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Evaluation of Optimal Flour Blends and Quality Acceptability of Dumpling Produced From Finger Millet, Bambara Groundnut and Khain Composite Flours

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Abstract
Blending flours from different plants have improved the nutrients composition of foods and have also brought to limelight the nutritional health benefits of some underutilized plants. This study aimed to determine the optimal flour blends of finger millet, bambara groundnut (BGN) and khain (Lecaniodiscus cupanioides) and quality acceptability of its dumplings. Finger millet, bambara groundnut and khain seeds were processed into flours and composites were formed by varying levels of khain (0 – 15 %) using 4 x 4 factorial in CRD. The composite flours were subjected to proximate composition, functional and pasting properties analysis. The optimal blends were determined based on high water absorption capacity, swelling capacity and high peak viscosity among other criteria suitable for dumpling production. The selected composite flours were used for dumpling production, and subjected to quality acceptability test using the 9-point hedonic scale. The study observed significant increased ($p<0.05$) in proteins, fats, fibre and ash content of the composite flours while moisture and carbohydrates decreased with respect to increase of BGN and khain in the blends. BGN addition decreased swelling power and solubility of the blends while khain incorporation increased swelling power of the composite flours. Interaction of both BGN and khain increased water absorption capacity and swelling power of the composite flours. Peak viscosity showed increase while peak time and temperature decreased as khain levels increased in the blends. Sample having 30% BGN scored higher in colour and was significantly different from the control. This implies that BGN addition improved the dumpling colour. All samples were rated high in overall acceptability and didn't show significant ($p>0.05$) difference. The study suggests that composite flours from varying levels of BGN (10 - 30 %) and khain (5 - 10 %) could produce acceptable dumplings.
Keywords: *Optimal flour blend, Pasting properties, Finger millet, Khain, Dumpling*

1.0 INTRODUCTION

Blending flours from different plants have been of research concern for years and have also contributed in curbing malnutrition and deficiencies in essential nutrients. Flour blend can be a mixture of cereal, legumes rich in protein and plant supplements (Usman and Okafor, 2016; Asaam *et al.,* 2018).

Reports have shown that some plants food could be used to manage diabetes in Nigeria, these include African bread fruit *(Treculia africana*) (Eleazu *et al.,* 2017), Plantain (*Musa paradisiacal*) (Ayodele and Erema, 2010; Friday *et al.*, 2016) and *Detarium microcarpam* (Onyechi, 2010), among others. However, the need to diversify food choice in order to minimize dietary monotony among diabetics have led to the search for other plant foods with anti-diabetic potentials such as high dietary fibre content of Finger millet, low glycemic index of Bambara groundnut (*Vigna subterranaean, L*.) and high phytochemical contents of *Lecaniodiscus cupanioides*.

Finger millet is an underutilized cereal with anti-diabetic potential and could store for longer period than other cereals. Finger millet has been used majorly for kunu (porridge) and burukutu (beverage) in northern Nigeria.

Bambara groundnut (*Vigna subterranea* (L.) Verdc) is a less utilized legume crop (Jideani and Diedericks, 2014). Its dietary fibre has great potential for food and other applications (Fasoyiro *et al*., 2012).

Lecaniodicus cupanioides is one of the underutilized large tropical perennial herbaceous vegetable plants, well known in ethno-medicine but not as food base despite its high beneficial phytochemical contents.

Developing a product from the flour composites of Finger millet, Bambara groundnut and *Lecaniodiscus cupanioides* (*Khain*) could bring these benefits into limelight, maximize exploitation of their benefits, improve nutrients composition, diversify their use and as a result add value to the indigenous plant foods.

Several studies have utilized blends of Finger millet/African Yam Bean/Wheat and Pearl millet/Bambara groundnut (Abioye *et al*., 2018; Agbara *et al*., 2018) in the production of foods, but there is therefore, paucity of information on the combination of Finger millet, Bambara groundnut and *'Khain'* (*Lecaniodiscus cupanioides)* seeds flours for dumpling production.

This study, therefore, seeks to determine the (i) optimal flour blends of Finger millet/Bambara groundnut and *Khain* (*Lecaniodiscus cupanioides*) suitable for dumpling production, (ii) proximate composition, functional and pasting properties of the flour blends and, (iii) quality acceptability of dumplings produced from the flour blends.

2. MATERIALS AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

2.1 Procurement of Raw Materials

Finger millet grains (*Eleusine coracana*) were purchased from Bukuru market in Jos, Plateau State Nigeria; Bambara groundnut seeds (*Vigna subterrenea*) were obtained from Mayo Lope market in Jalingo, Taraba State Nigeria; 'Khain' (*Lecaniodiscus cupanioides*) fruits were harvested from a forest in Lissam Sambo, Ussa, Taraba State Nigeria. Chemicals and reagents were procured from accredited chemical dealers.

2.2 Sample Preparation

Finger millet grains and Bambara groundnut seeds were cleaned, sorted to remove stones, dirt, chaffs, weeviled seeds and other extraneous matters. Khain fruits were sorted to remove immature ones.

2.2.1 Preparation of Finger Millet Flour

The preparation of Finger millet flour was done using the method of Jideani (2005). Finger millet seeds (10 Kg) were thoroughly washed using warm (65 ^{O}C) water, sun dried for 48 h, milled using attrition mill (Arttrition mill, De-Demark brand, model De-Demark super Gx 160.55), and passed through 600 µm sieve to obtain fine flour. The flour was heat sealed in polyethylene pouches and stored at room temperature until used for analysis.

2.2.2 Preparation of de-hulled Bambara groundnuts flour

Bambara groundnut flour was produced using the method described by Abdualrahman *et al.* (2012). The cleaned Bambara groundnuts (10 kg) seeds were soaked in water for 48 h, manually decorticated, sun dried, milled (Arttrition mill, De-Demark brand, model De-Demark super Gx 160.55) and sieved using 600 µm mesh sieve to obtain uniform particle size flour. The flour was heat sealed in polyethylene pouches and stored at room temperature until used.

2.2.3 Preparation of 'Khain' seed flour

The sorted, cleaned 'Khain' fruits (10 kg) were sun dried (36 ± 2 ^{O}C), cracked to remove the seeds. The seeds were further sun dried, milled (Attrition mill, De-Demark brand, model De-Demark super Gx 160.55) and sieved through a 600 µm mesh sieve. The flour was heat sealed in polyethylene pouches and stored until used for analysis and product formulation.

