the most crucial meal of the day and breakfast consumption has been confirmed to supply higher dietary fibre to the body when taken daily couple with micronutrients. Taking breakfast contributes to mental performance of individuals, enhances concentration, and drives physical activity [3]. According to Okache, *et al.* [4], breakfast foods and diet that are locally produced from manufacturing companies for adults and children are prepared from cereals, legumes, and a small number of tubers in the developing countries, but the most eaten breakfast meals are cereals. Breakfast from cereal grains must have been subjected to some treatment such as extrusion, drying and mixed with milk, yoghurt, or fruit before consumption [5]. Breakfast cereal products are found to contain high fibre content especially oat-based cereals. Many breakfast cereal products are rich in vitamins, minerals with low fat content in addition to high energy and fibre. Breakfast cereal whether is presweetened or containing whole grain lowers the risk of having diabetes and cardiovascular disease [6, 7].

Rice (*Oryza sativa*) is regarded as an edible starchy cereal food grain (family *Poaceae*). *Ofada* rice is one of the indigenous and locally produced rice that sprang from Southwest Nigeria [8]. *Ofada* rice is an unpolished short grain because of its fibre content having a red kernel which other rice does not contain [9, 10]. There are majorly two types of o*fada* rice; Brown o*fada* rice which is very much aromatic unlike White o*fada* rice that is non-aromatic [11]. Raw, long-grain white rice contains an appreciable amount of carbohydrate, calcium, pantothenic acid, iron, folate, thiamine, and vitamin E but the content of the dietary fibre is minimal. Vitamins, minerals, and fibre are embedded in brown rice. Red colored rice is associated with richness in minerals such as zinc and iron while the protein, crude fibre and fat content of black rice varieties are at a high level [12, 13]. The bran and husk of rice has been found to have a greater quantity of some minerals such as calcium, iron, zinc, and so on. Rice contains aspartic

acids in addition to glutamic but has a lesser lysine quantity. In the rice bran are large deposition of some predominant antinutritional factors which are Oryza cystatin, trypsin inhibitors, haemagglutinin-lectin,and phytate [14].

Cowpea (*Vigna unguiculata*) is a reliable legume crop that serves as food for the masses around the world, especially in economically developing nations. Production of cowpea is about 4.5 million metric tons annually across the world [15]. Although, the focus is on the beans of the plant, but the leaves and flowers are eatables in certain sections of the world [16]. Legumes generally are key sources of protein. Today, cowpea is taken as high-quality protein food consumed daily amongst the populations that are depressed economically in developing nations, with the purpose of curbing the elevated frequency of malnutrition in protein and energy [17]. Mostly, the content of protein in cowpea ranges from 18% - 30% and varies according to the species. The cowpea protein is predominantly made up of globulin portion which ranges from 50% - 70%, and this is split up into two main classes: Afiukwa, *et al.* [18]. Some inhibitors, such as α-amylase and α-glucosidase in cowpea have been reported to be greatly useful to human being health because they have the ability to decrease the rate at which glucose is released during digestion [19].

Date palm fruit has been found to contain a broad range of nutritional functional elements. There are lot of easily digestible sugars as glucose and fructose in date palm fruit [20]. It contains an appreciable amount of fibre and trace elements which include calcium, magnesium, potassium, phosphorus, selenium, and iron in addition to the vitamins such as niacin, ascorbic acid, and pyridoxine. Anthocyanins, phenolics, carotenoids, procyanidins and flavonoids which helps and serves as a defense against oxidative stress are the bioactive components that are found in date fruit [21]. This research helps to investigate utilization of unconventional grain such as o*fada* rice as breakfast cereal, with a view to increase its nutritional value by addition of protein-rich legume, cowpea flour using date palm fruit as sweetener.

2. Materials and Methods

2.1. Study Area

The product was developed at Flour Mills Nigeria Plc, Apapa, Lagos while analyses were carried out at the Food Science and Technology laboratory, Bells University of Technology, Ota, Nigeria between March and September, 2022

2.2. Material Collection and Equipment Used

Brown *ofada* rice grain was purchased from Panseke market in Abeokuta, Nigeria. White cowpea flour was sourced from Stapro Food Industries, Mushin, Lagos, Nigeria while the date palm fruit was purchased from Boundary market, Ajegunle, Lagos, Nigeria. The equipments were sourced from Flour Mills Nigeria Plc, Apapa, Lagos and these include Kompak KE19 Brabender single screw extruder with temperature up to 400 ^{o}C, Macpan MX5 mixer with 5 kg capacity, Perten laboratory hammer mill, Bastar laboratory attrition mill, Macpan rotary oven and Ohaus weighing scale.

