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Production and quality evaluation of cookies produced from flour blends of sprouted mungbean (*Vigna radiata*) and malted sorghum (*Sorghum bicolor* (L) Moench)

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Abstract
The effect of sprouting and malting on the quality characteristics of wheat, mungbean-sorghum composite flour and cookies were studied. Wheat, sprouted mungbean and malted sorghum flours were blended into different proportions and used to produce cookies. The samples were subjected to proximate, functional, pasting, physical and sensory analysis using standard methods. Protein increased from 9.31 % to 20.13 % in the flour samples showing significant ($p<0.05$) difference between the different flours samples with sample AB2 (0:80:20) having the highest protein content of 20.13 % and 26.67 % in the flour and cookie samples respectively. Final viscosity ranged from 906.50 RVU to 2304.00 RVU, showing a significant difference ($p<0.05$) between the control and the blended samples. There were significant differences ($p<0.05$) in the physical parameters of the samples. Sensory evaluation scores showed that cookies made with 65 % sprouted mungbean and 35 % malted sorghum flour can favourably compare with the control.

Keywords: sprouting, malting, final viscosity, sensory

1. Introduction

Cookies are popular confectionery products with a unique texture and taste, long shelf-life and a relatively cheap price (Petrovic *et al*., 2016). They are popular snacks widely consumed all over the world by people of all ages. The concept of using composite flour in production of cookies is not new and has been subject to numerous studies.

Mung bean (*Vigna radiata*) are legumes that are small, ovoid in shape and green in color. They are also known as green gram or golden gram and contain about 24% protein (Kudre *et al*., 2013) [21]. Mung bean is incorporated with cereals which contain high concentration of methionine and cysteine to enhance its nutrients.

Sprouting which is also known as germination has been reported to induce an increase in free limiting amino acid and available vitamins, with modified functional properties of seed components (Hallen *et al*., 2004) [16]. Thus, utilization of sprouted mung beans in cookies could avail the consumers a protein rich food product.

Sorghum, a gluten-free cereal, bears significance in the present-day scenario where the occurrence of celiac disease (CD), an immunological response to gluten intolerance is on the rise (Charvan *et al*., 2016). In other to increase the functionality, sorghum grains are being malted to promote the development of hydrolytic enzymes, which are not present in non-germinated grain (Dewar, 2003) [13]. Sorghum in vitro-digestion studies show that malting caused an improvement in protein digestibility and other protein quality characteristics including percentage of protein, nitrogen solubility index etc. (Dewar *et al*., 1995). Despite the nutritional advantages of sprouted mung bean and its potential for economic enhancement, relatively little research attention has been devoted to it. There is also limited information on cookies produced from sprouted mung bean and malted sorghum in Nigeria.

Production of cookies, a ready-to-eat baked food from flour blends of sprouted mung bean and malted sorghum will help in utilization of indigenous crops cultivated in Nigeria. It will also create awareness and variety; thus, preventing mung bean (an underutilized crop) from going into extinction. Information on sprouted mung bean-malted sorghum cookies will be made available to researchers and will add to the variety of existing cookies in the market.

2. Materials and Methods

Mung beans that was used for this study were obtained from the Department of Crop and Soil Science, Michael Okpara University of Agriculture, Umudike. Sorghum, wheat grains and other ingredients that were used in production of cookies were procured from Ubani Ibeku Main Market in Umuahia North Local Government Area, Abia State.

2.1 Production of wheat flour

The method described by Ndife and Fagbemi (2014) [24] was used in the production of wheat flour. The whole-wheat grains were cleaned by sorting out contaminants and were later washed, drained, and dried in the oven (60ºC for 8 hours). The dried whole-wheat grains were milled (using attrition mill) and sieved into fine flour of uniform particle size, by passing them through a 250 mm mesh sieve.

2.2 Production of malted sorghum flour

Malting was done according to the method described by IITA (1990) [18] with a slight modification. Sorghum grains were sorted, soaked for 12 hours in tap water. Soaked grains were drained and sprouted by spreading out on a covered muslin cloth. Water containing a small amount of sodium hypochlorite was sprinkled on it daily until sprouting began, while the seeds are allowed to germinate at 30ºC. After 48 hours of sprouting, sprouted sorghum was oven dried at 65ºC for 6 hours, sprouts were removed on palm by abrasion. The dried malted sorghum was milled into flour using an attrition mill and sieved through a 250 mm standard mesh sieve, cooled and package for further analysis.

2.3 Production of sprouted mung bean flour

Sprouting was carried out using the method described by Akubor *et al.* (2001) [6] with slight modifications. Mung bean seeds were soaked in water at a temperature of 30°C for nine (9) hours. The soaked beans were spread on a moistened muslin cloth and sprinkled with water daily while allowed to sprout for two days (48 hours). The sprinkled water contained a small amount of sodium hypochlorite to destroy or discourage the growth of microorganisms while the seeds are allowed to germinate at 30°C. After 48 hours of sprouting, sprouted mung bean was sun dried, sprouts were removed on palm by abrasion. The dried sprouted mung bean was milled into flour using an attrition mill and sieved through a 250 mm standard mesh sieve, cooled and package for further analysis.