2.3 Blending of Finger millet, Bambara groundnut and *khain* (*Lecaniodiscus cupanioides*) flours

Composite flours of Finger millet (F) and Bambara groundnut (B) (FB_1 [90% Fm/10% BGN], FB_2 [80% Fm/20%BGN], FB_3 [70% Fm/30% BGN] and F [100 % Fm]) were blended with different levels (0-15) w/w of *khain* (*Lecaniodiscus cupanioides*) flour as shown in Table 1. The composite flours were evaluated for critical flour quality parameters such as water absorption capacity (WAC), bulk density (BD), swelling capacity (SC), and solubility (S), least gelation capacity (LGC) and pasting properties (PP). Eight best flour samples (FK_1, FK_2, FB_1K_1, FB_1K_2, FB_2K_1, FB_2K_2, FB_3K_1, and FB_3K_2) were selected based on high water absorption capacity, swelling capacity and good pasting properties and were used for dumpling production.

Table 1: Blends of finger millet, bambara groundnut and *khain* (*Lecaniodiscus cupanioides*)

SAMPLES	FB	Kh	TOTAL
F	100	0	100
	95	5	100
	90	10	100
	85	15	100
FB_1	100	0	100
	95	5	100
	90	10	100
	85	15	100
FB_2	100	0	100
	95	5	100
	90	10	100
	85	15	100
FB_3	100	0	100
	95	5	100
	90	10	100
	85	15	100

F = Finger millet (100 %), FB =Finger millet/Bambara groundnut, K= *Khain*

2.4 Production of Dumplings

The following composite flours were used for dumpling production; $\mathbf{FK_1}$ (95% Fm/5% Kh), $\mathbf{FK_2}$ (90% Fm/10% Kh), $\mathbf{FB_1K_1}$ (95% [90% Fm/10% BGN]/5% Kh), $\mathbf{FB_1K_2}$ (90% [90% Fm/10% BGN]/10% Kh), $\mathbf{FB_2K_1}$ (95% [80% Fm/20%bBGN]/5% Kh), $\mathbf{FB_2K_2}$ (90% [80% Fm/20% BGN]/10% Kh), $\mathbf{FB_3K_1}$ (95% [70% Fm/30% BGN]/5% Kh), $\mathbf{FB_3K_2}$ (90% [70% Fm/30% BGN]/10% Kh)

2.4.1 Product formulation

Dumplings were produced using flour and water as follows: flour blends (100-200 g), Water (200 ml).

2.4.2 Dumplings Production

The selected flour blends were used in producing dumplings using the method of Onyeakagbu (2018). Water (150 ml) was poured into a clean pot and allowed to boil on high heat. Sample flour (50 g) was stirred into a bowl containing 50 ml of cold water with a wooden ladle continuously until a smooth consistency is achieved. When the water in the pot has boiled, the heat of the cooker was reduced to medium heat and the slurry (water and flour) was poured into the boiling water. The slurry was stirred for about 1-2 min and allowed to cook for 1 min on low heat. The slurry was then stirred continuously with addition of flour until the desired texture is attained, then the heat was turned off and the meal served.

2.5 Proximate Composition

The proximate composition (Moisture, Ash, Fat, Crude Fibre, Protein, Carbohydrate and Energy value) of flour blends of finger millet, bambara groundnut, and *khain* (*Lecaniodiscus cupanioides*) were determined according to the method of AOAC, (2010).

2.6 Functional Properties

2.6.1 pH determination

The pH of the food samples was measured with a Mettler Delta 350 pH meter using the method described by Onwuka, (2005). The sample homogenates were prepared by blending 10 g sample in l00 ml of deionized water. The mixture was filtered and the pH of the filtrate was measured. Triplicate readings were taken for each sample.

2.6.2 Bulk density determination

Bulk density was determined for each of the formulated samples using the method described by Onwuka, (2005). Each sample was slowly filled into l0ml measuring cylinder. The bottom of the cylinder was gently tapped on a laboratory bench until there was no further diminution of the sample after filling to l0 ml mark. Bulk density was estimated as mass per unit volume of the sample (g/ml). Triplicate measurements were taken. Bulk density was calculated thus:

$$BD = \frac{Mass\ of\ sample}{Volume\ obtained} - - - - - - - - - - - - - 1$$

2.6.3 Water absorption capacity (WAC)

Water absorption capacity was determined according to the modified method of Gandhi and Srivastava, (2007). One gram of the sample was mixed with 10ml distilled water in centrifuge tubes and then allowed to stand for 30 minutes. Sample was centrifuged at 2,000 rpm for 30 minutes. The supernatant was discarded and the tube weighed. Water absorption capacity (grams of water per gram sample) was calculated using the formula:

$$WAC = \frac{W_2 - W_1}{W_0} - - - - - - - - - - - - 2$$

Where: W_0 = Weight of dry sample (g), W_1 = Weight of tube and dry sample (g), W_2 = Weight of tube plus sediment (g)

2.6.4 Least gelation concentration (LGC)

Gelation capacity was determined by the method described by Onwuka (2005). Sample suspension of different concentrations was prepared in 5ml distilled water in test tubes. The sample test tubes were heated for 1 hour in boiling water bath followed by rapid cooling under running cold tap water. Further cooling of the test tubes was done for 2 hours at $4^{O}C$. The least gelation concentration was taken as the concentration when the sample from the inverted test tube did not fall or slip visually.

2.6.5 Swelling Capacity and Solubility

Swelling capacity and Solubility of flour samples were determined by the method described by Crosebie (1991). Two grams of the sample was measured into a test tube of known weight. Distilled water (15ml) was added to the sample and heated in a water bath at $60^{O}C$ for 30 min with constant stirring. The slurries were centrifuged using a Super-speed centrifuge (Model No. L-708-2, Philips Drucker, Oregon, USA) at 168xg for 15 min, the supernatant was decanted into a weighed evaporating dish and dried at $100^{O}C$ for 20 min. The difference in weight of the evaporating dish was used to calculate flour solubility. Swelling capacity was obtained by weighing the residue after centrifugation and dividing by the original weight of flour on dry weight basis. SC will be calculated as;

$$Swelling\ capacity\ (\%) = \frac{Final\ weight - Initial\ weight}{weight\ of\ sample} \times \frac{100}{1} ---------- 3$$

2.7 Pasting properties of flour samples

The pasting properties: Peak viscosity, Trough viscosity, Breakdown viscosity, Final viscosity, Setback viscosity, Peak time, and Pasting temperature were determined using the Rapid Visco-Analyzer (RVA Model 4500, Perten Instrument, Australia) according to Eriksson (2014). Rapid Visco-Analyzer (RVA) General Pasting Method (STD1) was used and the determinants were carried out in duplicate. The moisture content of the flour was predetermined. Approximately 3 g of flour was mixed with 25 ml of distilled water in a canister. The amount of water added to each sample was based on the moisture content of the sample. The paddle was placed into the canister containing the sample. The sample was inserted in the RVA. The total running time was recorded and the viscosity values were recorded as the temperature was increased from 50 ^{O}C to 95 ^{O}C before cooling to 50 ^{O}C again. Rotation speed was set to 960 rpm for the first 10 s and to 160 rpm until the end.