2.3. Preparation of Ofada Rice and Date Fruit

The o*fada* rice grain was sorted, destoned and chaff removed. The hammer mill used for the milling of the grain was incorporated with 2.0 mm mesh size to get a very fine particle size distribution. The cleaned rice was then milled and recycled to get desired homogeneous particle size. The fruits were sorted and washed with potable water free of contamination. The seeds were separated from the fruit using a sterile knife, leaving only the fleshy part for drying. The oven was preheated at 50 ^{o}C. The fruits were then spread on stainless tray and place inside the preheated oven and dry overnight. The dried fruit was then milled after cooling to room temperature.

2.4. Formulation of the Flour for Extrusion

Sucrose was substituted with date fruit. The composite and recipe were formulated based on Nigerian Industrial Standard (NIS) as shown in Table 1.

Table-1. Formulation of composite flour and recipe

Sample	% Composite flour		% Recipe	
	Ofada rice	Cowpea	Composite flour	Date powder
B4KN	70	30	75	25
B3KM	65	35	75	25
B2KL	60	40	75	25
B1KK	55	45	75	25

B5KO – Go Grain from Kellogg Tolaram Nigeria Limited was used as control or reference sample.

2.5. Breakfast Meal from Ofada Rice and Cowpea

The screw and the corresponding die were fixed to the extruder, after which the extruder was preheated to 175 ^{o}C. The blended flour from each proportion was weighed separately. The weighed blended flour was conditioned with water to 20% moisture level before mixing. Each conditioned-blended flour was fed into the hopper where it discharged into the barrel at 50 rpm while the screw of the extruder was rotating at 100 rpm during extrusion

process. The extrudates were then collected into stainless trays and were dried inside the oven at 100 ^{o}C for three (3) hours. Extrudates were then cooled to room temperature and then milled with attrition mill.

2.6. Proximate Analysis

Samples were analyzed for proximate compositions to determine moisture content (MC), total ash (TA), crude protein (CP), ether extract (EE), crude fiber (CF), according to standard methods of AOAC [22] and carbohydrate content was determined using equation (1).

$$\%\ Carbohydrate = 100 - (\%\ MC + \%\ TA + \%\ CP + \%\ EE + CF) \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

2.7. Functional Properties

Bulk density and water absorption index of the milled samples were determined using the procedure explained by Yousf, *et al.* [23]. Swelling power and solubility index were also determined by the method described by Singh, *et al.* [24].

2.8. Determination of Pasting Property

The pasting viscosity was determined as a consideration to evaluate the variations that occur in the starch during the extrusion process. Rapid Visco Analyzer (RVA TECMASTER, Perten Instrument) was used to analyze the pasting properties of the milled extrudate. Peak, trough, final, breakdown and setback viscosities, pasting temperature, and time to reach peak viscosity were the parameters estimated.

2.9. Storability Test

The breakfast cereal samples were subjected to shelf study using accelerated method [25] for 6 weeks. Fifty (50) g x 6 sachets each of all the samples were weighed into an Aluminum Foil Polyethylene packaging material and stored inside humidity chamber set for 6 weeks. The temperature and the relative humidity were set to 40 ^{o}C and 75% respectively. Each sachet was subjected to moisture content, peroxide value, and free fatty acids analyses every week.

2.10. Sensory Evaluation

Consumer assessment for acceptability of breakfast cereal was carried out. Forty (40) people were selected randomly from staff of Bells University of Technology, Ota, Nigeria for the evaluation. These are regular consumers of breakfast cereal. A designed questionnaire was distributed among the forty respondents to score the following attributes: appearance, taste, aroma, texture, colour, aftertaste and overall acceptability on a Hedonic scale of 9 points namely 9 (like extremely), 8 (like very much), 7 (like moderately), 6 (like slightly), 5 (neither like nor dislike), 4 (dislike slightly), 3 (dislike moderately), 2 (dislike very much) and 1 (dislike extremely). Each of the samples was coded differently and placed in separate identical and transparent cup. Each of the samples was presented on a clean table at different times to each respondent to avoid any bias in judgement. Between samples, the respondents were given unsalted crackers and distilled water to wipe away their palates. The responses were collated to compare the consumer preferences of the *ofada* rice-cowpea breakfast cereal.