2.4 Formulation of composite flour

Fig 1: Wheat Flour

Fig 2: Malted Sorghum Flour

Fig 3: Sprouted Mungbean Flour

Table 1: Flour Blends Formulation (%)

Samples (Wheat: Sprouted Mungbean: Malted sorghum)	Wheat flour	Sprouted Mung bean flour	Malted Sorghum flour
AB1	100	0	0
AB2	0	80	20
AB3	0	75	25
AB4	0	70	30
AB5	0	65	35

2.5 Biochemical analysis

Analyses were carried out on duplicate formulation, for each sample. The crude fat was estimated by exhaustive extraction with petroleum ether using a soxhlet apparatus (AOAC, 2010) [7]. The Kjeldahl method was used for the determination of protein (N × 6.25). The moisture, ash and crude fiber contents were determined by the AOAC (2010) [7] methods; total carbohydrate was obtained by difference while food energy was calculated by multiplying the values of crude protein, fat and carbohydrate by factors of 4, 9 and 4 respectively, finding the sum of their products and expressing the results in kilocalories. All reagents used were of analytical grades.

2.6 Functional analysis

2.6.1 Bulk density

The method by AOAC (2010) [7] was used. Ten grams (10 g) of each flour sample was weighed into a graduated cylinder and its volume recorded. The bottom of cylinder tapped gently at the top of the laboratory table several times until there was no further diminution of the sample level after filling to the 10ml mark.

$$\text{Calculation: Bulk density (g/ml)} = \frac{\text{Weight of sample (g)}}{\text{Volume of sample (ml)}}$$

2.6.2 Water and oil absorption capacity

This was determined by the method of AOAC (2010) [7]. Exactly one gram (1 g) of each sample was weighed into centrifuge tube and 10 ml of distilled water or vegetable oil was added to it and mixed thoroughly for 30 seconds. The mixture was then allowed to stand for 30 minutes at room temperature after stirring. Thereafter, it was centrifuged at 3000 rpm for 30 minutes. The volume of the water (the supernatant) or oil was then measured and recorded.

$$\text{Water or oil Absorption Capacity} = \frac{V_1 - V_2}{W} \times \frac{100}{1}$$

2.6.3 Swelling index

The method of AOAC (2010) [7] was used. Two grams of the sample was weighed into 10 ml measuring cylinder and the volume it occupied was recorded as (V_1), distilled water (27°C) was added until the 10 ml mark was reached. The cylinder containing the samples and distilled water was left to stand for 45 minutes after which a new volume V_2 was recorded. The swelling index of the samples was expressed by the formula below:

$$\text{Swelling index} = \frac{\text{Volume occupied by sample after swelling}}{\text{Volume occupied by sample before swelling}}$$

2.6.4 Gelatinization temperature and wettability
The gelatinization temperature (GT) and wettability were determined using standard methods as described by AOAC (2010) [7].

2.7 Pasting properties of composite flour using the Rapid Visco Analyzer.
Pasting characteristics were determined with a Rapid Visco Analyzer (RVU), 3C (RVA, model 3C, Newport scientific PTY Ltd, Sydney, Australia) as described by Ross *et al.*, (1987) [36] using standard methods. The viscosity was expressed in terms of Rapid Visco Units (RVU), which is equivalent to 10 centipoises.

2.8 Production of cookies
Fat and sugar were creamed for 5 minutes. Eggs and milk were added while mixing and then mixed for a total of about 30 minutes. Vanilla, nutmeg, flour, baking powder and salt were mixed thoroughly and added to the cream mixture where they were all mixed together to form a dough. The dough was rolled and cut into circular shapes of 5 cm diameter. Baking was carried out at 185ºC for 20±5 minutes. This same process was repeated in the production of other cookie samples with varying flour blends. Cookie samples were cooled and stored in airtight containers until needed.

Table 2: Recipe for production of cookie

Ingredients	Quantity
Flour	100 g
Margarine	40 g
Sugar	30 g
Egg	1 egg
Milk (full-fat filled, powdered)	10 g
Nutmeg	1 g
Vanilla (liquid)	25 ml
Salt	0.5 g
Baking powder	2 g

Source: Okpala and Ekwe (2013)

2.9 Physical analysis
2.9.1 Weight, diameter, thickness and break strength determination
The weight, diameter, thickness and height of the cookies were determined according to the method described by Ayo *et al*. (2007) [9]. The weight of the cookies samples was determined by weighing the cookies on a weighing balance. The height and diameter was determined by measuring them with a calibrated ruler respectively. The thickness of the cookies was measured with the aid of a digital Vernier caliper with 0.01 mm precision. Okaka and Isieh (1990) [28] standard methods was used in determining the break strength of the cookie samples.

2.9.2 Spread ratio determination
The spread ratio was determined using Gomez *et al*. (1997) [15] method. Three rows of five well-formed cookies were made and the height measured. Also, the same biscuits were arranged horizontally edge to edge and sum diameter measured. The spread ratio was calculated thus:

$$\text{Spread ratio} = \frac{\text{Diameter}}{\text{Height}}$$

2.10 Sensory evaluation
The method described by Ihekoronye and Ngoddy (1985) [17] was used. The organoleptic properties were evaluated by 20 panelists randomly selected from the students of Michael Okpara University of Agriculture, Umudike. Quality attributes such as appearance, taste, crispness, texture and general acceptability of the cookies were scored in a 9 point scale.

