GSC Advanced Research and Reviews

eISSN: 2582-4597 CODEN (USA): GARRC2

Cross Ref DOI: 10.30574/gscarr

Journal homepage: https://gsconlinepress.com/journals/gscarr/

(Research Article)

Check for updates

Physicochemical and sensory properties of cookies produced from malted sorghum and cassava grate composite flour blends

Patricia Omonegho Adejumo [1, *], Adegbola Ojo Adejumo [2], Funmilola Olutoyin Olukoya [1], Evelyn Oyeribhor [1] and Chioma Anagor [1]

[1] *Department of Food Technology, Auchi Polytechnic, Auchi. Nigeria.*

[2] *Department of Meat Processing, Imo Hill Farms Limited, Ilesha, Nigeria.*

GSC Advanced Research and Reviews, 2023, 15(01), 088–097

Publication history: Received on 01 March 2023; revised on 12 April 2023; accepted on 15 April 2023

Article DOI: https://doi.org/10.30574/gscarr.2023.15.1.0115

Abstract

Malted sorghum - cassava flour was formulated into blends to produce cookies. Sorghum grains were sorted, washed, steeped (12 hours), malted (48 hours) and oven dried. Freshly harvested cassava roots were manually peeled, washed, grated and dried (using hybrid solar dryer at 50 ºC). The dried malted sorghum grains and cassava were processed into flour and sieved. The blends were prepared by homogenously mixing malted sorghum flour and high quality cassava grate flour in varied proportion labelled as sample A (100 % Malted Sorghum Flour) Sample B (60 % Malted Sorghum Flour and 30 % Cassava Flour), sample C (70 % Malted Sorghum Flour and 30 % Cassava Flour) and Sample D (80 % Malted Sorghum Flour and 20 % Cassava Flour) separately prepared into cookies and subjected to proximate, mineral, anti-nutrients, physical and sensory analysis using standard analytical methods with chemicals of analytical grade. The result for moisture, Ash, Fat, Fibre, Protein, Carbohydrate and energy content for samples A, B, C and D respectively ranged from 3.11 % - 6.81 %; 1.41 % - 1.52 %; 21.66 % - 23.41 %; 2.20 % - 2.67 %; 4.41 % - 7.26 %; 60.86 % - 63.85 % 473.09 Kcal - 478.82 Kcal. The mineral result for sodium, potassium and calcium 15.06 mg/100 g, 12.70 mg/100 g, 14.40 mg/100 g and 17.00 mg/100 g; 24.70 mg/100 g, 28.17 mg/100 g, 21.60 mg/100 g and 25.17 mg/100 g; 11.30 mg/100 g, 13.10 mg/100 g, 10.09 mg/100 g and 10.09 mg/100 g respectively. The result recorded for colour ranged from 6.20 - 7.40; aroma was 6.30 - 7.30; taste ranged from 6.10 - 7.20; texture ranged from 5.60 - 5.90 and overall acceptability ranged from 5.70 - 6.50.

It can be concluded that combination of Malted Sorghum and Cassava Flour in cookies production will help to enhance the utilization of both crops, nutritional intake, increase variety and reduce wheat importation.

Keywords: Malting; Sorghum; Drying; Cassava; Grate; Cookies

1. Introduction

Humans have consumed bakery products for hundreds of years. They are crispy, unleavened and sometimes sweet pastry produced light by the addition of baking powder or soda, sometimes with chocolate or fruit input [1]. Cookies is a small, flat, sweet, baked food, usually containing flour, eggs, sugar, and either butter or cooking oil. It may include other ingredients such as raisins, oats, chocolate chips or nuts [2]; which come in an infinite variety of sizes, shapes, texture, composition, tenderness, tastes, and colours [3]. Consumption of bakery products has been increasing as a result of urbanization, and Food industries are exploiting this development by manufacturing nutritious bakery foods [4]. Cookies, a major portion of bakery products are feasible fibre carriers because of their longer shelf-life and have become one of the most desirable snacks for both young and elderly people due to their low manufacturing cost, more convenience and ability to serve as a vehicle for important nutrients [5].

* Corresponding author: Patricia Omonegho, Adejumo

In Nigeria, ready-to-eat baked products (snacks) consumption is continually growing and there has been increasing reliance on imported wheat. Staple crops that are grown other than wheat such as cassava, yam or sweet potatoes and cereals such as sorghum can be used for baked foods [6]. The economy of any country importing wheat for the production of baked foods such as cookies would be improved if other staple food like sweet potato, cassava, yam etc. that are grown locally are used in producing such products. Therefore, efforts are made to partially replace wheat flour with non-wheat flours as a possibility for increasing the utilization of indigenous crops cultivated in Nigeria as well as contribute to lowering cost of bakery products [7].