2.11. Statistical Analysis

All the analyses of this research work were done in triplicate. The data collected were subjected to statistical analysis while analysis of variance was carried out using SPSS 16, significant difference casted and means were split using Duncan's multiple range tests.

3. Results and Discussion

3.1. Proximate Composition of Extruded Products from Blends of Ofada Rice and Cowpea

The result of the proximate composition is shown in Table 2. The crude protein content of the experimented breakfast cereal samples analyzed ranged from 6.75% to 10.93% while the reference sample was 11.01%. This could be as a result of soybean inclusion in the reference sample as against cowpea in experimented samples. However, protein content increased as the proportion of cowpea increased. However, the values are higher than 5% recommended by Nigeria Industrial Standard for ready to eat composite cereals based products [26]. At 5% level of significance, there was significant difference in the protein content. The Crude Fat content of the experimented products analyzed ranged from 2.11% to 3.14% and was less than 3.66% obtained from reference sample. There was no significant difference in B3KM and B4KM samples.

The crude fiber content of the experimented cereal samples ranged from 7.00% to 9.00% and was far higher than the 2.00% value obtained from the control sample. High fiber content could be traced from the choice of *ofada* rice species used (brown *ofada* rice). Values from experimented samples vary significantly and were higher than 2.0% recommended by NIS for ready to eat breakfast from composite cereal. The result was in accordance with the value 6.07% to 9.08% reported by Okafor and Usman [1] in the production of breakfast cereal from blends of African yam bean, maize and defatted coconut.

Total ash content which is a reflection of availability of minerals in the breakfast cereal produced ranged from 1.07% to 1.81%. Although, this was relatively lower than 3.0% recommended by NIS and the variation could be as a result of processing method. The result revealed that there was significant difference in the values obtained from

experimented samples. The moisture content of the experimented breakfast cereal samples ranged from 1.59% to 3.68% as compared to the reference sample with 1.42%. However, the expected maximum moisture recommended by NIS is 4.5%. Reduced moisture level prevents microbial activities and extends shelf life of the food [27]. In the moisture level of sample B1KK and B3KM, no significant difference was noticed. Carbohydrate content of experimented samples ranged from 74.80% to 79.74% while that of control was 80.72%. However, there was significant difference in carbohydrate level of all the samples.

Table-2. Proximate composition of extruded products

Sample	Moisture content (%)	Ash content (%)	Crude fat (%)	Crude fiber (%)	Crude protein (%)	Carbohydrate (%)
B1KK	1.63^{b}±0.05	1.81^{c}±0.02	2.11^{a}±0.12	7.30^{c}±0.62	10.93^{d}±0.12	76.23^{b}±0.06
B2KL	1.73^{c}±0.02	1.71^{d}±0.01	3.14^{c}±0.08	9.00^{e}±0.79	9.63^{c}±0.09	74.80^{a}±0.02
B3KM	1.59^{b}±0.02	1.51^{b}±0.01	2.51^{b}±0.05	7.00^{b}±0.73	7.65^{b}±0.07	79.74^{d}±0.03
B4KN	3.68^{d}±0.03	1.07^{a}±0.05	2.46^{b}±0.03	8.50d±0.52	6.75^{a}±0.03	77.54^{c}±0.05
B5KO	1.42^{a}±0.06	1.18^{a}±0.03	3.66^{d}±0.11	2.00^{a}±1.01	11.01^{d}±0.05	80.72^{d}±0.15

Value are means ± standard deviation of triplicate reading. Values with the same superscript within the same column are not significantly different (P >0.05) from each other

Legend:
B1KK - *Ofada* rice flour: Cowpea flour (55:45)
B2KL - *Ofada*rice flour: Cowpea flour (60:40)
B3KM - *Ofada*rice flour: Cowpea flour (65:35)
B4KN - *Ofada* rice flour: Cowpea flour (70:30)
B5KO - Control Sample