2.11 Statistical analysis
All experiments in this study are reported as mean of duplicate analyses. One way analysis of variance of a completely randomized design using the Statistical Package of Social Science version 22 was carried out to compare between the mean values while treatment Means was separated using Duncan multiple range test at 95% confidence level ($p<0.05$).

3. Results and discussion
3.1 Proximate composition of composite flour produced from sprouted mungbean and malted sorghum
The results of proximate composition of the Sprouted Mungbean-malted sorghum flour samples are presented in Table 3. The moisture content of the Sprouted Mungbean-malted Sorghum flour samples ranged from 7.94 to 8.58%. It was observed that there are no significant ($p>0.05$) differences between the moisture content of the flour samples except for samples AB4 and AB5 which were significantly different ($p<0.05$) from the other samples. The range of the moisture content obtained in this study is higher than 7.50 to 8.80% obtained from flour samples produced from germinated lima bean, sorghum and wheat (Adebayo and Okoli, 2017) [1].

Table 3: Proximate composition of composite flour produced from sprouted mungbean and malted sorghum

Samples (Wheat: Sprouted Mungbean: Malted sorghum)	Moisture Content (%)	Crude Protein (%)	Crude Fibre (%)	Fat (%)	Ash (%)	Carbohydrate (%)	Energy Value (kcal)
AB1	$8.57^a±0.01$	$9.31^e±0.01$	$0.78^c±0.01$	$0.94^b±0.01$	$1.17^e±0.01$	$78.73^a±0.01$	$362.62^b±0.01$
AB2	$8.58^a±0.37$	$20.13^a±0.01$	$1.09^a±0.01$	$1.09^a±0.01$	$2.04^a±0.01$	$66.90^e±0.04$	$357.93^e±0.01$
AB3	$8.52^a±0.01$	$19.66^b±0.01$	$0.93^b±0.01$	$0.93^b±0.01$	$1.89^b±0.01$	$68.12^d±0.01$	$359.49^d±0.13$
AB4	$8.23^{ab}±0.01$	$18.95^c±0.01$	$0.84^c±0.01$	$0.84^c±0.01$	$1.75^c±0.01$	$69.47^c±0.01$	$361.24^c±0.13$
AB5	$7.94^b±0.01$	$18.11^d±0.01$	$0.75^d±0.01$	$0.75^d±0.01$	$1.56^d±0.01$	$71.03^b±0.01$	$363.33^a±0.16$

a-e: Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$).

Keys: AB1 (100% Wheat flour, 0% Sprouted Mungbean flour, 0% Malted Sorghum flour), AB2 (0% Wheat flour, 80% Sprouted Mungbean flour, 20% Malted Sorghum flour), AB3 (0% Wheat flour, 75% Sprouted Mungbean flour, 25% Malted Sorghum flour), AB4 (0% Wheat flour, 70% Sprouted Mungbean flour, 30% Malted Sorghum flour), AB5 (0% Wheat flour, 65% Sprouted Mungbean flour, 35% Malted Sorghum flour.

The crude protein content of the flour samples ranged from 9.31 to 20.13%. It was observed that there were significant (p<0.05) differences in protein content of the flour samples. Higher crude protein obtained in composite flour samples could either be attributed to the high protein content of legumes and/or the malting and sprouting processes.

The crude fibre content of the flour samples ranged from 0.61 to 1.01%. Sample AB2 had the highest crude fibre (1.01%) while sample AB5 had the least crude fibre (0.61%). The range of the crude fibre obtained in this study is lower than 2.53 to 2.95% reported by Inyang *et al*. (2018) [20] for Physical Properties, Nutritional Composition and Sensory Evaluation of Cookies Prepared from Rice, Unripe Banana and Sprouted Soybean Flour Blends.

The ash content of the flour samples produced from sprouted mungbean and malted sorghum ranged from 1.17 to 2.04%. There was a significant (p<0.05) difference in the ash content of the flour samples. The range of ash content obtained in this study is lower than 0.70 % to 3.68 % reported by Nwosu (2013) [26] for composite flour produced from flour blends of Bambara groundnut and wheat.

The carbohydrate content of the flour samples produced from sprouted mungbean and malted sorghum ranged from 66.90 to 78.73%. The range of carbohydrate recorded in the flour samples is higher than 60.24% to 69.56% reported by Patindola *et al*. (2005) [33] of weaning foods formulated with germinated wheat and mungbean.

The energy value of the flour samples produced from sprouted mungbean and malted sorghum ranged from 357.93 to 363.33 kcal. The decrease and increase in proportion of Sprouted Mungbean and Malted Sorghum flour brought about significant (p<0.05) differences in the energy value of the flour samples. This variation could be due to differences in their protein and carbohydrate content (Charvan *et al*., 2016).