Sorghum (*Sorghum bicolor*) is an ancient cereal grain belonging to the grass family [8]. It is one of the leading crop worldwide and ranked the fifth highest production of the cereal crops following maize, wheat, rice and barley with 57.6million tons of annual production globally in 2017 [9]. Sorghum has been widely grown in tropical and subtropical regions. In Asian and African countries such as India and Nigeria, sorghum is one of the important crops and is used to make foods such as bread and porridges. It is the principal source of energy and nutrition for humans [10] especially in some under developed and semi-arid regions. The unique profile confers sorghum with a number of health benefits such as reducing oxidative stress and cancer prevention [11], [12].

Roots and tuber crops such as yam and cassava are second only in importance to cereal as a global source of carbohydrates [13]. However, cassava is the second most important tropical root crop in West Africa [14], [15] whose main used form is the production of flour for the constitution of food at the family and industrial scale. Fokom [16] reported that Food and Agriculture Organization of the United Nations, International Center for Tropical Agriculture, the International Institute of Tropical Agriculture and Federal Institute for Industrial Research agreed that there is a need to include crops like cassava into production of low cost foods such as bread and baked foods for strategic development purpose. Therefore, incorporation of malted sorghum-cassava flour to make cookies provides a good opportunity to improve the nutritional quality of snacks consumed by many people especially growing children.

2. Material and methods

2.1. Preparation of Materials

Fresh cassava roots were harvested from CEDAP farm Auchi Polytechnic, Auchi Edo State. Sorghum grain (White), baking fat (simas), sugar (dangote), salt (Mr chef), sodium bicarbonate (baking powder) and milk powder (Dano) used for the production of cookies were obtained from Uchi market Auchi, Edo state. The method of Dziedzoave *et al.* [17] with slight modification was used to produce Cassava Grate Flour. Sorghum (*Sorghum bicolor*) grains were malted according to the method described by Hallen *et al.* [18] with slight modification. The flours were separately packaged in moisture proof polyethylene film and kept at ambient conditions (28±2 ^oC) for later use. Composite flours were prepared by blending malted sorghum and cassava as shown in Table 1 using a Philips blender (Model HR 2001).

Table 1 Formulation of malted Sorghum-cassava flour cookies production

Ingredients **Ratios**	**A** **60:40**	**B** **70:30**	**C** **80:20**	**D** **100:00**
Sorghum flour (g)	180	210	240	300
Cassava flour (g)	120	90	60	-
Fat (g)	200	200	200	200
Sugar (g)	100	100	100	100
Corn starch (g)	100	100	100	100
Vanilla extract (g)	1	1	1	1
Milk flavor (g)	12	12	12	12
Powdered milk (g)	12	12	12	12
Sodium bicarbonate (tsp)	½	½	½	½
Salt (tsp)	$^1/_8$	$^1/_8$	$^1/_8$	$^1/_8$

2.2. Sample Production

The cookies samples were prepared from table 1 above using the method as described by Ndulaka and Obasi [19] with slight modification. The measurements were carefully weighed using a digital scale (Platinum A110C) according to their different ratio proportions. The weighed baking fat and granulated sugar were creamed together with the mixer for 20 minutes for a creamy consistency. Sorghum flour, baking powder, powdered milk, corn starch, cassava flour, vanilla extract, milk flavor and salt were mixed together, this was then added to the creamy mixture and kneaded until dough of plastic but non sticky consistency was obtained. Kneading continued for 5minutes to obtain smooth plastic dough. The batter was shaped using a metre rule to attain a uniform measurement in the baking tray and then baked in an oven at 180 ^{o}C for 25 minutes. The cookies were allowed to cool on a rack after which they were packed in a low density polyethylene bag and kept in a plastic container until required for sensory evaluation and other analysis.

2.3. Mineral Analysis

The mineral analysis was carried out using Atomic Absorption spectrophotometer (AAS) for calcium (Ca) and Corning 400 flame photometer for potassium (K) and sodium (Na) [20]. This was determined by the dry ash extraction method following, which specified mineral element. 2.0 g of the sample (cookies) was burnt to ashes in a muffle, the resulting ash was dissolved in 100 ml of dilute hydrochloric acid. (1 ml HCl) and then diluted to 100 ml in a volumetric flask using distilled water. The digestion so obtained was used for the various analyses. The procedure was repeated for the four samples.

2.4. Sensory Evaluation

Twenty (20) panelists made up of male and female from the Department of Food Technology, Auchi Polytechnic, Auchi, Edo State were randomly selected. They were requested to evaluate the various cookies samples for colour, texture, aroma, taste and overall acceptability using a 9-point hedonic scale where 9 was equivalent to like extremely and 1 meant dislike extremely as described by Iwe [21]. The samples were presented in a well packaged material, coded with different random alphabets, served simultaneously to ease possibility of panelist evaluating the samples. Necessary precautions were taken to prevent bias of panelists. The sensory evaluation data were analyzed using analysis of variance (ANOVA).

2.5. Determination of Proximate Composition

The proximate composition of the prepared samples was determined using the standard method of Association of Official Analytical Chemist [22].

