

# Processing Treatments of Beniseed (*Sesamum indicum* Linn) on Nutrients, Anti-Nutrients Composition and Functional Properties of Flour

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## Abstract

Beniseed is an important oilseed, with high oil content and nutrient composition. The effect of processing (roasting, soaking, boiling, and germination) on proximate, mineral composition, anti-nutrients and functional properties of the beniseed flour were analysed. Also the sensory properties of cookies from blends of wheat and beniseed flours were determined. The results showed that moisture, fat, crude protein, carbohydrate, ash and crude fibre contents of the flours were significantly different and ranged from 3.20% - 4.79%, 34.34% - 50.43%, 15.19% - 30.65%, 18.90% - 22.16%, 4.54% - 6.01% and 4.30% - 7.59%, respectively. Processing significantly ( $p < 0.05$ ) reduced the anti-nutritional factors and germination gave the highest mineral values in the beniseed flours. Water absorption capacity, oil absorption capacity, foaming stability, foaming capacity and swelling index, ranged from 1.00 - 1.28, 1.10 - 1.13, 98.72 - 108.82, 2.94 - 19.80 and 1.14 - 1.54 respectively. Sensory evaluation showed that 20% soaked beniseed flour substitution of wheat had no significant difference with 100% wheat cookies. Germinated sample gave a more desired nutrient composition (low fat and carbohydrate, high protein and mineral composition) but performed poorly in sensory attributes. In conclusion, beniseed gave a good flour blend with wheat in baked products, also further processing of the germinated flour to improve the appearance will give more nutritious cookies.

## Keywords

Beniseed, Functional, Nutrients, Processing

## 1. Introduction

The development of an adequate substitute for wheat will help in cost reduction of baked products. Wheat which is the cereal of choice and has a good amount of gliadin and glutenin (special protein) when processed into a dough with water produce gluten which is an elastic substance important in yeast or aerated baked products [1]. Wheat can be substituted with available, cheap and good legumes or oilseed flour. Such composite flours from legumes and oilseed have high protein content and caloric value [2].

Beniseed or sesame called *Sesame indicum* botanically is among the oilseeds grown worldwide. The chemical composition of sesame seed shows that it is rich in oil (44% - 58%), protein (18% - 25%) and ash (5%) but poor in carbohydrate (13.5%) [3]. It is a desired soup ingredient in Nigeria most especially in the north region, middle belt and some parts of the eastern states. Beniseed contains approximately 50% oil of very high quality (oleic, linoleic, palmitic, stearic in the following ranges (35.9% - 47%), (35.6% - 47.6%), (8.7% - 13.8%), (2.1% - 6.4%) respectively as well as arachidic acids (0.1% - 0.7%). It also contains 25% protein which is rich in methionine and tryptophan [4]. Its oil is a natural salad oil requiring little or no winterization and is reported to be among the few vegetable oils used directly without refining process. Beniseed has not only nutritional benefits but also medicinal properties. Its oil contains some phytonutrients such as omega-6 fatty acids, flavonoid phenolic anti-oxidants, vitamins and dietary fibre with potent anti-cancer and generally health promoting properties. The seed is being regarded as healthy energy food for production of liver cells and prevention of aging. It is also used to manage respiratory, cholera, diarrheal, dysentery, bowel infections and bladder disease [5].

Cereal based food products (such as biscuits and bread) are very popular in Nigeria for all age groups, especially among school children. However, one major disadvantage of such food products is poor protein source with poor nutritional quality [6]. This is so because wheat flour is the major ingredient in baked product and composed as follows: carbohydrates (78.10%), protein (14.70%), fat (2.10%), minerals (2.10%) and considerable proportions of vitamins (thiamine and vitamin-B) and minerals (zinc, iron) [7]. Beniseed contains a lot of nutrients but its usability as ingredient in some food formulations may be hindered due to the presence of anti-nutrients. These anti-nutrients mainly found in the seed hulls have adverse effect on the mineral availability in human nutrition [8]. Reducing the anti-nutrients through processing prior to consumption will aid bio-availability of those nutrients. The main objective of this work is to determine the effect of processing methods on nutrients, anti-nutrients and functional property of beniseed flour.

## 2. Materials and Methods

### 2.1. Source of Materials

Beniseed (*Sesamum indicum*) was purchased from Eke Imoha market Ebonyi

State, Nigeria. The experiment was conducted in the laboratory of Food Science Technology Michael Okpara University of Agriculture Umudike, Abia State Nigeria.