3.2 Functional composition of composite flour produced from sprouted mungbean and malted sorghum (%)

The results of functional properties of flour samples produced from sprouted mungbean and malted sorghum are presented in Table 4. The bulk density of the flour samples ranged from 0.72 to 0.84 g/ml. There were significant differences (p<0.05) between the bulk density of the flour samples except for samples AB4 and AB5, that were not significantly different (p>0.05) from each other. This finding is lower than 0.65 to 0.96 g/ml reported by Ojinnaka and Nnorom (2015) [27] for flour blends of wheat, cocoyam and soybean.

The water absorption capacity of the flour samples ranged from 1.92 to 3.37 g/ml. There were significant differences (p<0.05) between the water absorption capacities of the flour samples. The effect of low water absorption capacity of the flour samples was probably due to the loose association of amylose and amylopectin in the native granules of starch and weaker associative forces maintaining the granules structure (Lorenz and Collins, 1990).

The wettability of the flour samples ranged from 1.22 to 3.32 min/sec. There were significant (p<0.05) differences between the wettability of the flour samples. Higher value of wettability obtained in sample AB1 indicates that it required much longer time than the other samples before it became completely wet while lower values of wettability recorded in sample AB5 indicates better reconstitution properties (Ojinnaka and Nnorom, 2015). [27]

3.3 Pasting properties of composite flour produced from sprouted mungbean and malted sorghum

The result of the pasting properties of the flour samples produced from sprouted mungbean and malted sorghum are presented in Table 5. The peak viscosity ranged from 790.00 to 2062.50 RVU. The decrease and increase in the proportion of sprouted mungbean and malted sorghum flour respectively brought about no significant (p>0.05) difference in the peak viscosity of the samples except for sample AB1 which had a significant (p<0.05) from other flour samples.

The breakdown viscosity ranged from 5.50 to 554.50 RVU. There were no significant (p>0.05) differences in the breakdown viscosity of the flour samples except for sample AB1 which had a significant (p<0.05) difference from other samples. The smaller the breakdown viscosity, the higher the paste stability (Akanbi *et al*., 2009) [5].

The final viscosity value ranged from 906.50 to 2304.00 RVU. There were no significant (p>0.05) differences in the flour samples except for sample AB1 which had a significant (p<0.05) difference.

The setback value ranged from 117.50 to 796.00 RVU. The setback viscosity was highest (796.00 RVU) in sample AB1 and lowest (117.50 RVU) in sample AB2. Setback viscosity indicates gel stability and potential retrogradation (Niba *et al*., 2001) [25].

The peak time value ranged from 5.83 to 7.00 min. The time at which peak viscosity occurred in minutes is termed peak time (Adebowale *et al*., 2005) [2].

The pasting temperature varied between 0.00 to 84.75^{o}C. The composite flour samples had the lowest pasting temperature of 0^{o}C while sample ABI had the highest pasting temperature (84.75^{o}C). The pasting temperature of zero (0^{o}C) observed in sample AB2, AB3, AB4, and AB5 respectively could be attributed to the differences in their chemical composition of starch due to the sprouting and malting processing methods which degrade starch granules and the nature of bonding within the starch structure (Radley, 1976) [25].

Table 4: Functional properties of composite flour produced from sprouted mungbean and malted sorghum

Samples (Wheat: Sprouted Mungbean Malted sorghum)	Swelling Index (g/ml)	Bulk Density(g/ml)	Oil Absorption Capacity (g/ml)	Water Absorption Capacity (g/ml)	Foaming Capacity (g/ml)	Gelation Temperature (°C)	Wettability (min/sec)
AB1	1.51^{d}±0.01	0.72^{c}±0.01	1.97^{a}±0.01	1.92^{e}±0.28	5.63^{a}±0.01	75.50^{e}±0.71	3.32^{a}±0.01
AB2	1.84^{c}±0.01	0.79^{b}±0.01	1.91^{b}±0.01	2.91^{d}±0.01	3.76^{e}±0.01	83.00^{a}±0.00	2.01^{b}±0.01
AB3	1.92^{b}±0.01	0.81^{ab}±0.01	1.86^{c}±0.01	3.11^{c}±0.01	3.88^{d}±0.01	80.50^{b}±0.71	1.56^{c}±0.01
AB4	2.01^{a}±0.01	0.83^{a}±0.01	1.82^{d}±0.01	3.19^{b}±0.01	3.95^{c}±0.01	79.00^{c}±0.00	1.44^{d}±0.01
AB5	2.04^{a}±0.01	0.84^{a}±0.01	1.76^{e}±0.01	3.37^{a}±0.01	4.00^{b}±0.01	77.50^{d}±0.71	1.22^{e}±0.01

a-e: Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different (p<0.05).

Keys: AB1 (100% Wheat flour, 0% Sprouted Mungbean flour, 0% Malted Sorghum flour), AB2 (0% Wheat flour, 80% Sprouted Mungbean flour, 20% Malted Sorghu flour), AB3 (0% Wheat flour, 75% Sprouted Mungbean flour, 25% Malted Sorghum flour), AB4 (0% Wheat flour, 70% Sprouted Mungbean flour, 30% Malted Sorghum flour), AB5 (0% Wheat flour, 65% Sprouted Mungbean flour, 35% Malted Sorghum flour).