3.2. Functional Properties of Extruded Products from Blends of Ofada Rice and Cowpea

The functional properties analyzed are bulk density, swelling power and water absorption index as shown in Table 3. The bulk density of the experimented cereal products ranged from 0.74 g/ml to 0.76 g/ml while that of control sample was 0.45 g/ml. Increased bulk density of experimented sample could be attributed to particle size distribution of the product. At 5% level of significance, there was no significant difference in the samples B1KK and B3KM. However, the values of experimented sample are higher than 0.60 g/ml - 0.66 g/ml reported by Kapoor and Haripriya [5]. This could be on the fact that the products are characterized with small inter-particle voids per unit volume of bed to facilitate shipping and good packaging of the products.

Water absorption index has been found to be important in determination of amount of water needed for rehydration or reconstitution of dried food products [28]. The water absorption index of the experimented cereal products showed no significant difference and ranged from 4 g/g to 5.34 g/g while that of control sample was 5.19 g/g. The swelling power obtained for the experimented samples ranged from 2.96 g/g to 3.46 g/g while that of the control was 5.86 g/g. The result revealed that at 5% level of significance, there was no significant difference in all the experimented samples except B2KL. High swelling power in the control sample might be traced to protein content.

Table-3. Functional properties of extruded products

Sample	Bulk Density (g/ml)	Water Absorption Index (g/g)	Swelling Power (g/g)
B1KK	0.74^{a}±0.02	4.40^{b}±0.01	3.08^{a}±0.01
B2KL	0.75^{ab}±0.01	5.34^{d}±0.02	3.46^{b}±0.10
B3KM	0.74^{a}±0.01	4.00^{a}±0.02	3.10^{a}±0.12
B4KN	0.76^{b}±0.00	4.89^{c}±0.03	2.96^{a}±0.07
B5KO	0.45^{c}±0.06	5.19^{d}±0.12	5.86^{c}±0.16

Value are means ± standard deviation of triplicate reading. Values with the same superscript within the same column are not significantly different (P >0.05) from each other

Legend:
B1KK - *Ofada* rice flour: Cowpea flour (55:45)
B2KL - *Ofada*rice flour: Cowpea flour (60:40)
B3KM - *Ofada*rice flour: Cowpea flour (65:35)
B4KN - *Ofada* rice flour: Cowpea flour (70:30)
B5KO - Control Sample

3.3. Pasting Properties of Extruded Products from Blends of Ofada Rice and Cowpea

The result of the pasting properties is presented in Table 4. These are properties of food as a result of variation in application of heat and water during processing. It was noticed that paste strength induced by swelling of the starch granules indicated the highest viscosity formed in the course of heating. Peak viscosity (cP), trough viscosity (cP) and final viscosity (cP) for BIKK, B2KL, B3KM and B4KN was 98, 93 and 118; 93, 91 and 113; 91, 89 and 109; and 93, 91 and 106 respectively. However, peak, trough and final viscosity for control sample, B5KO was 86 cP, 80 cP and 96 cP respectively. Lower value in the reference sample could be traced to low swelling capacity in maize.

Breakdown viscosity is a crucial parameter that often indicates stability of paste that food product can tolerate under heating and stress during processing. The breakdown viscosity of the experimented samples ranged from 2 cP to 5 cP while that of the control was 6 cP. High value of breakdown viscosity in control sample could affect

tendency of the flour to withstand heat and shear that might have caused variation in colour of the meal compared to products made from experimented samples as indicated in Figure 1. The breakdown viscosity value for experimented samples was lower than 5 cP to 7 cP reported by Asaam, *et al.* [29]. The variation could be as a result of difference in plant. Peak time for experimented sample ranged from 5.93 minutes to 6.87 minutes while that of the reference sample was 5.33 minutes. Comparatively, this was lower than 7.00 minutes reported as peak time in functional and pasting properties of yellow maize–soya bean–pumpkin composite flours and acceptability study of breakfast cereals by Asaam, *et al.* [29].