## 2.2. Sample Preparation

Beniseed was sorted, washed and air dried. It was then divided into five portions of equal weight (500 g) and was subjected to different treatments.

A portion of beniseed was put into water (1000 ml), dehulled by rubbing with the palms and separated by sedimentation, dried (Uniscope lab oven, model SM9023 ENGLAND) at 50°C and processed into flour. The sample was referred to as unprocessed beniseed flour (UBF). A second portion was soaked in distilled water at ratio of 1:10 (w/v) at room temperature (25°C ± 2°C) for 12 h dehulled, air rested, dried and milled into flour and designated soaked beniseed flour (SBF). The third portion was soaked in water for 2 h to achieve hydration and spread thinly on trays lined with wet filter paper for germination. It was partially dehulled (because it was difficult to remove all the seed coat), air rested, oven dried, milled and designated as germinated beniseed flour (GBF). A fourth portion (500 g) of the beniseed was soaked in water (1:5 w/v) for 4 h dehulled, air rested and roasted in a hot air oven (Uniscope Lab oven, Model SM9023 ENGLAND) at 120°C for 1 h cooled, milled and designated roasted beniseed flour (RBF). The last portion was dehulled after soaking in water (1:5 w/v) for 4 h, boiled at 100°C for 30 min at seed to water ratio of 1:10 (w/v). Consequently, the seeds were dried in an oven at 50°C cooled, milled and designated as boiled beniseed flour (BBF).

Wheat flour (WF) was also produced from wheat grain after sorting, washing, draining, oven drying, cooling, milling and sieving.

## 2.3. Composite Flour Formulation

Wheat and beniseed flour blends were formulated as shown in **Table 1**. Samples were stored at ambient temperature (28°C ± 2°C) in airtight plastic containers until required.

## 2.4. Cookies Formulation

Recipe formulation for cookies production was shown in **Table 2**.

## 2.5. Production of Cookies

The cookies were baked using the method of [9] with slight modification. Fat and sugar were creamed to a smooth consistency; eggs and milk were added and mixed. The dry ingredients; flour, baking powder and salt were mixed together and added to the cream followed by vanilla flavour and nutmeg, it was manually mixed (with hands in a stainless bowl) to form dough. The dough was kneaded into uniform thickness on a rolling board and cut into a uniform diameter of 50 mm using a cookie cutter. They were placed in greased pans and egg washed.

**Table 1.** Percentage composition for wheat and beniseed composite flours.

SAMPLE CODES	WF	SBF	GBF	RBF	BBF	UBF
WF1001	100	-	-	-	-	-
WSB010	90	10	-	-	-	-
WSB020	80	20	-	-	-	-
WSB030	70	30	-	-	-	-
WGB030	90	-	10	-	-	-
WGB020	80	-	20	-	-	-
WGB030	70	-	30	-	-	-
WRB010	90	-	-	10	-	-
WRB020	80	-	-	20	-	-
WRB030	70	-	-	30	-	-
WBB010	90	-	-	-	10	-
WBB020	80	-	-	-	20	-
WBB030	70	-	-	-	30	-
WUB010	90	-	-	-	-	10
WUB020	80	-	-	-	-	20
WUB030	70	-	-	-	-	30

Where: WF: Wheat Flour, SBF: Soaked Beniseed Flour, GBF: Germinated Beniseed Flour, RBF: Roasted Beniseed Flour, BBF: Boiled Beniseed Flour, UBF: Unprocessed Beniseed Flour, WF1001: 100% WF; WSB010: 90% WF: 10% SBF; WSB020: 80% WF: 20% SBF; WSB030: 70% WF: 30% SBF; WGB010: 90% WF: 10% GBF; WGB020: 80% WF: 20% GBF; WGB030: 70% WF: 30% GBF; WRB010: 90% WF: 10% RBF; WRB020: 80% WF: 20% RBF; WRB030: 70% WF: 30% RBF; WBB010: 90% WF: 10% BBF; WBB020: 80% WF: 20% BBF; WBB030: 70% WF: 30% BBF; WUB010: 90% WF: 10% UBF; WUB020: 80% WF: 20% UBF; WUB030: 70% WF: 30% UBF.