2.6. Energy Value

The energy value was calculated in KJ/100 g, using the Atwater Factor Method, as described by Osborne and Voogt [23]. It was calculated using the equation:

$$E.V = (9 \times Crude\ fat) + (4\ \times crude\ protein) + (4\ \times Carbohydrate)$$

2.7. Statistical analysis

Data obtained from the chemical, mineral, anti-nutrient, physical and sensory analyses were recorded in triplicate and subjected to statistical analysis of variance (ANOVA) with the mean value separated by Duncan's multiple range test at 5 % level of significance.

3. Results

Table 2 Proximate composition of cookies

Sample	Moisture (%)	Ash (%)	Fat (%)	Fibre (%)	Protein (%)	Carbohydrate (%)	Energy (Kcal)
A	5.72 $\pm$0.00^{b}	1.41$\pm$0.01^{a}	22.61$\pm$0.00^{b}	2.20$\pm$0.02^{a}	4.41$\pm$0.05^{a}	63.45$\pm$0.01^{c}	475.16±0.01 ^{b}
B	6.81$\pm$0.03^{a}	1.52$\pm$0.02^{c}	23.41$\pm$0.18^{d}	2.35$\pm$0.02^{b}	4.74$\pm$0.05^{b}	60.86$\pm$0.30^{a}	473.09±0.02 ^{a}
C	5.90$\pm$0.01^{c}	1.47$\pm$0.00^{b}	23.39$\pm$0.03^{c}	2.46$\pm$0.01^{b}	5.72$\pm$0.03^{c}	61.00$\pm$0.01^{b}	477.39±0.00 ^{c}
D	3.11$\pm$0.03^{a}	1.49$\pm$0.01^{bc}	21.66$\pm$0.04^{a}	2.67$\pm$0.07^{c}	7.26$\pm$0.05^{d}	63.85$\pm$0.09^{d}	478.82±0.01 ^{d}

Each value is a mean of triplicate determinations. Mean value with the same letter as superscript on the same column are not significantly different from one another ($p < .05$).

KEY:
Sample A: 100 % malted sorghum cookies;
Sample B: 60 % malted sorghum + 40 % cassava flour cookies;
Sample C: 70 % malted sorghum + 30 % cassava flour cookies;
Sample D: 80 % malted sorghum + 20 % cassava flour cookies

Table 3 Mineral composition of cookies (mg/100 g)

Sample	Sodium	Potassium	Calcium	Magnesium	Iron	Manganese	Zinc
A	15.06±0.04[c]	24.70±0.00[b]	10.09±0.00[a]	10.91±0.01[b]	0.08±0.00[a]	0.01±0.00[a]	0.42±0.00[c]
B	12.70±0.00[a]	28.17±0.00[d]	11.30±0.00[c]	10.62±0.02[a]	0.10±0.00[b]	0.01±0.00[a]	0.37±0.00[b]
C	14.40±0.00[b]	21.60±0.00[a]	10.09±0.00[b]	13.40±0.00[c]	0.11±0.01[b]	0.20±0.00[b]	0.32±0.00[a]
D	17.00±0.00[d]	25.17±0.00[c]	13.10±0.00[d]	14.30±0.03[d]	0.12±0.06[b]	0.03±0.00[c]	0.48±0.00[d]

Each value is a mean of triplicate determinations. Mean value with the same letter as superscript on the same column are not significantly different from one another ($p < .05$).

Table 4 Anti-Nutrients Components of cookies

Samples	Phytics (mg/g)	Oxalate (mg/g)	Phytic acid (mg/g)	Tannin (mg/g)	Phenol (mg/g)
A	12.09±0.03[d]	15.78±0.11[c]	3.50±0.08[d]	1.23±0.00[c]	30.79±0.11[c]
B	8.06±0.03[c]	13.64±0.03[b]	2.29±0.03[c]	0.62±0.02[a]	17.58±0.33[b]
C	3.79±0.00[a]	13.79±0.08[a]	1.68±0.00[a]	0.70±0.01[b]	15.33±0.43[a]
D	7.52±0.10[b]	13.25±0.10[a]	2.09±0.00[b]	0.61±0.01[b]	14.55±0.59[a]

Each value is a mean of triplicate determinations. Mean value with the same letter as superscript on the same column are not significantly different from one another ($p < .05$).

Table 5 Physical properties of cookies

Sample	Thickness (mm)	Weight (g)	Diameter (mm)	Spread ratio
A	10.80±0.00[a]	43.00±0.58[b]	85.60±0.00[d]	7.93±0.00[c]
B	10.83±0.00[b]	50.00±1.16[c]	104.80±0.00[b]	9.70±0.00[d]
C	10.81±0.00[a]	30.00±1.16[a]	76.90±0.00[a]	7.13±0.00[b]
D	13.70±0.00[c]	40.00±0.67[b]	86.10±0.00[c]	6.62±0.00[a]

Each value is a mean of triplicate determinations. Mean value with the same letter as superscript on the same column are not significantly different from one another ($p < .05$).