Table 5: Pasting properties of composite flour produced from sprouted mungbean and malted sorghum

Samples (Wheat: Sprouted Mungbean: Malted sorghum)	Peak Viscosity (RVU)	Trough (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Peak Time (Min)	Pasting Temperature (°C)
AB1	2062.50^{a}±3.54	1508.00^{a}±29.69	554.50^{a}±33.23	2304.00^{a}±28.28	796.00^{a}±1.41	5.83^{b}±0.14	84.75^{a}±0.07
AB2	806.00^{b}±5.66	800.50^{b}±4.95	5.50^{b}±0.71	918.00^{b}±4.24	117.50^{b}±0.71	6.90^{a}±0.14	0.00^{b}±0.00
AB3	790.00^{b}±24.04	781.00^{b}±25.46	9.00^{b}±1.41	906.50^{b}±34.65	125.50^{b}±9.19	7.00^{a}±0.00	0.00^{b}±0.00
AB4	803.50^{b}±3.54	797.00^{b}±2.83	6.50^{b}±0.71	915.00^{b}±2.83	118.00^{b}±0.00	6.83^{a}±0.23	0.00^{b}±0.00
AB5	792.5^{b}±2.12	784.00^{b}±2.83	8.50^{b}±0.71	911.50^{b}±3.54	127.50^{b}±0.71	6.93^{a}±0.00	0.00^{b}±0.00

a-b: Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different (p<0.05).

Keys: AB1 (100% Wheat flour, 0% Sprouted Mungbean flour, 0% Malted Sorghum flour), AB2 (0% Wheat flour, 80% Sprouted Mungbean flour, 20% Malted Sorghum flour), AB3 (0% Wheat flour, 75% Sprouted Mungbean flour, 25% Malted Sorghum flour), AB4 (0% Wheat flour, 70% Sprouted Mungbean flour, 30% Malted Sorghum flour), AB5 (0% Wheat flour, 65% Sprouted Mungbean flour, 35% Malted Sorghum flour

Table 6: Proximate composition of cookie samples produced from sprouted mungbean and malted sorghum (%)

Samples (Wheat: Sprouted Mungbean: Malted sorghum)	Moisture Content (%)	Crude Protein (%)	Crude Fibre (%)	Fat (%)	Ash (%)	Carbohydrate (%)	Energy Value (kcal)
AB1	11.85^{a}±0.01	10.55^{e}±0.01	2.11^{e}±0.01	10.96^{e}±0.01	1.99^{e}±0.01	62.54^{a}±0.01	391.00^{e}±0.13
AB2	10.81^{c}±0.01	26.67^{a}±0.01	3.07^{a}±0.01	12.34^{a}±0.01	3.01^{a}±0.01	44.10^{e}±0.01	394.14^{b}±0.13
AB3	11.50^{b}±0.01	25.59^{b}±0.01	2.82^{b}±0.01	12.19^{b}±0.01	2.95^{b}±0.01	44.95^{d}±0.01	391.87^{c}±0.24
AB4	11.53^{b}±0.01	24.51^{c}±0.01	2.68^{c}±0.01	11.95^{c}±0.01	2.87^{c}±0.01	46.47^{c}±0.00	391.45^{d}±0.16
AB5	10.37^{d}±0.01	23.43^{d}±0.01	2.43^{d}±0.01	11.78^{d}±0.01	2.81^{d}±0.01	49.18^{b}±0.01	396.46^{a}±0.13

a-e: Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different (p<0.05).

Keys: AB1 (100% Wheat flour, 0% Sprouted Mungbean flour, 0% Malted Sorghum flour), AB2 (0% Wheat flour, 80% Sprouted Mungbean flour, 20% Malted Sorghum flour), AB3 (0% Wheat flour, 75% Sprouted Mungbean flour, 25% Malted Sorghum flour), AB4 (0% Wheat flour, 70% Sprouted Mungbean flour, 30% Malted Sorghum flour), AB5 (0% Wheat flour, 65% Sprouted Mungbean flour, 35% Malted Sorghum flour.

3.4: Proximate composition of cookies samples produced from sprouted mungbean and malted sorghum.

The results of proximate composition of the cookies are presented in Table 6. There were significant (p<0.05) differences between the moisture content of the cookies except for samples AB3 and AB4 which had no significant (p>0.05) differences from other samples. The range of the moisture content obtained in this study is higher than 5.82 % reported by Banusha and Vasantharuba (2014) [10] for preparation of wheat-malted flour blend biscuit.

The crude protein content of the cookies ranged from 10.55 to 26.67%. The range of crude protein obtained in this study is higher than 13.23 to 16.50 % reported by Okoye and Obi (2017) [29] for chemical composition and sensory properties of germinated wheat-African yam bean composite flour cookies. Malting and sprouting leads to the degradation of higher molecular weight storage protein which may contribute to slight increase in protein content in malted and sprouted products (Wu, 1983) [38].

The fat content of the cookie samples ranged from 10.96 to 12.34%. There were significant differences (p<0.05) between the fat content of the cookie samples. Higher fat content of the cookie samples can be attributed to the fat content of raw mungbean flour as reported by Mubarak (2005) [23] which were significantly reduced with increase in boiling and toasting time; Agugo (2008) [3], observed reduction in the fat content of boiled mungbean and toasted mungbean respectively.