**Table 2.** Recipe for cookies formulation.

Ingredients	Quantity (g)
Composite flour (Wheat flour and Beniseed flour)	200
Margarine Fat (Assudamal Group Haano Cooking Margarine)	72
Sugar (Dangote refined granulated white sugar)	64
Powdered milk (Dano instant filled milk powder)	74
Egg	80
Baking powder (SSCL Royal Crown active baking powder)	2
Nutmeg	2
Salt	1

The cookies were baked at 180°C for 20 min. The cookies were removed and allowed to cool on a rack, after which they were packaged in low-density polyethylene bags and kept in a plastic container at ambient temperature (28°C ± 2°C) prior to evaluation.

### 3. Proximate Composition of Beniseed Flour

Moisture, crude protein, fat, crude fibre and ash contents of beniseed flour were determined according to [10] while carbohydrate was estimated by difference [*i.e.* 100% – protein (%) + fat (%) + crude fibre (%) + Ash (%)].

#### 3.1. Determination of Minerals

The dry ashing of the beniseed flour was carried out according to [10] as described by [11]. Calcium, Iron, Potassium, were determined using atomic absorption spectrophotometer (Buck Scientific, Model 210). Phosphorus was determined using the Spectrophotometre.

#### 3.2. Analysis of Anti-Nutrients: Oxalate, Phytates and Tannins

Oxalate and phytate were determined by the [10], method. Tannins were determined by the method described by [12].

#### 3.3. Analysis of Functional Properties

The procedures for determination of oil absorption capacity (OAC), water absorption capacity (WAC), swelling capacity (SC), foam capacity and stability (FC/FS) was by [10].

#### 3.4. Determination of Sensory Properties of Cookies

A total of 20 panelists who were familiar with the quality attributes of cookies, regular consumers of cookies and non-allergic to any cookies were recruited from staff and students of the Department of Food Science and Technology, Michael Okpara University of Agriculture Umudike, Abia State. Each panelist evaluated all the samples prepared for each treatment in one session. Panelists were instructed to evaluate appearance and colour first and then Taste each sample to evaluate flavour, texture, crispness, and general acceptability. A nine-point Hedonic scale was used with 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely [13]. Samples were identified with three-digit code numbers and presented to panelists. The panelists were instructed to rinse their mouths with water after testing every sample.

#### 3.5. Statistical Analysis

All data obtained were computed, expressed as mean  $\pm$  standard deviation, analyzed using SPSS One-way analysis of variance using ANOVA. Significant differences between the means were determined by Duncan's Multiple Range test.

## 4. Result and Discussion

The result of proximate composition of the beniseed flour sample in **Table 3** showed that moisture content ranged from 3.20% - 4.79%. Unprocessed, soaked and boiled flour samples had no significant ( $p > 0.05$ ) difference in moisture content while roasted and germinated had the lowest and highest significant ( $p <$

**Table 3.** Proximate composition of beniseed flour samples.

Samples	Moisture (%)	Fats (%)	Protein (%)	Fibre (%)	Ash (%)	Carbohydrate (%)	Energy value (Kcals)
UBF	3.37 <sup>bc</sup> ± 0.15	47.66 <sup>c</sup> ± 0.09	19.17 <sup>c</sup> ± 0.03	4.50 <sup>b</sup> ± 0.04	5.30 <sup>c</sup> ± 0.07	20.21 <sup>c</sup> ± 0.26	586.40 <sup>c</sup> ± 0.92
RBF	3.20 <sup>c</sup> ± 0.23	49.63 <sup>b</sup> ± 0.03	15.73 <sup>d</sup> ± 0.03	4.56 <sup>a</sup> ± 0.18	5.38 <sup>b</sup> ± 0.01	21.54 <sup>b</sup> ± 0.21	594.37 <sup>b</sup> ± 1.45
SBF	3.60 <sup>b</sup> ± 0.20	42.46 <sup>b</sup> ± 0.09	19.65 <sup>b</sup> ± 0.05	4.50 <sup>b</sup> ± 0.07	4.54 <sup>d</sup> ± 0.06	22.16 <sup>a</sup> ± 0.11	553.35 <sup>d</sup> ± 1.26
BBF	3.53 <sup>bc</sup> ± 0.31	50.43 <sup>b</sup> ± 0.04	15.19 <sup>e</sup> ± 0.03	4.32 <sup>c</sup> ± 0.02	4.62 <sup>d</sup> ± 0.01	21.92 <sup>ab</sup> ± 0.35	606.84 <sup>a</sup> ± 1.36
GBF	4.79 <sup>a</sup> ± 0.20	34.34 <sup>b</sup> ± 0.07	30.65 <sup>a</sup> ± 0.04	4.30 <sup>c</sup> ± 0.03	6.01 <sup>a</sup> ± 0.01	18.90 <sup>d</sup> ± 0.30	507.26 <sup>e</sup> ± 0.55