2.8 Product Acceptability Evaluation

The selected flour blends were used in producing dumplings by the method of Onyeakagbu (2018) as in 2.4.2 (Dumpling production) above.

Organoleptic evaluation of the prepared dumpling samples was carried out using 15 semi-trained panelists (students of department of Food Science and Technology, University of Agriculture, Markurdi; MAUTECH Yola; FUTMIN Minna and TSU Jalingo) who were familiar with quality attributes of dumplings. The samples were not served with soup or stew; they were coded and presented in identical containers. The panelists scored the products for colour, texture/stiffness, malleability/finger-feel, stickiness, flavor and overall acceptability on a 9-point Hedonic scale (Ihekoronye and Ngoddy, 1985). Each panelist indicated his/her level/degree of liking for each parameter on the questionnaire on a scale ranging from 9 = like extremely, through 5 = neither like nor dislike, to 1 = dislike extremely

2.9 Experimental Design

The experiment was carried out using a 4x4 factorial in Complete Randomized Design (CRD) to determine the optimal flour blends of Finger millet, Bambara groundnut and *Lecaniodiscus cupaniodes* suitable for dumpling production. The selection was done based on high water absorption capacity, swelling capacity and good pasting properties for dumpling production.

2.10 Statistical analysis

Split-plot analysis (using Genstat discovery edition 4) was used to analyze data from evaluation of optimal flour blends while data obtained from product acceptability were subjected to one-way analysis of variance (ANOVA) using the SPSS software version 23. Means were separated by Duncan's New Multiple Range Test (DNMRT) at 5 % level of significance ($p < 0.05$).

3. RESULTS AND DISCUSSION

3.1 Proximate composition of finger millet, bambara groundnut and *khain* (*Lecaniodicus cupanioides*) composite flours

3.1.1 Effect of composite flour of finger millet and bambara groundnut (FM/BGN) on the proximate composition of finger millet, bambara groundnut and khain (Lecaniodicus cupanioides) (FM/BGN/Kh) composite flours

Table 2 (Main plot effect) showed the effect of composite flour (FM/BGN) on the proximate composition of the flour blends of finger millet, bambara groundnut and *khain* (FM/BGN/Kh). There were significant ($p<0.05$) differences in the values of all the proximate parameters observed among samples. All the parameters showed increases with respect to BGN addition, except for moisture and carbohydrates contents that decreased. This showed that the composite flours of FM/BGN contributed to the changes in the proximate composition of the flour blends of FM/BGN/Kh. (Table 2). Suggesting that blending flours could improve the proximate composition of product made from cereal/legumes composites as observed by other reseachers (Abioye *et al.*, 2018; Yusuf and Ejeh, 2018).

Table 2: Effect of composite flour of finger millet and bambara groundnut on proximate composition of finger millet, bambara groundnut and *khain* (*Lecaniodicus cupanioides*) composite flours (Main plot effect)

PARAMETERS (%)	FM	FB_1	FB_2	FB_3	LSD
Protein	7.01^d	8.67^c	9.74^b	12.59^a	0.01
Moisture	10.99^a	10.70^b	10.47^c	10.11^d	0.01
Fat	4.28^d	4.38^c	4.58^b	4.80^a	0.02
Fiber	2.21^d	2.32^c	2.51^b	2.59^a	0.02
Ash	2.05^d	2.13^c	2.16^b	2.21^a	0.01
CHO	73.48^a	71.80^b	70.54^c	67.83^d	0.04
Energy (Kcal.)	360.46^d	361.30^c	362.37^b	364.88^a	0.21

Value with the same super script on the same row were not significantly ($p>0.05$) different. FM=100%Fingermillet, FB1=90%FM/10%BGN, FB2=80% FM/20%BGNFB3=70%FM/30%BGN, LSD=Least significant difference, CHO – Carbohydrate

3.1.2 Effects of khain levels (Kh) on the proximate composition of finger millet, bambara groundnut and khain (Lecaniodiscus cupanioides) (FM/BGN/Kh) composite flours

The effect of *khain* levels on the proximate composition of FM/BGN/Kh composite flours was shown in Table 3 (Sub-plot effect).

Addition of khain levels showed significant ($p<0.05$) effect on the proximate composition of the flour blends. This indicates that khain addition also contributed to the changes in the proximate composition of the flour blends of FM/BGN/Kh even among the different levels of *khain* incorporation in all the parameters observed. The protein, fat, fiber, ash and energy contents of the blends increased while carbohydrate and moisture contents decreased with increasing levels of *khain* in the blends. This showed that addition of *khain* flour contributed to these nutrients contents and also the high fibre content of *khain* was responsible for the decreased in moisture content. Fiber absorbs water in the blends resulting to low moisture content. High moisture could lead to low keeping quality of the flours. Saleh *et al*. (2013) suggested acceptable moisture level of < 12 % for flours.

Table 3: Effect of *khain* levels on the proximate composition of finger millet, bambara groundnut and *khain* (*Lecaniodiscus cupanioides*) composite flours (Sub-plot)

		KHAIN LEVELS			
PARAMETERS (%)	Kh (0%)	Kh (5%)	Kh (10%)	Kh (15%)	LSD
Protein	8.65^d	9.66	9.81^b	9.89^a	0.01
Moisture	10.72^a	10.64^b	10.52^c	10.40^d	0.01
Fat	4.33^d	4.44^c	4.57^b	4.71^a	0.02
Fiber	2.27^d	2.39^c	2.45^b	2.52^a	0.02
Ash	2.09^d	2.13^c	2.15^b	2.18^a	0.01
CHO	71.96^a	70.74^b	70.59^c	70.35^d	0.04
Energy	361.38^c	361.56^c	362.68^b	363.38^a	0.21

Value with the same super script on the same row were not significantly ($p>0.05$) different. Kh- *Lecaniodiscus cupanioides* (*Khain*), LSD=Least significant difference, CHO – Carbohydrates

3.1.3 Interaction effect of both composite flour of finger millet and bambara groundnut (FM/BGN) and khain levels (Kh) on the proximate composition of finger millet, bambara groundnut and khain (Lecaniodiscus cupanioides) (FM/BGN/Kh) composite flours

The interaction effect of composite flour (FM/BGN) and *khain* levels on the proximate composition of FM/BGN/Kh composite flours were presented in Table 4.