The ash content of the cookie samples ranged from 1.99 to 3.01%. Mungbean seeds are excellent sources of potassium (1145mg/100g), phosphorous (315mg/100g) and magnesium (132mg/100g), and also sodium, calcium and iron (Mubarak, 2005) [23].

The carbohydrate content of the cookie samples ranged from 44.10 to 62.54%. The range of carbohydrate recorded in the cookies samples is lower than 60.24 to 69.56% reported by Imtiaz *et al*. (2011) [19] of weaning foods formulated with germinated wheat and mungbean. These results are in agreement with findings of some earlier studies, they reported that germination produced a small increase in carbohydrate levels in legume utilization (Inyang *et al*., 2018) [20].

3.5 Physical evaluation of cookie samples produced from sprouted mungbean and malted sorghum.

The results of physical evaluation of the cookies are presented in Table 7. The weight of the cookie samples ranged from 7.84 g in sample AB1 to 8.98 g in sample AB5. The range obtained in this study is lower than 29.44 to 30.62 g reported for cookies made from flour blends of wheat, yam and soybean (Apotiola and Fashakin, 2013) [8].

The diameter of the cookie samples ranged from 4.85 cm in sample AB1 to 4.03 cm in sample AB5. The observed ranged of diameter is lower 4.55 cm to 5.85 cm reported from cookies made from flour blends of acha, wheat and mungbean (Dabels *et al*., 2016) [12].

The breaking strength of the cookies ranged from 4.11 kg to 5.04 kg. Higher breaking strength obtained in cookies made from composite flours indicates greater hardness of cookies structure (Banusha and Vasantharuba 2014) [10].

Table 7: Physical evaluation of cookie samples produced from sprouted mungbean and malted sorghum.

Samples (Wheat: Sprouted Mungbean: Malted sorghum)	Weight (g)	Diameter (cm)	Thickness (cm)	Spread Ratio	Breaking Strength (kg)
AB1	7.84^{e}±0.01	4.85^{a}±0.01	0.54^{a}±0.01	7.38^{a}±0.01	4.11^{a}±0.01
AB2	8.01^{d}±0.01	4.54^{b}±0.01	0.45^{b}±0.01	7.61^{b}±0.01	4.22^{b}±0.01
AB3	8.16^{c}±0.01	4.36^{c}±0.01	0.43^{bc}±0.01	7.76^{c}±0.01	4.38^{c}±0.01
AB4	8.45^{b}±0.01	4.19^{d}±0.01	0.41^{cd}±0.01	7.98^{d}±0.01	4.76^{d}±0.01
AB5	8.98^{a}±0.01	4.03^{e}±0.01	0.38^{d}±0.01	8.54^{e}±0.01	5.04^{e}±0.01

a-e: Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different (p<0.05).

Keys: AB1 (100% Wheat flour, 0% Sprouted Mungbean flour, 0% Malted Sorghum flour), AB2 (0% Wheat flour, 80% Sprouted Mungbean flour, 20% Malted Sorghum flour), AB3 (0% Wheat flour, 75% Sprouted Mungbean flour, 25% Malted Sorghum flour), AB4 (0% Wheat flour, 70% Sprouted Mungbean flour, 30% Malted Sorghum flour), AB5 (0% Wheat flour, 65% Sprouted Mungbean flour, 35% Malted Sorghum flour).

3.6 Sensory properties of cookie samples produced from sprouted mungbean and malted sorghum.

The results of sensory properties of the cookies are presented in Table 8. The appearance score of the cookies ranged from 5.65 in sample AB3 to 7.85 in sample AB1.

The taste score of the cookie samples ranged from 4.65 in sample AB2 to 7.80 in sample AB1. There were significant differences (p<0.05) between the taste score of the cookie samples except for samples AB3 and AB4 and samples AB1 and AB5 which had no significant (p>0.05) difference from each other. The scores for the taste of the cookies is lower than 6.3 to 8.3 reported for cookies produced from flour blends of wheat, acha and mungbean (Dabels *et al*., 2016) [12].

Table 8: Sensory properties of cookie samples produced from sprouted mungbean and malted sorghum

Samples (Wheat: Sprouted Mungbean: Malted sorghum)	Appearance	Taste	Texture	Crispness	General Acceptability
AB1	7.85^{a}±1.14	7.80^{a}±0.89	7.15^{a}±1.57	7.10^{a}±1.12	7.90^{a}±0.79
AB2	5.85^{c}±0.99	4.65^{c}±1.69	5.65^{b}±1.09	5.35^{b}±1.31	5.30^{c}±1.03
AB3	5.65^{c}±1.27	5.65^{b}±1.31	5.65^{b}±0.88	5.95^{b}±1.19	5.60^{c}±1.09
AB4	6.55^{b}±1.05	6.00^{b}±0.86	6.10^{b}±1.12	5.80^{b}±0.83	6.20^{b}±0.95
AB5	7.00^{b}±0.92	7.20^{a}±0.62	7.10^{a}±0.91	6.90^{a}±0.79	7.35^{a}±0.81

a-c: Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different (p<0.05).