\*Values are mean ± standard deviation of triplicate determinations. Means with different superscripts within the same column are significantly different ( $p < 0.05$ ). Keys: UBF: Unprocessed Beniseed Flour RBF: Roasted Beniseed Flour SBF: Soaked Beniseed Flour BBF: Boiled Beniseed Flour GBF: Germinated Beniseed Flour.

0.05) values respectively for moisture. The moisture content of the flours was within the range of 0% - 13% reported to be appropriate for cereal and flour storage without microorganism degradation of the triglyceride [8].

The crude fat content ranges from 34.34% in germinated to 50.43% in boiled beniseed flour. There were significant differences ( $p < 0.05$ ) in the fat content of flour samples. The higher value for fat content in boiled beniseed may be due to the breaking up of the cell structure and cell wall of the seeds at high temperature during boiling or roasting making the fat to dissolve and easy to be released from the seeds. These values are in agreement with the values between 41.3% and 56.8% reported by [14] for raw beniseed. The decrease in the value of fat for germinated sample agree with earlier report by [15], that reduction in fat content increases as germination progresses. This reduction might also be due to activities of lipolytic enzymes as germination progresses. Such enzymes hydrolyse fat to fatty acids and used as a source of energy for the developing embryo during germination [15]. The high fat value of beniseed flour compares favourably with other oilseeds used commercially [16]. So beniseed will be economically viable if oil is commercially extracted from it. The observed reduction in fat content of germinated sample indicates a better and longer shelf life.

The crude protein content varied significantly ( $p < 0.05$ ) among the samples. Boiled sample had the least protein value (15.19%) while the germinated beniseed flour had the highest value (30.65%). The quantity of nitrogen compounds in the unprocessed beniseed makes it an excellent source of plant protein, if bio-available and quickly digested by the human body. Reduction in protein content of the boiled beniseed flour is attributed to the leaching of soluble protein into water [17]. From the result germination significantly increased the protein content when compared to the other samples. This agrees with earlier work of increased protein content during germination of various cereals, legumes and oilseeds [15]. The protein difference may be due to a net synthesis of enzyme (proteases) by germinating seeds.

The crude fibre content differed significantly ( $p < 0.05$ ) in some samples. It's lowest in germinated sample (4.30%) but roasted (5.56%) sample had the highest. Previous report showed that food (diet) low in crude fibre is not suitable as it

may cause bloating of the intestine or constipation. Also such low fibre diets have been linked to diseases of the colon such as piles, appendicitis and cancer. The crude fibre content compared favourably with the value (4.28%) for soya bean reported by [8].

Ash content was observed to be significantly different ( $p < 0.05$ ) among samples, the highest ash content was found in the germinated flour. This could be due to the inclusion of the sprouted roots and endogenous enzyme breaking down of complex organic compounds which releases more nutrients [18]. The energy values of the samples were significantly different ( $p < 0.05$ ), boiled beniseed contained the highest energy value. The energy values obtained in this study were similar to 563 kcals which [19] reported for whole beniseed and compared it with groundnut (605 kcals), soybean (452.4 kcals), watermelon seed (576.1 kcals) among others [20]. High energy food products function as a protective agent for other nutrients in the food [21].

The results of mineral analysis of processed beniseed flour showed significant ( $p < 0.05$ ) difference in the samples (see **Table 4**). The most abundant element in the samples was calcium followed by phosphorus, potassium and iron. All the minerals had highest ( $p < 0.05$ ) values in germinated beniseed flour.

Calcium as a micronutrient is important to health and bodybuilding. It has various biological functions in the body. It acts as; a messenger for almost all biological processes, makes protein stable and used for bones ossification and impulse transmission nerve. Potassium is a very useful constituent of body cells which help the muscles to function appropriately [17]. In all cases however, the values obtained for minerals in all the samples met the recommended daily requirements for both children and adults [22].