From Table 4, the combine effect of composite flour of Fm/BGN and *khain* levels showed significant ($p<0.05$) increase on the protein, fat, ash and fiber content of the blends (FM/BGN/Kh). The interaction effect of the *khain* levels and the composite flour (FM/BGN) impacted an increasing effect on the above mentioned nutrients. On the other hand, significant ($p<0.05$) decrease was observed in moisture and carbohydrate as the levels of *khain* and BGN increased in the blends. Moisture decreased in samples with higher BGN addition. This is associated with the hydrophilic substances in BGN such as protein that could bind water making it unavailable. Low moisture content prevents growth of microorganisms and enhances shelf-life of product. Omah and Okafor, (2015) and Agbara *et al.* (2018) also observed decreased moisture in flour blends.

Table 4: Interaction effect of composite flour (FM/BGN) and *khain* levels on the proximate composition of finger millet, bambara groundnut and *khain* (*Lecaniodiscus cupanioides*) composite flours

			Flour blends			Parameters		
F/B	K	Protein	Moisture	Fat	Ash	Fiber	CHO	Energy
FM	0	6.13^{d}	11.07^{a}	4.19^{c}	2.03^{c}	2.11^{d}	74.55^{a}	360.43^{a}
	5	7.18^{c}	11.03^{b}	4.27^{b}	2.04^{bc}	2.20^{c}	73.28^{b}	360.24^{a}
	10	7.32^{b}	10.96^{c}	4.30^{b}	2.06^{ab}	2.25^{b}	73.12^{c}	360.43^{a}
	15	7.40^{a}	10.91^{d}	4.37^{a}	2.08^{a}	2.29^{a}	72.96^{d}	360.74^{a}
FB_1	0	8.30^{d}	10.84^{a}	4.28^{c}	2.07^{c}	2.23^{c}	72.28^{a}	360.81^{c}
	5	8.68^{c}	10.76^{b}	4.31^{c}	2.14^{b}	2.29^{b}	71.82^{b}	360.76^{c}
	10	8.80^{b}	10.68^{c}	4.42^{b}	2.16^{ab}	2.32^{b}	71.62^{c}	361.46^{b}
	15	8.90^{a}	10.50^{d}	4.53^{a}	2.17^{a}	2.44^{a}	71.47^{d}	362.17^{a}
FB_2	0	9.29^{d}	10.60^{a}	4.37^{d}	2.12^{c}	2.33^{d}	71.28^{a}	361.64^{c}
	5	9.78^{c}	10.51^{b}	4.55^{c}	2.15^{b}	2.48^{c}	70.53^{b}	362.22^{b}
	10	9.92^{b}	10.47^{c}	4.65^{b}	2.16^{b}	2.58^{b}	70.23^{c}	362.41^{b}
	15	9.99^{a}	10.31^{d}	4.75^{a}	2.19^{a}	2.64^{a}	70.12^{d}	363.19^{a}
FB_3	0	10.88^{d}	10.35^{a}	4.47^{d}	2.17^{d}	2.40^{d}	69.73^{a}	362.66^{c}
	5	13.00^{c}	10.25^{b}	4.64^{c}	2.19^{c}	2.59^{c}	67.32^{b}	363.04^{c}
	10	13.20^{b}	9.97^{c}	4.89^{b}	2.23^{b}	2.64^{b}	67.40^{b}	366.40^{b}
	15	13.29^{a}	9.87^{d}	5.20^{a}	2.26^{a}	2.71^{a}	66.87^{c}	367.41^{a}
LSD		0.02	0.03	0.05	0.02	0.04	0.08	0.41

Key: Value with the same super script on the same column within groups were not significantly (p>0.05) different. FM (100% Finger millet), FB1 (90%FM/10%BGN), FB2 (80%FM/20%BGN), FB3 (70%FM/30%BGN), K (*Khain* flour levels (%)), CHO – Carbohydrate

3.2 Functional properties of finger millet, bambara groundnut and *khain* (*Lecaniodiscus cupanioides*) composite flours

3.2.1 Effect of composite flour of finger millet and bambara groundnut on the functional properties of finger millet, bambara groundnut and khain (Lecaniodiscus cupanioides) composite flours (Main plot effect)

The effect of composite flour (FM/BGN) on the functional properties of the flour blends of FM/BGN/Kh was presented in Table 5.

Composite flours FM (100 % finger millet), FB_1 (90 % finger millet/10 % BGN), FB_2 (80 % finger millet/20 % BGN) and FB_3 (70 % finger millet/30 % BGN) had significant ($p<0.05$) effect in all the functional attributes measured. All the parameters measured significantly ($p<0.05$) decreased as BGN levels in the blends increased. This could be attributed to the presence of protein in BGN which competes with starch molecules over available water thereby interfering with the solubility and swelling of the starch. However, water absorption capacity of the composite flours significantly ($p<0.05$) increase as BGN levels in the blends increased. Protein in BGN contributed to the high absorption of water observed between the composite flours and the FM (control). Blending of FM/BGN increased WAC of flour which was similar to the observations of Awolu, (2017). WAC is vital in bulking and consistency of product and gives an indication of quantity of water available for gelatinization of starch (Edema *et al.*, 2005). High WAC makes dumpling soft and sticky.

Table 5: Effect of composite flour of finger millet and bambara groundnut on the functional properties of finger millet, bambara groundnut and *khain* (*Lecaniodiscus cupanioides*) composite flours (Main plot effect)

PARAMETERS	FM	FB_1	FB_2	FB_3	LSD
B/D (g/ml)	0.71^a	0.69^b	0.66^c	0.64^c	0.00
pH	6.63^a	6.43^b	6.31^c	6.32^d	0.01
Solubility (%)	5.40^a	5.02^b	4.59^c	4.13^d	0.13
SP (%)	376.75^a	326.15^b	312.78^c	304.03^d	1.71
WAC (g/g)	2.10^d	2.35^c	2.58^b	2.69^a	0.01

Key: Value with the same super script on the same row were not significantly (p>0.05) different. FM=100%Finger millet, FB1=90%FM/10%BGN, FB2=80% FM/20%BGN, FB3=70% FM/30%BGN, LSD=Least significant difference, WAC=Water absorption capacity, SP=Swelling Power, BD=Bulk Density

3.2.2 Effect of khain levels on the functional properties of finger millet, bambara groundnut and khain composites (Sub-plot effect)

The effect of *khain* levels on the functional properties of flour blends of finger millet, bambara groundnut and *khain* was shown in Table 6.