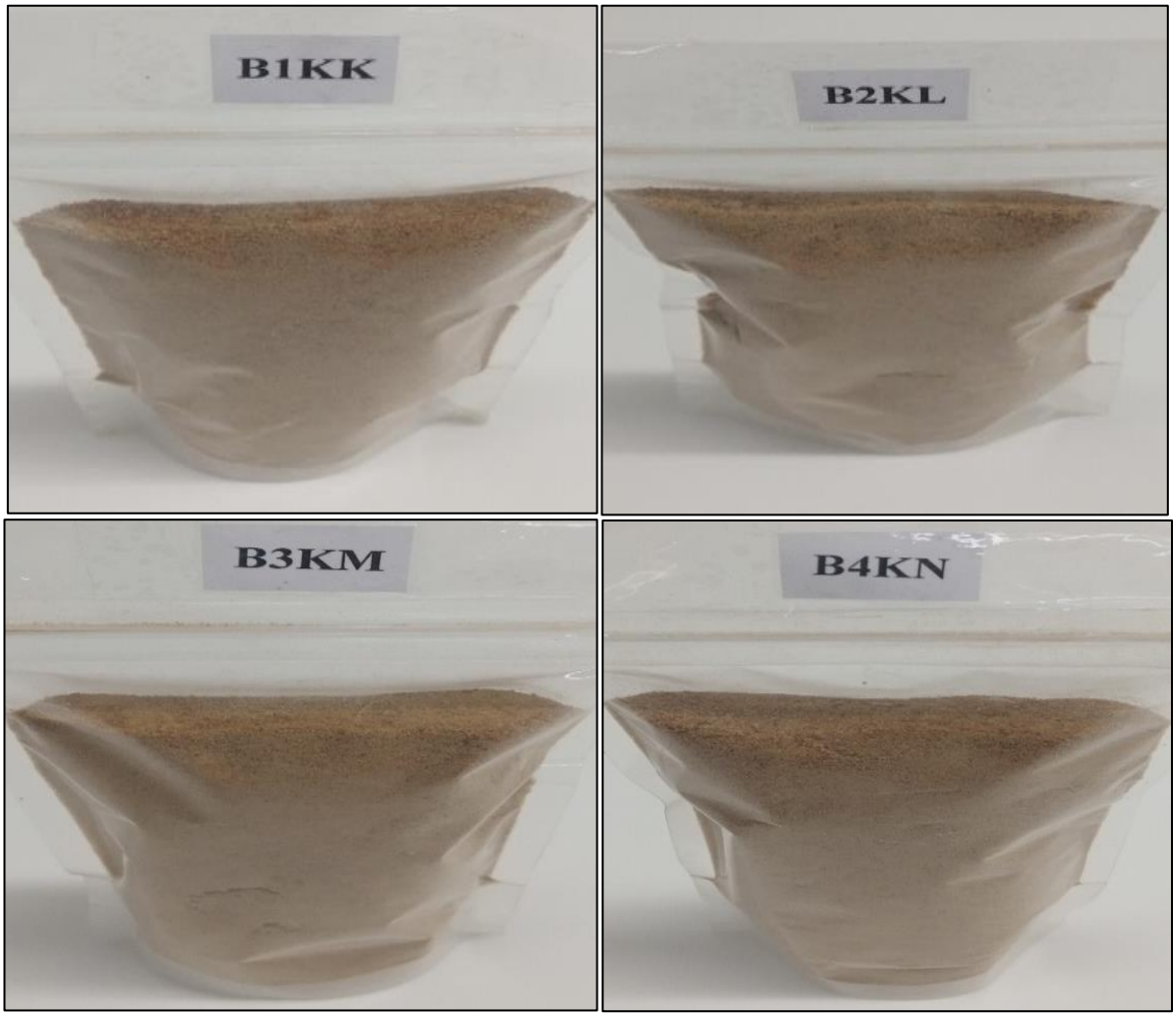
The setback viscosity is referred to as the distinction between the final viscosity and the trough viscosity [30, 31]. It is a function of retrogradation and gel stability. The setback viscosity of the breakfast cereals samples analyzed was found to range from 15 Cp to 25 cP while that of the control sample was 16 cP. Apparently, setback viscosity decreased as proportion of *ofada* rice increased. Obviously, this could be as a result of decrease in final viscosity. However, as the setback viscosity increases, the propensity for retrogradation to occur during cooling might also increased.