In **Table 5** phytate contents of beniseed flour were affected significantly ( $p < 0.05$ ) by the processing methods (0.60% - 0.63%) when compared with the unprocessed beniseed flour (0.73%). The reduction in phytate level in boiled and roasted samples may not likely be as a result of destruction of compound, but may rather be its complex forming ability with protein molecules and minerals as a result of change in chemical reactivity [23]. The lowest ( $p < 0.05$ ) oxalate level was recorded in the boiled sample (0.17%). The surprise increase of oxalate

**Table 4.** Result of mineral composition of beniseed flour samples (mg/100g).

Samples	Calcium	Phosphorus	Potassium	Iron
UBF	175.66 <sup>c</sup> ± 0.03	39.79 <sup>b</sup> ± 0.02	29.61 <sup>d</sup> ± 0.01	1.33 <sup>c</sup> ± 0.03
RBF	151.83 <sup>d</sup> ± 0.03	35.53 <sup>d</sup> ± 0.02	30.84 <sup>c</sup> ± 0.03	2.02 <sup>b</sup> ± 0.01
SBF	175.92 <sup>b</sup> ± 0.02	37.63 <sup>c</sup> ± 0.02	30.87 <sup>b</sup> ± 0.02	2.03 <sup>b</sup> ± 0.02
BBF	125.55 <sup>e</sup> ± 0.02	35.21 <sup>e</sup> ± 0.02	23.71 <sup>e</sup> ± 0.01	0.92 <sup>d</sup> ± 0.02
GBF	195.64 <sup>a</sup> ± 0.03	45.10 <sup>a</sup> ± 0.02	33.90 <sup>a</sup> ± 0.02	2.16 <sup>a</sup> ± 0.02

\*Values are mean ± standard deviation of triplicate determinations. Means with different superscripts within the same column are significantly different ( $p < 0.05$ ). UBF: Unprocessed Beniseed Flour RBF: Roasted Beniseed Flour SBF: Soaked Beniseed Flour BBF: Boiled Beniseed Flour GBF: Germinated Beniseed Flour.

**Table 5.** Results of anti-nutritional factors of beniseed flour samples.

Samples	Phytate (%)	Oxalate (%)	Tannin (%)
UBF	0.73 <sup>a</sup> ± 0.02	0.56 <sup>b</sup> ± 0.03	1.35 <sup>b</sup> ± 0.03
RBF	0.63 <sup>b</sup> ± 0.02	0.30 <sup>c</sup> ± 0.04	1.59 <sup>a</sup> ± 0.02
SBF	0.62 <sup>c</sup> ± 0.01	0.17 <sup>e</sup> ± 0.00	1.25 <sup>c</sup> ± 0.01
BBF	0.60 <sup>d</sup> ± 0.01	0.23 <sup>d</sup> ± 0.03	1.00 <sup>d</sup> ± 0.01
GBF	0.60 <sup>d</sup> ± 0.02	0.54 <sup>b</sup> ± 0.04	1.25 <sup>c</sup> ± 0.02

\*Values are mean ± standard deviation of triplicate determinations. Means with the same superscripts within the same column are not significantly different ( $p > 0.05$ ). UBF: Unprocessed Beniseed Flour RBF: Roasted Beniseed Flour SBF: Soaked Beniseed Flour BBF: Boiled Beniseed Flour GBF: Germinated Beniseed Flour.

in the germinated sample might be attributed to the roots and residue hulls (hulls were difficult to remove) after germination prior to drying and milling.

The reduction observed in the soaked and boiled beniseed flour may be associated with washing out of oxalate during soaking and heating into the water. Nutritive values of many food products could be affected by the concentrations of anti-nutrients. Some of the anti-nutrients like oxalic and phytates precipitate bivalent minerals (calcium, magnesium, zinc and iron) or form complexes that are insoluble and thus interfere with their utilization in the body [8].

The tannin content varied significantly ( $p < 0.05$ ) across all the samples with the highest value recorded in the roasted beniseed flour (1.59%) and lowest value recorded in the boiled beniseed sample (1.00%).

The result of the functional qualities of beniseed flour samples was shown in **Table 6**. Oil absorption capacity (OAC) values ranged from 0.97 in roasted to 1.13 mg/100g in boiled beniseed flour. The low OAC of the beniseed flour samples was due to the low hydrophobic proteins in the beniseed when compared to OAC of other seeds like praseed (130.4%) [24] and tigernut flour (107%) [25].

