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Research article

# Consumer acceptability of acha and malted Bambara groundnut (BGN) biscuits sweetened with date palm

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ABSTRACT

Biscuits are ready to eat and convenient food product consumed among all age groups in most countries. The objective is to evaluate utilisation of acha, malted BGN and date palm flour in gluten-free, sugar-free biscuits. Mixture design was used to establish the appropriate proportion of acha, malted BGN and date palm flours for consumer acceptable biscuit. The sensory, physical, proximate and microbial properties of the biscuits were determined. The linear mixture model for taste, flavor and overall acceptability significantly ($p < 0.05$) explained the effect of the components on the sensory quality of the biscuits with strong correlation coefficient ranging from 0.574 for flavor to 0.944 for taste. The adequate precision was greater than 4 and the lack of fit was not significant. Hence, the linear mixture model could be used to navigate the space. Significant differences ($p \leq 0.05$) existed in color, taste, flavor, texture, crispiness and overall acceptability of the biscuits. The biscuit produced with 60:10:30 acha, malted BGN and date palm, respectively was most preferred with a mean of 7.3. There was no significant difference between the preferred biscuit and the control 60:10:30 acha, malted BGN and sugar, respectively in colour, taste, flavour, texture except in crispiness. The physical properties for the most preferred biscuit are weight 23.0 g, height 3.0 g, spread ratio 7.7 and break strength 750 g with fat 20.1%, protein 11.9%, ash 2.6%, moisture 1.2%, crude fibre 4.3% and carbohydrate 60.0%. The microbial count for the most acceptable sample ranged from $1.0x10^3$to $4.0x10^3$cfu/g for bacteria and $1.0x10^4$to $5.0x10^4$cfu/g for mold/yeast. Hence, acha, malted BGN and date palm flours could produce consumer acceptable gluten-free, sugar-free biscuits.

**Practical implication**

This study demonstrates the possibility of producing consumer acceptable gluten-free, and sugar-free biscuits from acha, malted BGN and date palm fruit as sweetener. The mixture design process can be used for commercial production of these biscuits for children, adults, diabetic patients and for food security and economic impact.

## 1. Introduction

The consumption of cereal foods like biscuits is prevalent globally and in Nigeria where estimated, 80% of the total consumption is among children and an excellent supplementary food for energy malnourished children and adults (Khattak and Mohamed, 2003). However, most of these cereal foods are deficient in protein content and protein quality (Alobo, 2001).

Date palm (*Phoenix dactytifera* L) called ‘Debino’ in Hausa language from the family of *Arecaceae* with 20% moisture, 3,000 kcal/kg energy, carbohydrate (88% total sugar), 0.5% fat, 5.6% protein, vitamins (vitamin A, B, C, K) and 11.5% dietary fibre. The date fruit contains almost half of the amount of sugar in the form of fructose (Al-shahib and Marshal, 2003).

Many sugar substitutes are used in baking especially in a situation where low calorie alternatives may affect positively on medical condition such as diabetes where sugar consumption is severally limited. Some natural alternatives used in place of white sugar for bakery purposes are raw honey, maple syrup, molasses, fruit sugars, barley malt syrup and brown rice syrup (Morgan, 2015).

Acha *(Digitaria exilis*), an old African cereal grain is also known as *fonio* or hungry rice (Jideani and Jideani, 2011). The grain is uniquely rich in methionine and cystine and evokes low sugar on consumption (Ayo et al., 2007). The appealing research emphasis on acha which was

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reported recently was because of the special quality it has in controlling blood glucose (Olapade, 2011; Jideani, 1999; Agu et al., 2007, 2008). The baking potential of acha either as whole or in composite flour was reported by several researchers with a significant level of approval (Olapade et al., 2011; Olapade and Oluwole, 2013; Agu et al., 2014; Olagunju et al., 2018).

An important African legume found in semi-arid Africa is Bambara groundnut (*Vigna subterranea* L.) (BGN). Most Africans particularly the more impoverished people use it as an essential source of protein in their diet because they cannot pay for costly animal protein (Baryeh, 2001; Hillocks et al., 2012; Talabi et al., 2019). However, Alozie et al. (2009), Dikshit et al. (2003) and Maphosa and Jideani (2017) observed that malting BGN improves the protein content especially increased methionine with higher values than most grain legumes. Improvement in B-group vitamins, sugars and digestabilities, and decrease in phytates and protease inhibitors are the metabolic effects of malting process while the amount of oil content is half the quantity established in legumes such as peanut. There are documented works on the enrichments of foods with malted BGN (Olapade and Oluwole, 2013; Nwadi et al., 2020).