Khain incorporation into the blend significantly (p<0.05) affected all the functional attributes measured. Significant (p<0.05) decrease was observed in bulk density, pH, and solubility with increase in *khain* levels. However, swelling power and water absorption capacity significantly (p<0.05) increased as *khain* levels increased in the blends. This could be attributed to the soluble fiber in *khain* which resulted to its high swelling power and water absorption capacity as shown in Table 6. This agreed with the observations of Arueya, (2018) that *Khain* contains soluble dietary fibre (elastic fibres or mucilage) which can bind and retain water several times their weight, up to 15 %.

Table 6: Effect of *khain* levels on the functional properties of finger millet, bambara groundnut and *khain* (*Lecaniodiscus cupanioides*) composite flour (Sub-plot effect)

	KHAIN LEVELS				
PARAMETERS	0 %	5 %	10 %	15 %	LSD
BD (g/ml)	0.9108^a	0.6763^b	0.5663^c	0.5442^c	0.00220
pH	6.6600^a	6.3542^b	6.3533^b	6.3167^c	0.00710
Solubility (%)	7.7270^a	4.4520^b	3.7520^c	3.2180^d	0.1312
SP (%)	248.31^d	317.91^c	364.38^b	389.13^a	1.707
WAC (g/g)	2.0367^d	2.1653^c	2.5957^b	2.9253^a	0.00740

Value with the same super script on the same row were not significantly (p>0.05) different. BD=Bulk Density, Kh- *Lecaniodiscus cupanioides* (*Khain*), LSD=Least significant difference, WAC=Water absorption capacity, SP=Swelling Power

3.2.3 The interaction effect of composite flour of finger millet, bambara groundnut and khain levels on the functional properties of finger millet, bambara groundnut and khain (Lecaniodiscus cupanioides) composite flours

The result of the interaction effect of composite flour (FM/BGN) and *khain* levels on the functional properties of finger millet (Fm), bambara groundnut (BGN) and *khain* (*Lecaniodiscus cupanioides*) composite flours were shown in Table 7.

The interaction of composite flours (FM/BGN) and *khain* levels showed significant (p<0.05) effect on the functional properties of the blends (FM/BGN/Kh). The combine effect of composite flours with *khain* levels decreased bulk density, pH and solubility of the blends. This could be due to the low bulk density and solubility of *khain*. BGN and *khain* have finer and light weight flour particle size and the insoluble protein in BGN contributed to the low solubility of the composite flours. The combine effect of Fm/BGN and *khain* levels increased the swelling power and water absorption capacity of the flour blends. The interaction of *khain* levels with Fm/BGN increased swelling power of the blends contrary to the decreased shown with BGN addition in Table 5. This is owned to the high WAC of *khain* which could make available water for starch to swell effectively. This confirmed the observations of Arueya, (2018) that *Khain* contains soluble dietary fibre (elastic fibres or mucilage) which can bind and retain water several times their weight, up to 15 %. High swelling power and water absorption capacity are important attributes of dumplings.

Table 7: Interaction effect of composite flour of finger millet, bambara groundnut and *khain* levels on the functional properties of finger millet, bambara groundnut and *khain* (*Lecaniodiscus cupanioides*) composite flours

F/B	K	Bulk density (g/ml)	pH	Solubility (%)	Swelling power (%)	Water Absorption Capacity (g/g)
FM	0	0.92ᵃ	6.60ᶜ	8.60ᵃ	268.05ᵈ	1.99ᵈ
	5	0.72ᵇ	6.52ᵈ	5.00ᵇ	328.97ᶜ	2.03ᶜ
	10	0.61ᶜ	6.73ᵃ	4.50ᶜ	432.00ᵇ	2.13ᵇ
	15	0.59ᵈ	6.67ᵇ	3.50ᵈ	478.00ᵃ	2.26ᵃ
FB_1	0	0.92ᵃ	6.72ᵃ	8.50ᵃ	252.60ᵈ	2.03ᵈ
	5	0.69ᵇ	6.42ᵇ	4.60ᵇ	321.00ᶜ	2.15ᶜ
	10	0.59ᶜ	6.26ᵈ	3.80ᶜ	359.00ᵇ	2.23ᵇ
	15	0.55ᵈ	6.32ᶜ	3.20ᵈ	372.00ᵃ	2.99ᵃ
FB_2	0	0.91ᵃ	6.70ᵃ	7.55ᵃ	242.11ᵈ	2.05ᵈ
	5	0.68ᵇ	6.23ᵇ	4.21ᵇ	313.50ᶜ	2.21ᶜ
	10	0.55ᶜ	6.16ᶜ	3.50ᶜ	336.50ᵇ	2.87ᵇ
	15	0.52ᵈ	6.14ᶜ	3.11ᵈ	359.00ᵃ	3.19ᵃ
FB_3	0	0.89ᵃ	6.62ᵃ	6.26ᵃ	230.47ᵈ	2.08ᵈ
	5	0.62ᵇ	6.25ᶜ	4.00ᵇ	308.17ᶜ	2.27ᶜ
	10	0.52ᶜ	6.27ᵇ	3.20ᶜ	330.00ᵇ	3.15ᵇ
	15	0.51ᵈ	6.14ᵈ	3.06ᶜ	347.50ᵃ	3.26ᵃ
LSD		0.004	0.01	0.26	3.41	0.02

Key: Value with the same super script on the same column within groups were not significantly (p>0.05) different. FM -100% Finger millet, FB1 - 90%FM/10%BGN, FB2 - 80%FM/20%BGN, FB3 - 70%FM/30%BGN, K - *Khain* flour levels, BGN- Bambara groundnut

3.3 Pasting properties of composite flours of finger millet, bambara groundnut and *khain* (*Lecaniodiscus cupanioides*)

3.3.1 Effect of composite flours (finger millet/bambara groundnut) on the pasting properties of finger millet, bambara groundnut and khain (Lecaniodiscus cupanioides) composite flours (Main plot effect)

The result of the effect of composite flours (finger millet/bambara groundnut) on the pasting properties of the flour blends of FM/BGN/Kh were presented in Table 8.