Water absorption capacity (WAC) had the least value in soaked beniseed flour (1.00 mg/100g) and highest in boiled beniseed flour (1.28 mg/100g). The foaming capacity (FC) ranged from 2.94 in germinated to 19.80 mg/100g in soaked beniseed flour. Soaking affects the morphology of the flour by increasing air spaces aiding foaming. The values for foaming capacity of beniseed flour were lower than the value for wheat (40%) described by [26]. The amount of soluble proteins and polar and non-polar lipids in food products determines the foaming ability. Flexible protein molecules tend to reduce surface tension and so give a good foaming ability while globular proteins with highly ordered molecules are relatively hard to surface denaturation, this result in low foaming ability. Soaked sample also show highest ( $p < 0.03$ ) foaming stability (108.82 min/sec). Swelling capacity (SC) value varied significantly ( $p < 0.05$ ) among all samples. The highest value (1.54 g/100g) was recorded in the boiled beniseed flour and lowest (1.14 g/100g) in the soaked beniseed flour.

From the results of the sensory evaluation of cookies (**Table 7**), there was significant difference ( $p < 0.05$ ) in appearance in some samples. The appearance of



**Table 6.** Functional composition (mg/100g) of beniseed flour samples.

Samples	OAC	WAC	FC	FS	SC
UBF	1.10 <sup>ab</sup> ± 0.10	1.23 <sup>b</sup> ± 0.03	4.16 <sup>b</sup> ± 0.03	100.32 <sup>d</sup> ± 0.55	1.40 <sup>b</sup> ± 0.06
RBF	0.97 <sup>b</sup> ± 0.02	1.14 <sup>c</sup> ± 0.01	3.92 <sup>b</sup> ± 0.00	102.95 <sup>b</sup> ± 0.04	1.46 <sup>ab</sup> ± 0.06
SBF	0.98 <sup>b</sup> ± 0.011	1.00 <sup>d</sup> ± 0.01	19.80 <sup>a</sup> ± 0.33	108.82 <sup>a</sup> ± 0.98	1.14 <sup>c</sup> ± 0.03
BBF	1.13 <sup>a</sup> ± 0.12	1.28 <sup>a</sup> ± 0.03	3.85 <sup>b</sup> ± 0.00	98.72 <sup>e</sup> ± 0.55	1.54 <sup>a</sup> ± 0.05
GBF	1.10 <sup>ab</sup> ± 0.00	1.20 <sup>b</sup> ± 0.03	2.94 <sup>c</sup> ± 0.00	101.63 <sup>c</sup> ± 0.57	1.42 <sup>b</sup> ± 0.04

\*values are mean ± standard deviation of triplicate determinations. Means with the same superscripts within the same column are not significantly different ( $p > 0.05$ ). Keys: UBF: Unprocessed Beniseed Flour RBF: Roasted Beniseed Flour SBF: Soaked Beniseed Flour BBF: Boiled Beniseed Flour GBF: Germinated Beniseed Flour OAC: Oil Absorption Capacity, WAC: Water Absorption, FC: Foaming Capacity, FS: Foaming Stability and SC: swelling capacity.