Table 6 Sensory attributes of cookies

Sample	Colour	Aroma	Taste	Texture	Overall acceptability
A	6.20±0.80[a]	6.60±0.82[a]	6.20±0.83[a]	5.70±0.82[a]	6.20± 0.87[a]
B	6.20±0.78[a]	6.30±0.78[a]	6.50±0.78[a]	5.60±0.76[a]	5.70 ± 0.68[a]
C	6.40±0.78[a]	6.40±0.78[a]	6.10±0.80[a]	5.80±0.94[a]	6.30 ± 0.76[a]
D	7.40±0.92[a]	7.30±0.91[a]	7.20±0.91[a]	5.90±0.96[a]	6.50 ± 0.85[a]

Each value is a mean of triplicate determinations. Mean value with the same letter as superscript on the same column are not significantly different from one another ($p < .05$).

4. Discussion

4.1. Proximate

The proximate composition of cookies produced from malted sorghum – cassava flour is shown on Table 2. A significant difference (P<0.05) was observed in the proximate composition of the cookies. The moisture content value obtained were 5.72 %, 6.81 %, 5.90 % and 3.11 % for samples A, B, C and D respectively. 20 % cassava flour inclusion (sample D) had the least moisture content value while 40 % cassava inclusion (sample B) had the highest value. This result is also in line with the work of Akinwale *et al.* [24] who reported 4.28 % – 6.07 % moisture content for malted sorghum and tigernut flour cookies. High moisture samples > 12 % usually have short shelf stability. All the cookies had low moisture content and this suggests that they will have prolonged shelf-life. Moisture content is a property that indicates the storage stability of a sample. At lower moisture content the deterioration of baked product would be lowered due to reduced activity of microorganisms. Ezeama [25] also reported that microbial proliferation was minimum at low moisture content and it confers higher shelf-life stability of the cookies.

The ash content value obtained were 1.41 %, 1.52 %, 1.47 % and 1.49 % for sample A, sample B, sample C and sample D respectively on Table 2. Significant difference occurred among the samples (P<0.05). Sample A (100 % Malted Sorghum cookies) has the least value while sample B (40 % cassava inclusion) had the highest ash content value. The increase observed showed that cassava inclusion enhanced the ash content of the cookies. Malted sorghum and other cereal grains have been reported to have low levels of ash [26]. Ash content is an indication of the mineral content of food sample.

The fat content of malted sorghum - cassava cookies as shown on Table 2 were 22.61 %, 23.41 %, 23.39 % and 21.66 % for sample A, sample B, sample C and sample D respectively. Significant differences occurred among the four samples (P<0.05). Cookies produced from 40 % cassava flour inclusion (sample B) have the highest percentage of fat (23.41 %) and cookies produced from 20 % cassava flour (sample D) had the least (21.66 %). The high fat content may be due to the quantity of baking margarine used. Fats are an integral part of cookies being the third largest component after flour and sugar [27]. Cookies are in fact a rich source of fat and carbohydrates hence, are energy giving food [28].

The fibre content of the cookies from Table 2 revealed that sample A had 2.20 %, Sample B 3.25 %, sample C 2.46 % and sample D 2.67 % with Sample A (100 % malted sorghum flour) having the least value and sample D (40 % cassava flour) having the highest fibre content. Significant difference was observed among the samples (P<0.05). The result of the cookies showed that the higher the cassava flour inclusion in the flour blend the higher the fibre content. High fibre content is important for digestion, hormone production and cardiovascular health [29].

The protein content value obtained were 4.41 %, 4.74 %, 5.72 % and 7.26 % for sample A, sample B, sample C and sample D respectively. Significant difference was observed among the four samples. Sample D has the highest protein content (7.26 %) and sample A had the least value (4.41 %). The result showed that the lesser the cassava flour inclusion the higher the protein content. Protein is a macromolecule of importance in food. Protein is required for growth, repair and maintenance of the body; it also act as carrier for other nutrients lipid, iron, vitamin A, sodium and potassium [30, 31].

The carbohydrate content of the cookies produced from malted sorghum – cassava flour was 63.45 %, 60.86 %, 61.00 % and 63.85 % for sample A, sample B, sample C and sample D respectively, with sample D having the highest value and sample C (30 % cassava flour inclusion) had the least. Significant difference was observed among the four samples (P<0.05). The decrease in the carbohydrate content of the cassava inclusion cookies might be caused by other ingredients used for the cookies formulation.

Energy values of cookies was 475.16 Kcal, 473.09 Kcal, 477.39 Kcal and 478.82 kcal. Significant difference occurred among the four samples. The energy value slight increase could be a function of replacement of the malted sorghum with cassava flour and 20 % replacement gave the highest value. Protein, fat and carbohydrate values contributed to the calorie content of the cookies. Okaka *et al.* [32] stated that consumption of 15 - 20 pieces of cookies can provide adequate energy per day based on recommended dietary allowances for children (7.6 MJ) and for adults (10.8 MJ).