The effect of composite flours (FM/BGN) on peak viscosity of the flour samples were not significant ($p<0.05$). Addition of BGN did not alter the peak viscosity of the flour blends (see Table 8). However, breakdown viscosity of the flour samples increased while trough viscosity, final viscosity and set back viscosity decreased as BGN levels increased in the flour blends. This implies that BGN addition could reduce the flour's ability to remain undistorted when allowed to a hold period of constant high temperature and mechanical stress by rapid and continuous mixing as observed by James *et al.* (2018). This also signifies the instability of BGN starches under hot condition and could disintegrate due to continuous stirring and shearing at constant temperature.

Composite flours (FM/BGN) have significant ($p<0.05$) effect on the peak time and pasting temperature but the effect at different levels of BGN addition were not significant ($p>0.05$). The pasting temperature increased with BGN addition in the flour blends, while peak time for the flours to form gel decreased. The high temperature resulted to the quick rupture of the starch granules for gelatinization thereby reducing the peak (cooking) time. This is desired in dumpling making.

Table 8: Effect of composite flour (finger millet/bambara groundnut) on the pasting properties of finger millet, bambara groundnut and *khain* (*Lecaniodiscus cupanioides*) composite flours (Main plot effect)

PARAMETERS	FM	FB_1	FB_2	FB_3	LSD
PV (RVU)	367.9^a	382.6^a	375.9^a	368.1^a	20.51
TV (RVU)	245.4^a	238.1^a	219.6^b	212.6^b	10.85
BDV (RVU)	122.5^c	144.6^b	156.4^a	155.5^{ab}	11.11
FV (RVU)	366.6^a	372.2^a	352.0^b	337.0^c	11.48
SBV (RVU)	121.39^d	134.32^a	131.77^b	124.38^c	2.41
PT (min.)	5.46^a	5.28^b	5.28^b	5.27^b	0.09
Temp. (^OC)	64.45^b	66.91^a	67.24^a	68.08^a	1.37

Key: Value with the same super script on the same row were not significantly ($p>0.05$) different. FM - 100% Finger millet, FB1 - 90%FM/10%BGN, FB2 - 80% FM/20% BGN, FB3 - 70%FM/30%BGN, PV- Peak viscosity, TV-Trough viscosity, BDV- Breakdown viscosity, FV- Final viscosity, SBV- Set back viscosity, PT- Peak time, Temp - Pasting temperature, BGN- Bambara groundnut

3.3.2. Effect of khain levels on the pasting properties of finger millet, bambara groundnut and khain (Lecaniodiscus cupanioides) composite flours (Sub-plot effect)

The result of the effects of *khain* levels on the pasting properties of FM/BGN/Kh composite flours were shown in Table 9.

The result showed significant ($p<0.05$) difference in all the pasting properties of the flours. *Khain* at 5 % level of addition showed significant ($p<0.05$) increase in all the parameters measured except pasting temperature. Peak viscosity increased at 5 % and 10 % levels of *khain* addition but decreased at 15 % level. This could be attributed to high water absorption capacity of *khain* (Table 6). High WAC makes dumpling soft and sticky. Peak viscosities attained during the heating portion of samples indicates the water binding capacity of the composite flours. *Khain* addition lowers peak time and pasting temperature at 15 % level. The low pasting temperature/short time is not suitable for dumpling dough. High temperature is required to enable rupture of starch molecules to form gel.

Table 9: Effect of *khain* levels on the pasting properties of finger millet, bambara groundnut and *khain* (*Lecaniodiscus cupanioides*) composite flours (Sub-plot effect)

	KHAIN LEVELS				
PARAMETERS	0 %	5 %	10 %	15 %	LSD
PV (RVU)	289.0^c	403.2^a	420.4^a	381.8^b	20.5
TV (RVU)	166.1^c	232.5^b	255.5^a	261.6^a	10.85
BDV (RVU)	123.3^b	170.8^a	164.8^a	120.2^b	11.1
FV (RVU)	275.2^c	362.0^b	394.3^a	396.4^a	11.48
SBV (RVU)	108.77^d	129.53^c	138.79^a	134.76^b	2.41
PT (min.)	5.33^b	5.55^a	5.39^b	5.11^c	0.09
Temp (^OC)	78.29^a	77.05^a	54.87^b	50.48^c	1.37

Key: Value with the same super script on the same row were not significantly ($p>0.05$) different. PV- Peak viscosity, TV-Trough viscosity, BDV- Breakdown viscosity, FV- Final viscosity, SBV- Set back viscosity, PT- Peak time, Temp - Pasting temperature

3.3.3 Interaction effect of composite flour (finger millet/bambara groundnut) and khain levels on the pasting properties of finger millet (FM), bambara groundnut (BGN) and khain (Lecanioidiscus cupanioides) composite flours

The interaction effects of composite flour (Fm/BGN) and *khain* levels on the pasting properties of finger millet (FM), bambara groundnut (BGN) and *khain* (*Lecanioidiscus cupanioides*) composites were shown in Table 10.

The interaction of composite flour (Fm/BGN) and *khain* levels showed significant ($p<0.05$) effects in all the pasting parameters measured. The interaction between flour composite (F/B) and *khain* levels showed increase in peak viscosity at 5 % and 10 % *khain* addition but decreased at 15 % in all the composite flours (FB). This could be due to the high WAC of protein and fiber in BGN and *khain*. Peak time and pasting temperature decreased as Fm/BGN and *khain* levels interact and had the lowest values at 15 % *khain* addition in all the composite flours (Fm/BGN) (Table 10). Composite flours with 15 % *khain* level of addition were not suitable for flours used in dumpling production due to low peak viscosity, low pasting temperature and short peak time properties.