Keys: AB1 (100% Wheat flour, 0% Sprouted Mungbean flour, 0% Malted Sorghum flour), AB2 (0% Wheat flour, 80% Sprouted Mungbean flour, 20% Malted Sorghum flour), AB3 (0% Wheat flour, 75% Sprouted Mungbean flour, 25% Malted Sorghum flour), AB4 (0% Wheat flour, 70% Sprouted Mungbean flour, 30% Malted Sorghum flour), AB5 (0% Wheat flour, 65% Sprouted Mungbean flour, 35% Malted Sorghum flour.

The texture score of the cookie samples ranged from 5.65 in sample AB2 and AB3 to 7.15 in sample AB1. The scores for the texture of the cookies is lower than 6.0 to 8.5 reported for cookies produced from composite flours of wheat, acha and mungbean (Dabels *et al*., 2016) [12]. The range of the texture score translate from neither like nor dislike to like moderately in 9-point hedonic scale of Ihekoronye and Ngoddy (1985) [17].

General acceptability score of the cookie samples ranged from 5.30 to 7.90. There were no significant differences (p>0.05) between the general acceptability of the cookie samples except for samples AB1, AB4 and AB5 which had a significant difference. High rating of general acceptability observed in sample AB1 could either be attributed to high rating of appearance, texture and crispness or the fact that the panelists were already used to cookies produced from 100% wheat flour.

Fig 4: Cookies produced with 100% Wheat flour

Fig 5: Cookies produced with 80% Sprouted mungbean and 20% malted sorghum flour

Fig 6: Cookies produced with 75% Sprouted mungbean and 25% malted sorghum flour

Fig 7: Cookies produced with 70% Sprouted mungbean and 30% malted sorghum flour

Fig 8: Cookies produced with 65% Sprouted Mungbean and 35% Malted Sorghum flour.

4. Conclusion

This study has clearly demonstrated the applicability of sprouted mungbean and malted sorghum flour in production of nutritious and acceptable cookies. Results of proximate composition of the flour samples revealed increase in ash and decrease in protein, fibre, moisture content, fat, carbohydrate and energy value. Results of functional properties showed increase in bulk density, water absorption capacity, wettability, gelatinization temperature, foaming capacity and swelling index. These suggests that the composite flour will have less retrogradation when used in food formulation, prevent staling by reducing moisture loss, and will have extended shelf life where fat absorption is desired. Overall, the pasting and physicochemical properties obtained indicate that flour have useful technological properties for many applications. The use of sprouted mungbean and malted sorghum flours will go a long way in enhancing nutrition, health and wellbeing of the consumers. It will also reduce food insecurity and diversify the use of sorghum and mung bean**.**

5. References

1. Adebayo SF, Okoli EC. Production and Evaluation of Biscuits from Germinated Lima Bean (*Phaseolus lunatus*), Sorghum and Wheat Flour Blends. Journal of Environmental Science, Toxicology and Food Technology. 2017; 11(7):44-48.
2. Adebowale AA, Sanni LO, Awonorin SO. Effect of Texture Modifiers on the Physicochemical and Sensory Properties of Dried Fufu. Food Science and Technology International. 2005; 11:373-382.
3. Agugo UA. Effect of Heat Treatment on the Nutritional and Value of Mungbean, 2008.
4. Project. Department of Nutritional and Dietetic, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria, 5-7, 28, 32-35.
5. Akanbi CT, Nazamid S, Adebowale AA. Functional and Pasting Properties of a Tropical Breadfruit Starch from Ile-Ife, Osun state, Nigeria. International Food Research Journal. 2009; 16:151-157.
6. Akubor PI, Achi OK, Onimawo IA. Functional properties and biscuit making potential of cowpea/maize flour blends. Journal of Management and Technology Published by Federal Polytechnic, Idah. 2001; 3:220-226.
7. AOAC. Official Methods of Analysis. 19thEdition., Association of Official Analytical Chemists, Washington D.C., USA, 2010.