Biscuits are produced mostly from wheat flour sweetened with sugar but because of their availability and cost, there is an ongoing effort to partially or replace wheat flour with non-wheat flours towards increasing the utilization of indigenous crops cultivated in Nigeria for sustainable development (Noorfarahzilah, 2014; Olapade, 2011). The innovation is to use indigenous crops cultivated in Nigeria such as acha, malted BGN and date fruit as a sweetener. These crops are nutritious, affordable and underutilized for non-gluten and sugar-free biscuits. The objectives of this work were to (1) formulate composite flour from acha grain, malted BGN, and date palm fruits for acceptable biscuits using mixture design and (2) establish the consumer acceptability of the most preferred biscuit sweetened with date palm and that sweetened with sugar (control).

## 2. Materials and methods

### 2.1. Source of materials

The consumable materials such as brown acha (*Digitaria exilis*), cream colored BGN (*Vigna subterranea* L.), Date palm (*Phoenix dactylifera* L.) margarine (Simas, Indonesia), salt (Dangote, Lagos), baking powder (Princess K, Kano), and milk (Peak, Lagos) were purchased from a local market in Bauchi, Bauchi State, Nigeria. The equipment and chemicals used were obtained from the Department of Food Science and Technology, Federal Polytechnic Bauchi, Bauchi State, Nigeria. The chemicals were of analytical grade.

### 2.2. Production of acha flour

Acha (*Digitaria exilis*) grain was sorted to remove tiny stones and foreign materials and washed with clean tap water three times for 20 min. The washed grains were drained, cabinet dried (APV Mitchell Dryers, England) at 60 °C for 8 h, milled using a hammer mill (Bremmer, Germany) and sieved using 0.3 mm screen size. The flour was packaged in polyethylene bag and stored in a refrigerator at 4–6 °C until required for analysis (Ayo et al., 2008).

### 2.3. Production of malted BGN flour

BGN was cleaned and sorted to remove unwanted materials. The legume was washed thoroughly with clean tap water and soaked for 12 h at an average room temperature of 28 ± 2 °C. The seeds were spread on wet jute bags and covered with a moistened muslin cloth to sprout for 24 h. Germinated seeds were evenly spread on oven trays and dried in an air oven (Gallenkamp, Germany) at 60 °C for 6 h, the vegetative part of the dried BGN seeds was removed manually and winnowed. The clean seeds were milled into fine flour using the hammer mill (Bremmer, Germany) and sieved through an aperture 0.4 mm sieve (Endecotts Ltd, London, England). The flour was packaged in high-density polyethylene bags and stored in a refrigerator at 4 °C until needed (Alobo, 1999).

### 2.4. Production of date palm fruit flour

Inorder to remove immature, overripe and damaged fruits, the date palm fruits were sorted, washed and seeds removed. The pulps were milled and dried in a cabinet drier (APV Mitchell Dryers, England) at 65 °C for 8 h. The dried date palm fruits were sieved using a 0.3 mm screen aperture sieve, packed in a plastic container and stored until required for analysis (Al-Hooti et al., 1995).

### 2.5. Effect of acha, malted BGN and date palm on the sensory properties of biscuits

A D-optimal mixture design experiment was conducted to establish the impact of acha (60, 75%), malted BGN (10, 25%) and date palm (15, 30%) on the sensory qualities of the biscuits. The three mixture components were constrained to 100%. The design consisted of 12 formulations (Table 1) comprising of three vertex model points, three replicated vertices, three model centre edge points, two axial check blends and one center point. The biscuits were baked in randomized order to reduce the chance that differences in experimental materials and baking conditions strongly bias the results. To each run was added baking powder (3.2 g), egg (2.8 ml), salt (0.4 g), margarine (30 g) and milk/water (30 ml) combined in a bowl, mixed until the dough was formed and kneaded until smooth. The rolling and cutting process was done on the pastry surface. The pastry was flattened with a rolling pin to the thickness of 3.5 mm, cut with a 35 mm biscuit cutter. The cut biscuits were placed on baking trays to facilitate easy removal of the baking biscuits. The oven was preheated to 220 °C after which the baking sheet was greased with shortening (fat). The set was transferred into a hot oven and was baked for 15–25 min, until golden brown. The baked biscuits were removed, from the trays, cooled and packaged in polythene bags and stored until required for sensory evaluation (Obiora, 2011).