Table 10: Interaction effect of composite flours (finger millet/bambara groundnut) and *khain* levels on the pasting properties of finger millet, bambara groundnut and *khain* (*Lecaniodiscus cupanioides*) composite flours

F/B	*Khain* Levels	PV (RVU)	TV (RVU)	BDV (RVU)	FV (RVU)	SBV (RVU)	PT (min)	TEMP. (^{O}C)
FM	0	268.1^{c}	178.7^{c}	89.5^{d}	299.7^{d}	121.07^{b}	5.597^{ab}	98.35^{a}
	5	343.9^{b}	227.6^{b}	116.3^{c}	341.2^{c}	113.60^{c}	5.667^{a}	78.36^{g}
	10	418.9^{a}	280.1^{a}	188.8^{a}	395.7^{b}	115.60^{c}	5.457^{b}	50.76^{b}
	15	440.7^{a}	295.2^{a}	145.5^{b}	429.9^{a}	134.67^{a}	5.137^{c}	50.40^{b}
FB_1	0	285.5^{c}	171.8^{c}	114.4^{b}	282.7^{c}	111.57^{c}	5.300^{b}	77.45^{a}
	5	435.5^{a}	248.4^{b}	181.1^{a}	384.8^{b}	136.4^{b}	5.537^{a}	76.97^{a}
	10	441.1^{a}	260.5^{ab}	180.6^{a}	414.6^{a}	154.10^{a}	5.270^{b}	62.50^{b}
	15	368.2^{b}	271.7^{a}	96.5^{b}	406.9^{ab}	135.17^{b}	5.000^{c}	50.73^{c}
FB_2	0	300.7^{c}	157.9^{c}	142.8^{b}	270.8^{c}	110.87^{c}	5.237^{b}	78.28^{a}
	5	419.8^{a}	226.8^{b}	193.1^{a}	361.4^{b}	134.77^{b}	5.400^{ab}	76.65^{a}
	10	430.0^{a}	250.1^{a}	179.9^{a}	397.8^{a}	147.70^{a}	5.437^{a}	51.65^{b}
	15	353.2^{b}	243.8^{ab}	109.4^{c}	378.2^{ab}	134.40^{b}	5.057^{c}	50.38^{b}
FB_3	0	301.9^{c}	156.0^{b}	145.9^{bc}	247.6^{b}	96.90^{b}	5.200^{c}	79.08^{a}
	5	413.8^{a}	227.2^{a}	186.6^{a}	360.5^{a}	133.37^{a}	5.600^{a}	76.23^{b}
	10	391.5^{ab}	231.4^{a}	160.2^{b}	369.1^{a}	137.77^{a}	5.430^{ab}	54.63^{c}
	15	365.1^{b}	235.9^{a}	129.2^{c}	370.7^{a}	134.80^{a}	5.267^{bc}	50.40^{d}
LSD		41.71	22.05	22.70	23.02	4.820	0.1854	2.731

Key: Value with the same super script on the same column within groups were not significantly ($p>0.05$) different. FM - 100% Finger millet, FB1 - 90%FM/10%BGN, FB2 - 80% FM/20% BGN, FB3 -70%FM/30%BGN, PV- Peak viscosity, TV-Trough viscosity, BDV- Breakdown viscosity, FV- Final viscosity, SBV- Set back viscosity, PT- Peak time, Temp - Pasting temperature, BGN- Bambara groundnut.

3.4 Least gelation concentration (LGC)

The least gelation concentration (LGC) of the composite flours was shown in Table 11.

Sample FB_2K_2 (90 % [80 % finger millet/20 % BGN] and 10 % *khain*) had the lowest least gelation concentration (LGC) of 7 % but was not significantly ($p>0.05$) different from the other samples. The low LGC among samples with higher *khain* levels could be due to the soluble dietary fibre (elastic fibres or mucilage) content of *khain* which can bind and retain water several times their weight and served as binder as observed by Arueya, (2018). LGC obtained ranged from 7 – 10 % w/v. This implies that the flours obtain in this study have moderate LGC, meaning that little quantity of the flours would be needed to form stable gel. An LGC guide is the measurement of the ratio of flour to water in dumpling production. These values compared favorably with those (4 - 14%) reported for cereal/legumes/tubers composites (Ohizua *et al*., 2017; Awolu *et al.,* 2017; Chandra *et al.*, 2015). Least gelation concentration (LGC) measures the least or lowest amount of flour needed to form a gel in a measured volume of water. It is also the lower protein concentration at which gel remained in the inverted tube. It varies from flour to flour and the variation is attributed to the ratios of the different constituent such as protein, carbohydrates and lipids in different pulse/legume flours; this implies that interaction between such components may also have a significant role in functional properties (Aremu *et al.*, 2007). Low LGC is required for better gelling ability of the flour (Ohizua *et al.*, 2017).

3.5 Sensory evaluation of dumplings produced from composite flours of finger millet, bambara groundnut and *khain* (*Lecaniodiscus cupanioides*)

The sensory evaluation of dumplings produced from composite flours of finger millet (FM), bambara groundnut (BGN) and *khain* (*Leconiodiscus cupanioides*) are represented in Table 11.

Statistically, significant ($p<0.05$) difference was observed in the malleability of the dumplings among samples. However, colour, stickiness, texture/stiffness, flavour and overall acceptability of the dumplings were not significantly ($p>0.05$) different among samples. This showed that inclusion of BGN and *khain* did not affect the sensory qualities of the dumplings when compared with the control except for malleability.

Colour is an important index in food quality which influences the consumer's sense of judgment. Consumers are most times moved by what they see. Colour and appearance of food play very important role in food selection because it gives consumer the first impression. In this study there was no significant ($p>0.05$) difference in colour among dumplings of composite flours samples. Sample containing 95 % (70 % finger millet/30 % BGN) and 5 % *khain* (FB_3K_1) and sample containing 90 % (70 % finger millet/30 % BGN) and 10 % *khain* (FB_3K_2) were rated higher (7.40 and 7.70 respectively) compare to the control (100 % finger millet), this showed that addition of BGN enhanced the dumpling colour by reducing the intensity of the dark brown colour of finger millet. The dumplings colour obtained in this study had comparable colour ratings with dumplings from Ofada rice/plantain flour blends (Arueya, 2018).

In term of texture/stiffness, significant ($p>0.05$) difference was not observed among the samples though they varied in scores. Addition of BGN and *khain* did not cause notable effect on texture. Samples were rated higher in texture by the panelists compare to the report of Arueya, (2018) on texture of Ofada rice/plantain flour blends, this could be attributed to the reduction in viscosity during holding period, breakdown/disintegration of starch granules and low setback viscosity indicating less susceptibility to retrogradation (Table 9) resulting into soft dumpling dough that was preferred by the panelists. Sample containing 95 % finger millet and 5 % *Khain* (FK_1) has the highest score (7.50) on texture among the blends.

Sample FK_1 was perceived as the best in terms of malleability; sensory score was 8.30, while the least score was given to sample FB_3K_1 (6.65) owning to the high protein and oil in BGN. These interfere with the elasticity and shorten the dough. High amylose in BGN leads to retrogradation thereby producing stiff and hard dough. Significant ($p<0.05$) differences existed among samples in malleability. However, some samples showed similarities in behavior. Sample FK_1 and control (Fm) are similar. This means that *khain* inclusion at 5 % level did not alter the malleability of the dumpling.