The result for proximate showed that 20 % inclusion of cassava flour in the production of cookies gave the best nutritional composition.

4.2. Mineral

The mineral composition of malted sorghum-cassava cookies is represented on Table 3. The values obtained for sodium were sample A (15.06 mg/100 g), sample B (12.70 mg/100 mg), sample C (14.40 mg/100 g) and sample D (17.00 mg/100 g). Significant difference was observed among the flour samples with sample D having the highest value and sample B having the least. The potassium content of malted sorghum - cassava cookies was 24.70 mg/100 g, 28.17 mg/100 g, 21.60 mg/100 g and 25.17 mg/100 g for sample A, sample B, sample C and sample D respectively. Sample B had the highest value while sample C had the least. Significant difference occurred among the samples. High potassium and low sodium contents recorded in the cookies samples is advantageous and has been reported to protect against arterial hypertension [33].

The calcium content for malted sorghum–cassava cookies recorded were sample A (10.09 mg/100 g), sample B (11.30 mg/100 g), Sample C (10.09 mg/100 g) and Sample D (13.10 mg/100 g). Significant difference was observed among the four samples, sample D had the highest value while samples A and sample C had the least. The high calcium content of the cookies produced in this study is an indication that the cookies will promote bone development and strong teeth in children as reported by Bolarinwa *et al*. [34].

The result of the magnesium showed that sample A had 10.91 mg/100 g, sample B 14.03 mg/100 g, sample C 10.62 mg/100 g and sample D 13.40 mg/100 g. Sample C had the lowest value of (10.62 mg/100 g) while sample B had the highest value of (14.03 mg/100 g). There was a significant difference among the samples ($p<0.05$). Magnesium content of the cookies increases as malted sorghum is replaced with cassava flour. The result showed that cassava is a good of source of magnesium.

The result of Iron content recorded was sample A 0.10 mg/100 g, sample B 0.08 mg/100 g, sample C 0.11 mg/100 g and sample D was 0.12 mg/100 g. Sample B had the lowest level of (0.08 mg/100 g) while sample D has the highest value of (0.12 gm/100 g). This might be due to the proportion of cassava flour used for substitution. There was significant difference ($p <0.05$) among the samples.

The result of the manganese content recorded were 0.10 mg/100 g for sample A, 0.01 mg/100 g for sample B, 0.02 mg/100 g for sample C and 0.03 mg/100 g for sample D. Both sample A and sample B had the lowest value of 0.01 mg/100 g while sample D (0.03 mg /100 g) had the highest value. There was a significant difference among the samples ($p < 0.05$).

The result of the Zinc content recorded were 0.48 mg/100 g for sample A, 0.42 mg/100 g for sample B, 0.37 mg/100 g for sample C and 0.32 mg/100 g for sample D, sample D had the lowest value of (0.32 mg/100 g) while the sample A had the highest value of (0.48 mg/100 g) there was a significant difference ($p<0.05$) among the sample. The result showed that sorghum and cassava are not a good source of Zinc although the higher the substitution of malted sorghum with cassava flour the higher the zinc content of the cookies.

4.3. Anti-Nutrients

Table 4 above shows the anti-nutritional properties of cookies produced from malted sorghum cassava composite flour. The properties include phytate Oxalate, phytic acid, Tannin and phenol. The result of the phytate above showed that sample A had 12.09 mg/100 g, sample B had 8.06 mg/100 g sample C had 3.79 and sample D 7.52 mg/100 g. The four sample were significantly different from each other ($p<0.05$). The phytate content decreased with increased substitution of malted sorghum with cassava composite flour. The result showed that cassava flour is a poor source of phytate [35] reported that the maximum tolerable dose of phytate in the body is from 250 - 500 mg/100 g. it could be inferred that the cookies are safe for consumption.

The result of the Oxalate content recorded were 15.78 mg/100 g for sample A, 13.79 mg/100 g for sample B, 13.64 mg/100 g for sample C and 13.25 mg/100 g for sample D. Sample B (40 %) cassava flour inclusion had the highest value while sample D (20 % cassava flour inclusion) had the least value. Significant difference occurred among the sample. The result showed that cassava reduce the quantity of oxalate in the cookies, it could be inferred that cassava is not a good source of oxalate. The result of phytic acid were sample A 3.50 mg/100 g, sample B 2.09 mg/100 g, Sample C 2.29 mg/100 g and sample D 1.68 mg/100 g. There was a significant difference among the sample ($p<0.05$).