8. Apotiola ZO, Fashakin JK. Evaluation of cookies from (wheat, yam, and soybean) blend. Food Science and Quality Management. 2013; 14:11-16.
9. Ayo JA, Nkama I, Adewori R. Physicochemical invitro digestibility and organoleptic evaluation of “Acha” wheat biscuit supplemented with soybean flour. Nigeria Food Journal. 2007; 25(1):77-89.
10. Banusha S, Vasantharuba S. Preparation of Wheat-Malted Flour Blends Biscuit and Evaluation of its Quality Characteristics. American-Eurasian Journal of Agriculture and Environmental Science. 2014; 14(5):459-463.
11. Chavan UD, Yewale KV, Dayakar RB. Preparation of Bread and Cookies from Sorghum Flour. International Journal of Recent Scientific Research. 2016; 7(5):11145-11153.
12. Dabels N, Igbabul BD, Amove J, Iorlam B. Nutritional Composition, Physical and Sensory Properties of Cookies from Wheat, Acha and Mungbean Composite Flours. International Journal of Nutrition and Food Sciences. 2016; 5(6):52-78.
13. Dewar R. Information Theory Explanation of the Fluctuation Theorem, Maximum Entropy Production and Self-Organized Criticality in Non- Equibrium Stationary States. Journal of Physics. 2003; 23(4):23-28.
14. Enwere NJ, Hung YC, Ngoddy PO. Texture and Microstructure of African yam bean (*Sphenostylis stenocarpa*) products. Journal of Textural Studies. 1990; 21:377-394.
15. Gomez MI, Obilana AB, Martin OF, Madzuanuse M, Manyo ES. Manual of Laboratory Procedures for Quality Evaluation of Sorghum and Millet, International Crops. Research Institute for Semi and Tropics (ICRISAT), India, 1997, 64.
16. Hallen E, Ibanoglu S, Ainsworth P. Effect of fermented-germinated cowpea flour addition on the rheological and baking of wheat flour. Journal of Food Engineering. 2004; 63(2):177-184.
17. Ihekoronye AI, Ngoddy PO. Integrated Food Science and Technology for the Tropics. Macmillan, London, 1985, 283-289.
18. IITA. Cereal in Tropical Africa. A Reference Manual, International Institute of Tropical Agriculture, Ibadan, Nigeria, 1990, 7-8.
19. Imtiaz H, Burhanuddin M, Gulzar MA. Evaluation of Weaning Foods Formulated from Germinated Wheat and Mungbean from Bangladesh. African Journal of Food Science. 1990; 5(17):897-903.
20. Inyang EU, Effiong CF, Edima-Nyah AP. Physical Properties, Nutritional Composition and Sensory Evaluation of Cookies Prepared from Rice, Unripe Banana and Sprouted Soybean Flour Blends. International Journal of Food Science and Biotechnology. 2018; 3(2):70-76.
21. Kudre TG, Benjakul S, Kishimura H. Comparative study on chemical compositions and properties of protein isolates from mungbean, black bean and Bambara groundnut. Journal of Science and Food Agriculture. 2013; 93:2429-2436.
22. Lorenz K, Collins F. Quinoa (Chenopodium quinoa). Starch Physicochemical Properties and Functional Characteristics. Starch-starke. 1990; 38:58-61.
23. Mubarak AE. Nutritional Composition and Antinutritional Factors of Mungbean Seeds (Phaseolus aureus) as Affected by some Home Traditional Processes. Journal of Food Chemistry. 2005; 89(4):489-495.
24. Ndife J, Kida F, Fagbemi S. Production and Quality Assessment of Enriched Cookies from Wheat and Full Fat Soya. European Journal of Food Science and Technology. 2014; 2(1):19-28.
25. Niba LL, Bokanga MM, Jackson FL, Schlimme DS, Li BW. Physicochemical Properties and Starch Granular Characteristics of Flour from Various *Manihot esculenta* (cassava) Genotypes. Journal of Food Science. 2001; 67:20-24.
26. Nwosu JN. Production and Evaluation of Biscuits from Blends of Bambara Groundnut (*Vigna subterranae)* and Wheat (*Triticum easttrum)* Flours. International Journal of Food and Nutrition Science. 2013; 2:1.
27. Ojinnaka MC, Nnorom CC. Quality evaluation of wheat-cocoyam-soybean cookies. Nigerian Journal of Agriculture, Food and Environment. 2015; 11(3):123-129.
28. Okaka JC, Iseih MI. Development and Quality Evaluation of Cowpea-Wheat Biscuit. Nigeria Food Journal. 1990; 8:56-60.
29. Okoye JI, Obi CD. Chemical Composition and Sensory Properties of Germinated Wheat-African Yam Bean Composite Flour Cookies. Discourse Journal of Agriculture and Food Sciences. 2017; 5(2):21-27.
30. Okpala LC, Ekwe OO. Nutritional Quality of Cookies Produced from Mixtures of Fermented Pigeon Pea, Germinated Sorghum and Cocoyam Flours. European Journal of Food Research & Review. 2013; 3(1):38-49.
31. Okpala LC, Okoli EC. Development of Cookies made with Cocoyam, Fermented Sorghum and Germinated Pigeon Pea Flour Blends Using Response Surface Methodology. Journal of Food Science and Technology. 2012; 34(2):23-26.
32. Onwuka GI. Food Analysis and Instrumentation (Theory and Practice). Naphtali Printers, Lagos Nigeria, 2005, ISBN 978047686.
33. Patindola J, Wanga Y, Jane J. Structure-Functionality Changes in Starch following Rough Rice Storage. Starch/starke. 2005; 57:197-207.
34. Petrović J, Pajin B, Šereš Z, Lončarević I, Fišteš A, Šubarić D, Zarić D. The Effect of Soy Flour on Cookie Quality. Review of Faculty of Engineering. Analecta Technical Szegedeinesia. 2016; 10(2):55.
35. Radley JA. Examination and Analysis of Starch and Starch Products. Applied Science Publishing Limited, London, 1976, 46.
36. Ross AS, Walker CE, Booth RI, Orth RA, Wrigley CW. The Rapid Visco Analyzer: A New Technique for the Estimation of Sprout Damage. Journal of Cereal Chemistry. 1987; 32:827-829.
37. Satinder K, Sativa S, Nagi HPS. Functional Properties and Antinutritional Factors in Cereal Bran. Asian Journal of Food and Agro-Industry. 2011; 4:122-131.
38. Wu HM. Production and Textural Properties of Soy-Cheese Whey Curd. Journal of Food Science. 1983; 48(1):1562-1563.