**Table 7.** Result sensory analysis.

Samples	Appearance	Colour	Flavor	Texture	Taste	Crispness	General Acceptability
WUW001	7.75 <sup>a</sup> ± 0.96	7.65 <sup>a</sup> ± 1.27	7.40 <sup>a</sup> ± 1.31	7.30 <sup>a</sup> ± 0.92	7.60 <sup>a</sup> ± 1.10	6.90 <sup>a</sup> ± 1.0 2	8.15 <sup>a</sup> ± 0.93
WSB010	6.75 <sup>abc</sup> ± 1.21	6.35 <sup>bc</sup> ± 1.23	7.05 <sup>ab</sup> ± 1.43	6.65 <sup>abc</sup> ± 1.31	7.30 <sup>ab</sup> ± 1.34	6.55 <sup>ab</sup> ± 1.28	7.80 <sup>ab</sup> ± 0.89
WSB020	7.05 <sup>ab</sup> ± 1.67	6.60 <sup>bc</sup> ± 1.60	6.50 <sup>abcd</sup> ± 1.05	5.90 <sup>cde</sup> ± 1.68	6.35 <sup>bcd</sup> ± 1.14	5.40 <sup>bcdef</sup> ± 1.43	7.10 <sup>bcd</sup> ± 1.29
WSB030	4.85 <sup>ef</sup> ± 1.76	4.90 <sup>de</sup> ± 1.80	5.95 <sup>cde</sup> ± 1.36	5.45 <sup>def</sup> ± 1.47	5.35 <sup>efg</sup> ± 1.84	6.05 <sup>abcd</sup> ± 1.79	6.05 <sup>def</sup> ± 1.36
WGB020	4.35 <sup>f</sup> ± 1.42	4.45 <sup>e</sup> ± 1.67	4.45 <sup>g</sup> ± 1.79	4.60 <sup>f</sup> ± 1.39	3.55 <sup>i</sup> ± 1.70	4.35 <sup>f</sup> ± 1.35	4.55 <sup>g</sup> ± 1.90
WSB030	4.85 <sup>ef</sup> ± 1.76	4.90 <sup>de</sup> ± 1.80	5.95 <sup>cde</sup> ± 1.36	5.45 <sup>def</sup> ± 1.47	5.35 <sup>efg</sup> ± 1.84	6.05 <sup>abcd</sup> ± 1.79	5.55 <sup>f</sup> ± 2.06
WGB010	5.65 <sup>de</sup> ± 1.63	5.90 <sup>bcd</sup> ± 1.29	5.30 <sup>defg</sup> ± 1.34	5.45 <sup>def</sup> ± 1.47	4.55 <sup>ghi</sup> ± 1.93	4.85 <sup>ef</sup> ± 1.79	6.05 <sup>def</sup> ± 1.36
WGB020	4.35 <sup>f</sup> ± 1.42	4.45 <sup>e</sup> ± 1.67	4.45 <sup>g</sup> ± 1.79	4.60 <sup>f</sup> ± 1.39	3.55 <sup>i</sup> ± 1.70	4.35 <sup>f</sup> ± 1.35	4.55 <sup>g</sup> ± 1.90
WGB030	4.80 <sup>ef</sup> ± 1.82	4.90 <sup>de</sup> ± 1.94	4.65 <sup>g</sup> ± 1.69	5.20 <sup>ef</sup> ± 2.01	3.95 <sup>hi</sup> ± 2.21	5.00 <sup>def</sup> ± 1.69	5.55 <sup>f</sup> ± 2.06
WRB010	6.30 <sup>bcd</sup> ± 1.22	5.95 <sup>bcd</sup> ± 1.85	5.35 <sup>defg</sup> ± 1.66	5.25 <sup>ef</sup> ± 1.59	5.00 <sup>fgh</sup> ± 2.25	5.35 <sup>cdef</sup> ± 1.84	5.90 <sup>ef</sup> ± 1.97
WRB020	6.45 <sup>bcd</sup> ± 1.32	5.80 <sup>bcd</sup> ± 1.54	6.20 <sup>bcd</sup> ± 1.82	6.50 <sup>abcd</sup> ± 1.40	6.60 <sup>abcd</sup> ± 1.98	6.35 <sup>abc</sup> ± 1.98	7.77.10 <sup>bcd</sup> ± 1.74
WRB030	6.65 <sup>bcd</sup> ± 1.60	6.15 <sup>bc</sup> ± 1.39	6.15 <sup>bcd</sup> ± 1.79	6.15 <sup>bcd</sup> ± 1.46	6.25 <sup>bcd</sup> ± 1.65	6.40 <sup>abc</sup> ± 1.43	6.75 <sup>cde</sup> ± 1.37
WBB010	6.90 <sup>abc</sup> ± 1.55	6.85 <sup>ab</sup> ± 1.60	6.25 <sup>bcd</sup> ± 1.52	5.95 <sup>cde</sup> ± 1.36	6.20 <sup>bcd</sup> ± 1.64	6.00 <sup>abcde</sup> ± 1.26	7.70.05 <sup>bcd</sup> ± 1.19
WBB020	6.70 <sup>bcd</sup> ± 1.42	6.55 <sup>bc</sup> ± 1.32	5.85 <sup>cde</sup> ± 1.31	5.75 <sup>cde</sup> ± 1.65	6.05 <sup>cdef</sup> ± 1.64	5.45 <sup>bcdef</sup> ± 1.70	6.50 <sup>def</sup> ± 1.32
WBB030	5.90 <sup>cd</sup> ± 1.77	6.05 <sup>bc</sup> ± 1.50	6.00 <sup>bcd</sup> ± 1.65	5.40 <sup>def</sup> ± 1.79	5.40 <sup>defg</sup> ± 1.67	5.30 <sup>cdef</sup> ± 1.78	6.10 <sup>def</sup> ± 1.48
WUB010	6.80 <sup>abc</sup> ± 1.24	6.70 <sup>abc</sup> ± 1.30	7.05 <sup>ab</sup> ± 1.10	7.05 <sup>ab</sup> ± 1.05	6.95 <sup>abc</sup> ± 1.23	6.80 <sup>abc</sup> ± 1.40	7.55 <sup>abc</sup> ± 1.19
WUB020	6.20 <sup>bcd</sup> ± 1.01	5.80 <sup>bcd</sup> ± 1.51	5.65 <sup>cdef</sup> ± 1.50	5.55 <sup>def</sup> ± 1.39	5.95 <sup>cdef</sup> ± 1.70	6.00 <sup>abcde</sup> ± 1.97	6.40 <sup>def</sup> ± 1.64
WUB030	5.65 <sup>de</sup> ± 1.57	5.65 <sup>cd</sup> ± 1.57	5.05 <sup>efg</sup> ± 1.64	6.05 <sup>bcd</sup> ± 1.64	5.30 <sup>efg</sup> ± 1.63	5.50 <sup>bcdef</sup> ± 1.85	6.20 <sup>def</sup> ± 1.40