Table-4. Pasting properties of extruded products

Sample	Peak (Cp)	Trough (Cp)	Breakdown (cP)	Final Viscosity (cP)	Setback (cP)	Peak Time (min)
B1KK	98	93	5	118	25	6.87
B2KL	93	91	2	113	22	6.60
B3KM	91	89	2	109	20	6.67
B4KN	93	91	3	106	15	5.93
B5KO	86	80	6	96	16	5.33

Legend:
B1KK - *Ofada* rice flour: Cowpea flour (55:45)
B2KL - *Ofada*rice flour: Cowpea flour (60:40)
B3KM - *Ofada*rice flour: Cowpea flour (65:35)
B4KN - *Ofada* rice flour: Cowpea flour (70:30)
B5KO - Control Sample

Figure-1. Extruded meal products



B1KK - *Ofada* rice flour: Cowpea flour (55:45); B2KL – *Ofada* rice flour: Cowpea flour (60:40); B3KM - *Ofada*rice flour: Cowpea flour (65:35); B4KN - *fada* rice flour: Cowpea flour (70:30); B5KO - control sample

3.4. Shelf-Life Study of Extruded Products from Blends of Ofada Rice and Cowpea

The result of shelf-life study as presented in Table 5 showed that moisture content, free fatty acid and peroxide value of the experimented samples increased slightly during six weeks storage. Sample B3KL had highest moisture level 1.47% on the sixth week; sample B2KL had highest peroxide value 1.30 meq/kg on the sixth week of the storage; and sample B4KN had highest free fatty acid value 1.57 mg(KOH) / g on the sixth week of the experiment. The result was within the acceptable quality limits for peroxide value 1 – 10 limit; ≤ 4.5% moisture content; and ≤ 2 mg(KOH) / g free fatty acid [24].

Table-5. Result of moisture content, peroxide value and free fatty acid during storage of extruded products

Week	Parameter	B1KK	B2KL	B3KM	B4KN	B5KO
1	M	1.02	1.05	1.02	1.03	1.04
	PV	1.26	1.21	1.21	1.22	1.20
	FFA	1.26	1.32	1.31	1.32	1.31
2	M	1.03	1.05	1.02	1.03	1.04
	PV	1.24	1.21	1.21	1.22	1.21
	FFA	1.24	1.32	1.32	1.32	1.32
3	M	1.06	1.08	1.12	1.19	1.11
	PV	1.24	1.23	1.24	1.25	1.26
	FFA	1.26	1.32	1.36	1.37	1.37
4	M	1.04	1.16	1.15	1.16	1.16
	PV	1.26	1.26	1.27	1.26	1.26
	FFA	1.26	1.34	1.36	1.46	1.45
5	M	1.14	1.17	1.39	1.19	1.22
	PV	1.25	1.26	1.27	1.26	1.27
	FFA	1.25	1.44	1.54	1.56	1.51
6	M	1.17	1.18	1.47	1.19	1.23
	PV	1.27	1.30	1.29	1.27	1.27
	FFA	1.27	1.52	1.54	1.57	1.54