The result of tannin was 1.23 mg/100 g, 0.70 mg/100 g, 0.61 mg/100 g and 0.62 mg/100 g for sample A, B, C and D respectively. Sample C had the lowest value of (0.61 mg/100 g) while sample A had the highest value of (1.23 mg/100 g). Tannin content was affected by degree of substitution of malted sorghum with cassava flour. Tannins are capable of forming insoluble complexes with protein resulting to quality reduction and interfere with dietary iron absorption [36, 37, 38]. Adeparusi [39] also reported that tannins affect protein digestibility and adversely influence the bioavailability, obtained from plant sources leading to poor iron and calcium absorption. Despite tannin has detrimental effect, it also has several benefits in processed food and human health; the antimicrobial property of tannic acid can be used to increase the shelf-life of certain foods in food processing [40].

The result of the phenol content recorded were 30.79 mg/100 g for sample A, 17.58 mg/100 g for sample B, 15.33 mg/100 g for sample C and 14.55 mg/100 g for sample D. Sample D had the lowest value of (14.55 mg/100 g) while sample A had the highest value of (30.79 mg/100 g). There was significant difference among the samples. Phenol content increases with increased substitution of malted sorghum with cassava flour. The result showed that malted sorghum flour is a good source of phenol.

4.4. Physical Properties

Table 5 above shows the physical properties of malted sorghum – cassava flour cookies. The result showed that sample A had 13.70 mm, sample B had 10.80 mm, sample C had 10.83 mm and sample D had 10.81 mm for thickness. There was no significant difference between samples A and C but samples A and C were significantly different from samples B and D.

The weights of the cookies recorded were Sample A (40.00 g), sample B (43.00 g), sample C (50.00 g) and sample D (30.00 g) respectively. Significant differences occurred among the samples with the sample B (30 % cassava inclusion) having the highest value while sample C (20 % cassava inclusion) had the least.

The values obtained for the diameter of the cookies were recorded as sample A (85.60 mm), sample B (85.60 mm), sample C (104.80 mm) and sample D (76.90 mm). Significant difference occurred among all the samples. Sample B (30 % cassava inclusion) had the highest value and sample C (20 % cassava inclusion) had the least. The spread ratio had the following values for sample A, sample B, sample C and sample D respectively 6.62, 7.93, 9.70 and 7.13. Sample C (30 % cassava inclusion) had the highest value while sample A (100 % malted sorghum cookies) had the least. Significant differences were observed among all samples. Spread ratio represent the ratio of diameter to thickness and cookies having higher spread ratio are considered more desirable [41]. Hence this implies that sample B (with 30 % cassava flour) was rated the most desirable cookies. Spread factor is the ratio that depends on the values of the thickness and diameter of the cookies. It is an important quality parameter, the higher the spread ratio, the higher will be product yield. Dhankhar [42] reported values for cookies made with wheat flour had spread factor of 7.58.

4.5. Sensory

Table 6 above showed sensory properties of cookies produced from malted sorghum – cassava composite flour. The result of the colour showed that sample A recorded 6.20, sample B 6.20, sample C 6.40 and sample D 7.40. Sample A had the lowest value (6.20) while sample D had the highest value (7.40). No significant difference ($p > 0.05$) was observed among the samples The result of the aroma content recorded were 6.60, 6.30, 6.40 and 7.30, for sample A, B, C and D respectively. Sample B had the lowest value of 6.40, while sample D had the highest value of 7.30. There was no significant difference ($p > 0.05$) among the samples.

The result for taste recorded were 6.20 for sample A, sample B 6.50, sample C 6.10 and sample D 7.20. Sample C had the lowest value (6.10) while D had the highest value (7.20). There was no significant difference ($p > 0.05$) among the samples.

The texture result showed that sample A recorded 5.70, sample B 5.60, sample C 5.80 and sample D 5.90. sample B had the lowest value of (5.60) while sample D had the highest value of (5.90). No significant difference ($p>0.05$) was observed among the samples. The result of the overall acceptability recorded were 6.50, 5.70, 6.30 and 6.20 for sample A, B, C and D respectively. Sample B had the lowest value of 5.70 while sample A had the highest value of 6.50. There was no significant difference ($p>0.05$) among the samples. The sensory result indicates acceptable cookies could be produce from malted Sorghum-cassava flour especially at 20 % cassava flour inclusion.

5. Conclusion

Results of the study revealed that cookies of desirable chemical, mineral, anti-nutrient, physical and sensory properties have been produced from malted Sorghum-cassava grate flour. The use of malted sorghum and cassava flour of such blends could lead to improved utilization of indigenous food crops in Nigeria where the import of wheat flour is a necessity.

Compliance with ethical standards

Acknowledgments

The authors are grateful to the management of Auchi Polytechnic, Auchi, Edo State, Nigeria for providing conducive environment to carry out this research.

Disclosure of conflict of interest

We the authors declare there is no conflict of interest.

References

[1] Adhikari, N. and Acharya, D.R. (2015). Effect of incorporation of Malted Sorghum Flour on quality of biscuit, Sunsari Technical College Journal, 2(1):33 – 37.

[2] Priya, S.R. and Lalitha, R. (2016). Physical, chemical and microbial properties of cookies developed using coconut products. International Journal of Recent Scientific Research, 7(3): 9670-9674.