WF1001: 100% WF; WSB010: 90% WF: 10% SBF; WSB020: 80% WF: 20% SBF; WSB030: 70% WF: 30% SBF; WGB010: 90% WF: 10% GBF; WGB020: 80% WF: 20% GBF; WGB030: 70% WF: 30% GBF; WRB010: 90% WF: 10% RBF; WRB020: 80% WF: 20% RBF; WRB030: 70% WF: 30% RBF; WBB010: 90% WF: 10% BBF; WBB020: 80% WF: 20% BBF; WBB030: 70% WF: 30% BBF; WUB010: 90% WF: 10% UBF; WUB020: 80% WF: 20% UBF; WUB030: 70% WF: 30% UBF.

cookies baked with 10% and 20% soaked, 10% boiled, 10% unprocessed beniseed flours substituted with wheat were not significantly different ( $p > 0.05$ ) from 100% wheat cookies. The cookies substituted with 20% germinated beniseed flour was least preferred among all samples.

The colour of the 100% wheat flour cookie was most preferred but not significantly different ( $p > 0.05$ ) with the cookies substituted with 10% boiled and 10% unprocessed beniseed flour. The 10% soaked, 20% and 30% germinated substituted beniseed flour cookies were least preferred in terms of colour. There were significant differences ( $p < 0.05$ ) among the samples. The cookies substituted with 10% and 20% soaked, 20% and 30% roasted, 10% and 30% boiled and 10% unprocessed beniseed flour were more preferred in terms of flavor to the other samples. For texture, there was no significant difference ( $p > 0.05$ ) between the 100% wheat flour cookie and the cookies substituted with 10% soaked, 20% roasted and 10% unprocessed beniseed flour. However, the cookies substituted with germinated beniseed flour sample were least preferred among all. Taste showed slight differences ( $p < 0.05$ ) between the cookies, with obvious significant difference ( $p < 0.05$ ) observed in the beniseed germinated flour substituted wheat cookies.

In terms of crispness, all substituted beniseed flour cookies were quite comparable with the 100% wheat flour cookies except for the cookies substituted with germinated beniseed flour. General acceptability showed that there was no significant difference ( $p > 0.05$ ) between the 100% wheat flour cookies and cookies from 10% soaked and 10% unprocessed substituted beniseed flour. The poor performance of the cookies substituted with beniseed flour especially the germinated samples (with residue seed coat) could be attributed to the bitter taste of some inherent compounds found in beniseed flour particularly at high temperature.

## 5. Conclusion

This study revealed that processing had significant effect on the nutrients, anti-nutrients and functional properties of beniseed flour samples. Germinated flour sample had highest protein and ash contents, lowest fat and carbohydrate values with increased mineral and reduced anti-nutrients, making it a more preferred flour sample. From the study beniseed can substitute wheat in many other food products to improve food security and reduce malnutrition especially in Nigeria where there are a lot of vulnerable groups.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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