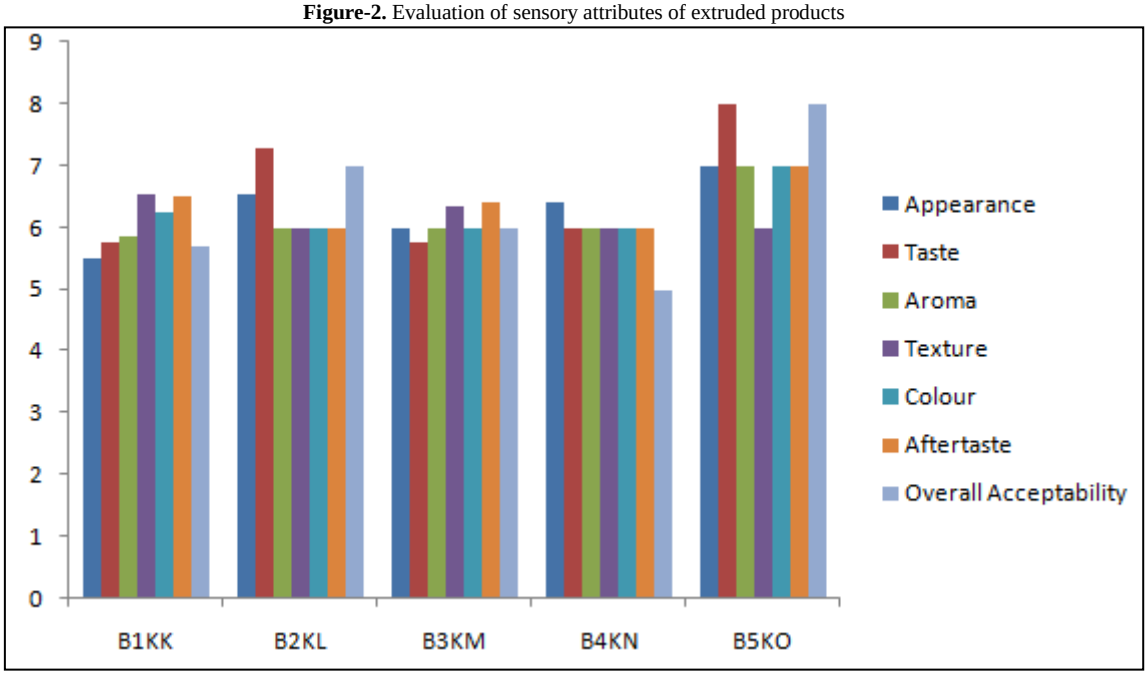
M = Moisture (%), PV = Peroxide value (meq/kg), FFA = Free fatty acid (mg (KOH)/g).
All measurement is in triplicates, mean values presented.
Legend:
B1KK - *Ofada* rice flour: Cowpea flour (55:45)
B2KL - *Ofada*rice flour: Cowpea flour (60:40)
B3KM - *Ofada*rice flour: Cowpea flour (65:35)
B4KN - *Ofada* rice flour: Cowpea flour (70:30)
B5KO - Control Sample

3.5. Sensory Evaluation of Extruded Products from Blends of Ofada Rice and Cowpea

Result of sensory analysis to evaluate sensory attributes such as appearance, taste, aroma, texture, colour, aftertaste and overall acceptability is shown in Figure 2. Control sample, B5KO was rated high in all the attributes except texture. The performance of experimented samples was in such a way that BIKK was rated high in texture, colour and aftertaste with 6.55, 6.25 and 6.50 respectively. B2KL was rated high in appearance, taste, aroma and overall acceptability with 6.55, 7.30, 6.00 and 7.00 respectively. The performance of B1KK and B2KL could be as a result of high proportion of cowpea in the research. Specifically, white cowpea variety used was found to be versatile, delicious and easily blend into recipes as healthy protein diet [17, 32]. However, B2KL, B3KM, and B4KN

were equally rated high in aroma and this could be attributed to aromatic nature of brown *ofada* rice. At 5% level of significance, in BIKK, no significant difference in appearance, taste and aroma as well as in colour, aftertaste and overall acceptability; in B2KL, no significant difference in texture, colour and aftertaste; in B3KM, no significant difference in taste, colour and aftertaste as well as in appearance, aroma and texture; in B4KN, no significant difference in texture, colour, aftertaste and overall acceptability as well as in taste and aroma.

Figure-2. Evaluation of sensory attributes of extruded products



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B2KL - *Ofada*rice flour: Cowpea flour (60:40)
B3KM - *Ofada*rice flour: Cowpea flour (65:35)
B4KN - *Ofada* rice flour: Cowpea flour (70:30)
B5KO - Control Sample

4. Conclusion and Recommendations

The results of this research have shown breakfast meal developed from unconventional grain, *ofada* rice blended with cowpea and date palm fruit as natural sweetener. The choice of cowpea was to give considerable amount of protein followed food recommended standard. Research investigation revealed that bulk density, water absorption, swelling power and the final viscosity of the products compared favourably with that of the reference sample from Kellogg Go Grain. Method of processing before and after extrusion enhances pasting properties of the products to justify comparative analysis with ready to eat product in the market. Low moisture, peroxide and fatty acid level reflects stability of the products and there was no off-flavour development in the products during the study period. Consumer perception of the breakfast cereal based products indicated that B2KL was most preferred and acceptable to the panelist and thus recommended for commercialization.

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Conflict of Interest

The authors declare that they have no known competing interests or personal relationship that could have appeared to influence the work presented in this paper.

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