[3] Abass, A., Onabolu, A.O. and Bokanga, M. (1998). Impact of the high-quality cassava flour technology in Nigeria. In Akoroda, M. O. & Ngve, J. M. (Eds). Root crops in the 21th century. Proceedings of the 7th Triennial Symposium of the International Society for Tropical Root Crops Africa Branch (ISTRC- AB). Cotonou, Benin, 11-17 October. Benin: Center International des Conference.

[4] Akubor, P. and Ukwuru, M. Functional properties and biscuit making potential of soybean and cassava flour blends. Plant Foods for Human Nutrition, 58(3): 1-12.

[5] Amin T, Bashir T, Dar BN, Nayak HR. (2016). Development of high protein and sugar-free cookies fortified with pea (Pisum sativum L.) flour, soya bean (Glycine max L.) flour and oat (Avena sativa L.) flakes. International Food, 23(1):72-76

[6] Oluwamukomi, M.O., Oluwalana, I.O. and Akinbowale, O.F. (2011). Physiochemical and Senosry Properties of Wheat-Cassava Composite Flour enriched with Soyflour, African Journal of Food Science, 5(2):50-56.

[7] Ayo, J.A. and Gaffa, T. (2002). Effect of Undefatted Soybean Flour on the Protein Content and Sensory Quality of Kunnu Zaki, Nigeria Food Journal, 20:7-9.

[8] Khady, B.A., Emmanuel, T. Jacqueline, D., Ndiaga, C. and Phillipe, T. (2010). Comparative Study of Phenolic Compounds, the antioxidant power of various Senegalese Sorghum Varieties and an amylolytic enzymes of their malt, Biotechnology Agronomy Social Environment, 14(1): 131 – 139.

[9] FAO (2017). FAOSTAT, Food and Agriculture Organization of the United Nation. Retrieved from http://www.fao.org/faostat/en/#dsta/ac.

[10] Rooney, L.W. and Waniska, R.D. (2000). Sorghum Food and Industrial Utilization in C.W. Smith and R.A. Frederickaon (Eds.), Sorghum: Origin, History, Technology and Production, 2: 688 – 729.

[11] Gonzalez-Montilla, F.M., Chavez-Santoscoy, R.A., Gutierrez-Uribe, J.A. and Sieria-Salvidar, S.O. (2012). Isolation and identification of phase II enzyme inductors obtained from black shaway/Sorghum bicolor (L) MoenchJbran. Journal of Cereal Science, 55(2): 126 – 131.

[12] Yang, L., Browning, J.D. and Awika, J.M. (2009). Sorghum 3-deoxyanthocyanins possess strong phase II enzyme inducer activity and cancer cell growth inhibition properties. Journal of Agricultural and Food Chemistry, 57(5): 1797 – 1804. https://doi.org/10.1021/jf8035066.

[13] Oladipo, F., Bolarin, O., Daudu, A., Kayode, A., and Awoyele, P. (2017). Utilization of soil conservation practices among root and tuber farmers in Oyun Local Government Area of Kwara State, Nigeria. *Agrosearch*, 17(2), 99–109.

[14] Adisa, R.S., Adefalu, L.L., Olatinwo, L.K., Balogun, K.S. and Ogunmadeko, O.O. (2015). Determinants of Post-harvest losses of yam among yam farmers in Ekiti State, Nigeria; Bulletin of the Institute of Tropical Agriculture, Kyushu University, 38:073 – 078.

[15] Falola, A., Salami, M., Bello, A. and Olaoye, T. (2017). Effect of yam storage techniques usage on farm income in Kwara State, Nigeria; Agrosearch, 17(1):54 – 65.

[16] Fokom R, Adamou S, Djontzo T E, Ngwasiri P N, Essono D, Kotue T C, Ngono E S, Tomedi E M, Tchoumbougnang F, Nwaga D. (2019). Quality and Properties of Cassava Base Biscuit as affected by Fish Flours and Arbuscular Mycorrhizal (AM) Fungi. Nutrition Food Science International Journal, 9(3): 59-66.

[17] Dziedzoave, N.T., Graffham, A.J. and Boating, E.O. (2003). Training Manual on the production of High quality cassava flour. Training material produced under the DFID-funded research project (R7418) on “New Market for Cassava”.

[18] Hallen, E., Ibanglu, S. and Ainswoth, P. (2004). Effect of fermented/germinated cowpea flour added on the rheological and bakery properties of wheat flour” Journal of Food Engineering, 63:174-184.

[19] Ndulaka, J.C. and Obasi, N.E. (2018). Effects of storage and Beta-carotene contents of cookies Leke products Formulated from Blends of wheat flour and Garri from Bio-fortified Cassava varieties. Internationnal Organisation of science Research Journal of Environmental science, Toxicology and Food Technology (IOSR-JESTFF), 12(6), 89-100. www.iosrjournals.org

[20] AOAC (2005). Official Methods of Analysis of the AOAC. 18th Ed. Association of Official Analytical Chemists, Gaithersburg.