There were no significant ($p>0.05$) differences in flavour among samples as perceived by the panelists. Though sample FB_3K_2 (90 % [70 % finger millet/30 % BGN] and 10 % *khain*) was rated higher (7.00) than the others. Sensory scores for both malleability and flavour of samples as rated by panelists in this study were higher compared to what was rated for same in Ofada rice/ plantain dumplings (Arueya, 2018).

The result for the stickiness showed there were no significant ($p<0.05$) differences among the samples as rated by the panelists (Table 11). However samples with higher BGN and *khain* inclusion were rated lower compared to those with higher finger millet by the panelist. The low rating could be due to the high PV of BGN and *khain*

as a result of high water absorption capacity (Table 10). High water absorption capacity of flour produces sticky dough. The overall acceptability of all the samples were statistically not significant (p>0.05). Sample FB_3K_2 had the least score (6.85) while sample FK_1 and sample containing 95% (90 % Finger millet/10 % BGN) and 5 % *Khain* (FB_1K_1) were preferred (7.35) samples in overall acceptability among blends.
A careful look at the sensory scores indicated that all the samples were much liked when compared with the control.

Table 11: Sensory evaluation of dumplings produced from the selected composite flours of finger millet, bambara groundnut and *khain* (*Lecaniodiscus cupanioides*)

Samples	Colour	Texture/ Stiffness	Malleability	Stickiness	Flavour	Overall Acceptability	LGC
FM	$6.35^{c} \pm 1.18$	$8.00^{a} \pm 0.80$	$8.30^{a} \pm 0.87$	$8.00^{a} \pm 0.97$	$6.35^{a} \pm 1.04$	$7.50^{a} \pm 1.10$	$10.0^{a} \pm 0.00$
FK_1	$6.55^{c} \pm 0.89$	$7.50^{ab} \pm 1.10$	$8.30^{a} \pm 0.87$	$7.55^{abc} \pm 1.15$	$6.70^{a} \pm 0.98$	$7.35^{a} \pm 0.93$	$10.0^{a} \pm 0.00$
FK_2	$6.60^{c} \pm 1.19$	$7.05^{bc} \pm 1.23$	$7.60^{b} \pm 0.60$	$7.60^{ab} \pm 1.05$	$6.80^{a} \pm 1.20$	$7.25^{a} \pm 1.07$	$9.0^{a} \pm 0.00$
FB_1K_1	$6.40^{c} \pm 1.05$	$7.05^{bc} \pm 1.15$	$7.50^{b} \pm 0.69$	$6.85^{bcd} \pm 1.14$	$6.65^{a} \pm 1.31$	$7.35^{a} \pm 0.93$	$10.0^{a} \pm 0.00$
FB_1K_2	$6.70^{bc} \pm 0.98$	$7.20^{bc} \pm 1.01$	$7.35^{bc} \pm 0.93$	$6.85^{bcd} \pm 0.93$	$6.55^{a} \pm 1.10$	$7.20^{a} \pm 0.83$	$8.0^{a} \pm 0.00$
FB_2K_1	$6.55^{c} \pm 1.28$	$6.75^{c} \pm 0.72$	$6.80^{cd} \pm 1.01$	$6.80^{cd} \pm 1.06$	$6.45^{a} \pm 1.05$	$6.90^{a} \pm 0.97$	$10.0^{a} \pm 0.00$
FB_2K_2	$6.80^{bc} \pm 1.01$	$7.15^{bc} \pm 0.99$	$7.10^{bcd} \pm 1.07$	$6.55^{d} \pm 1.15$	$6.95^{a} \pm 1.23$	$7.05^{a} \pm 1.05$	$7.0^{a} \pm 0.00$
FB_3K_1	$7.40^{ab} \pm 1.14$	$7.15^{bc} \pm 0.88$	$6.65^{d} \pm 0.93$	$6.80^{cd} \pm 1.20$	$6.90^{a} \pm 1.29$	$7.25^{a} \pm 1.16$	$10.0^{a} \pm 0.00$
FB_3K_2	$7.70^{a} \pm 1.22$	$6.60^{c} \pm 1.14$	$6.80^{cd} \pm 1.24$	$6.80^{cd} \pm 1.32$	$7.00^{a} \pm 1.34$	$6.85^{a} \pm 0.88$	$8.0^{a} \pm 0.00$

Key: Value with the same super script on the same column were not significantly (p>0.05) different. FM = Control (100% FM), FK1 = 95%FM/5%Kh, FK2 = 90%FM/10%Kh, FB1K1 = 95%(90%FM/10%BGN)/5%Kh, FB1K2 = 90%(90%FM/10%BGN)/10%Kh, FB2K1= 95%(80%FM/20%BGN)/5%Kh, FB2K2 = 90%(80%FM/20%BGN)/10%Kh, FB3K1 = 95% (70%FM/30%BGN)/5%Kh, FB3K2 = 90%(70%FM/30%BGN)/10%Kh, LGC = Least gelation capacity, FM - Finger millet, BGN - Bambara groundnut, Kh – Khain

4. CONCLUSION

Blending bambara groundnut and khain increased the protein, fats, ash and fibre content of the composite flours while moisture and carbohydrates decreased. Addition of khain flour to the blends increased WAC and swelling power of the resultant composite flours due to the soluble dietary fibre in *khain*.

Khain addition at 15 % level had low peak viscosity, low pasting temperature and short peak time properties. These functional attributes were not suitable for flours used in dumpling production. Addition of BGN to the composite flours could enhance the dumplings colour while khain substitutions improved the texture of dumpling produced from the composite flours.

It was observed that composite flours made from varying levels of BGN (10 -30 %) and khain (5 - 10 %) could produce acceptable dumplings.

RECOMMENDATION

Further research should be carried out on optimal determination of finger millet, bambara groundnut and khain (*lecaniodiscus cupanioides*) composite flours using the response surface methodology.
Application of composite flours of finger millet, bambara groundnut and khain (*lecaniodiscus cupanioides*) into other food system such as porridge, snacks, instant breakfast cereals, noodles etc.

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COMPETING INTERESTS

The authors declared that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AUTHORS' CONTRIBUTIONS

''Ibrahim Doris Gideon' designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript, managed the analyses of the study, managed the literature searches, reviewed and edited the manuscript and Ani Jane Chinyere' supervised the study, reviewed and edited the manuscript'. All authors read and approved the final manuscript."

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