[21] Iwe, M.O. (2010). Some sensory methods and data analysis. In handbook of sensory methods and analysis (second ed.) ISBN:978-32124-8-6 published in Rojoint communication services LTD, Enugu, Nigeria, 80 – 85.

[22] AOAC. (2000). Official Methods of Analysis of the Association of Official Analytical Chemists (15th ed). Association of Official Analytical Chemist, Washington DC.

[23] Osborne, D.R. and Voogt, F. (1978). The Analysis of Nutrients in Foods. London: Academic Press.

[24] Akinwale, T.E., Ibidapo, O.E., Owolabi, S., Efeirbe, N.E. and Adejilola, O.E. (2020). Production of Gluten free cookies from blends of Malted Sorghum and Tigernut Flour, American Journal of Food Science and Technology; 8(3): 106 – 111.

[25] Ezeama, C. F. (2007). Food microbiology: Fundamentals and applications. Natural Prints Ltd. Lagos.

[26] Murekatete, N., Yufei, H., Xiangzhen, K and Caimeng, Z, (2012). Effects of fermentation on nutritional and functional properties of soybean, maize and germinated sorghum composite flour. International Journal of Food Engineering, 8(1):1-15.

[27] Manley, D., 2000. Technology of Biscuits, Crackers and Cookies. CRC Press, Boca Raton, FL., ISBN-13: 9781855735323, Pages: 499.

[28] Kure, O.A., Bahago, E.J. and. Daniel E.A, (1998). Studies on the proximate composition and effect of flour particle size on acceptability of biscuit produced from blends of soyabeans and plantain flours. Namida Tech-Scope Journal, 3: 17-21

[29] Poudel, S. (2021). Effect of Incorporation of Malted Sorghum in the Quality of Biscuit, [B.Sc Dissertation, Food Technology Instruction Committee, Institute of Science and Technology, Tribhuvan University], Food Instruction Committee, 072 – 076.

[30] Adejumo, P.O., Adejumo, A.O., Edebiri, O.E. and Olukoya, F.O. (2020). Effect of unripe banana and pigeon pea flour on the chemical, anti-nutreitional and sensory properties of whole wheat-based cookies. GSC Advanced Research and Reviews, 4(01), 017.023.

[31] Mahan, K and Escott-Stump, S. (2008). Krause’s food and nutrition therapy, 12thg edition Canada; Saunders Elsevier.

[32] Okaka, J.C., E.N.T. Akobundu and A.N.C. Okaka, 1992. Human Nutrition: An Integrated Approach. ESUT Publication, Enugu, pp: 122-126.

[33] Wardlaw, F.M. (2004). Perspectives in Nutrition, McGraw Hill Companies, New York, USA, 6th edition, 413 – 445.

[34] Bolarinwa, I.F., Olaniyan, S.A., Adebayo, L.O and Adenola, A.A. (2015). Malted Sorghum – Soy Composite Flour: Preparation, Chemical and Physio-chemical Properties, Journal of Food Process Technology, 6(8): 1 – 7.

[35] Bergeron, D., Bushway, R.J., Roberts, F.L., Kornfield. I., Okedi, J. and Bushway, A.A. . (1988). The nutrient compositon of insect flour sample from Lake Victoria, Uganda. Journal of Food Composition and Analysis, 1(4):371-377.

[36] Abulude, F.O., Adesaanya, W.O., Ogunkoya, M.O., Elemide, O.A. and Esiet, E.E. (2007) The nutritional compositin of ogi and its by-products. Acta Alimentaria, 36(4):489-493. DOI:10.1556/AAlim.2007.0001.

[37] Admassu, S. 2009. Potential health benefits and problems associated with phytochemicals in food legumes. East African Journal of Sciences 3(2): 116–133.

[38] Tadele, Y. (2015). Important anti-nutritional substances and Inherent toxicants of Feeds. Food Science and Quality Management 36: 40–48.

[39] Adeparusi, E. O. 2001. Effect of processing on the nutrients and anti-nutrients of lima bean (Phaseolus lunatus L.) flour. Die Nahrung 45(2): 94–96.

[40] Chung, K.T., Lu, Z. and Chou, M, (1998). Mechanism of inhibition of tannic acid and related compounds on the growth of intestinal bacteria. Food Chem. Toxicol,. 36:1053-1060. DOI:10.1016/s0278-6915(98)00086-6.

[41] Onabanjo, O.O. and Ighere, D.A. (2014). Nutritional, Functional and Sensory Properties of Biscuit produced from Wheat Potato Composite. Journal of Food Technology Research, 2(1):111-121.

[42] Dhankhar, P. (2013). A Study on Development of Coconut Based Gluten Free Cookies, International Journal of Engineering Science Invention, 2(12):10-19. ISSN (Online): 2319 – 6734.