### 2.6. Sensory evaluation of the twelve biscuits

The sensory evaluation of the biscuits was carried out using 50 semi-trained panelists selected from the Federal Polytechnic Bauchi, Nigeria based on their familiarity with the product. The panelists were served three-digit coded biscuits (23 g) on clean white plates in different boots under white fluorescent light. They were instructed to rate the biscuits for color, taste, flavor, texture, crispiness and overall acceptability on a 9-point hedonic scale with 1 equals “dislike extremely” and 9, “like extremely” (Larmond, 1977).

The sensory data were fitted to the linear mixture model (Equation 1) using Design expert version 10.

$$Y = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \tag{1}$$

Where Y is the sensory qualities to be predicted, β is the strength of each component ($\beta_1$, $\beta_2$, $\beta_3$ respectively for acha, malted BGN and date palm flours) and X is the component proportions ($X_1$, $X_2$, $X_3$, respectively for acha, malted BGN and date palm flours) The goodness of the model fit was determined by the lack of fit F-value and adequacy precision (Design-Expert version 10). The trace (piepel) and three-dimensional response surface plots were used to interpret the effects of the components on the sensory responses.

### 2.7. Ethics approval and consent to participate

The study got approval from Animal Research Ethics Committee, Nnamdi Azikiwe University, Awka on the basis that the sensory evaluation study is human subject research, and informed consent was obtained from all the panelists for the evaluation.

**Table 1.** Experimental design for acha-malted BGN-date palm composite biscuits*.

| Sample codes | Mixture components (%) | | |
|---|---|---|---|
| | Acha | Malted BGN | Date palm |
| XKL | 60.0 | 10.0 | 30.0 |
| ZWY | 60.0 | 17.5 | 22.5 |
| BMC | 75.0 | 10.0 | 15.0 |
| ESL | 62.5 | 20.0 | 17.5 |
| VHQ | 60.0 | 25.0 | 15.0 |
| FPA | 62.5 | 12.5 | 25.0 |
| TRJ | 60.0 | 15.0 | 25.0 |
| DGI | 75.0 | 10.0 | 15.0 |
| ONU | 67.5 | 10.0 | 22.5 |
| WBM | 67.5 | 17.5 | 15.0 |
| SRE | 60.0 | 25.0 | 15.0 |
| AHJ | 65.0 | 15.0 | 20.0 |

* BGN = Bambara groundnut.

### 2.8. Production of optimum acha-malted BGN-date flours composite biscuit

Numerical optimisation was used to obtain the optimal combination of the acha, malted BGN and date palm flours while maximizing taste and overall acceptability.

The optimal mixture of acha, malted BGN and date palm flours was used to produce the biscuit following the method described by Obiora (2011) in section 2.5. The control biscuit was baked with sugar rather than date palm flour. The most acceptable biscuit was assessed for weight, spread ratio, breakstrength, proximate, microbial and the sensory profile was compared with the biscuit baked with sugar.

### 2.9. Weight of the most acceptable biscuit

The weights of the biscuits after cooling for 1 h were measured using a weighing balance (Testus weighing balance, China).

### 2.10. Determination of the spread ratio of the most acceptable biscuit

The spread ratio of the most consumer acceptable biscuit was determined using Gomez et al. (1997) method. Three rows of six well-formed biscuits were made and height measured. They were also arranged horizontally, edge to edge and the sum of the diameter measured. The spread ratio is calculated as diameter divided by height.

### 2.11. Determination of the break strength of the most acceptable biscuit

The break strength was determined using break strength device method according to Okaka and Isieh (1990). Biscuit sample of known thickness (0.4 cm) was placed centrally between two parallel wooden bars (2 cm apart), weights were added on the biscuit until the biscuit snapped. The least weight that caused the breaking of the biscuit was recorded as the break strength of the biscuit.

### 2.12. Proximate analysis of the most acceptable biscuit

Proximate composition (fat, moisture, protein, ash, crude fiber) was determined for the most consumer acceptable biscuit using standard methods (AOAC, 2010). Carbohydrate content was determined by difference.

### 2.13. Microbiological analysis of the most acceptable biscuit

The pour plate method was adopted as described by Cheesbrough (2006). Nutrient agar and potato dextrose agar were prepared for microorganisms and fungi respectively. Serial dilution was carried out for bacteria and fungi counts using 0.1 ml of $10^{-2}$ dilution of the freshly prepared suspension of the biscuit and subsequent dilutions ($10^{-3}$, $10^{-4}$) for samples stored at ambient temperature. Incubation was done for 24 h at 37 °C for bacteria and 4–7 days at 25 °C for fungi. An electronic colony counter (Gallenkamp, 443 300 66087, UK) was used to count the

**Table 2.** Effect of acha, malted BGN and date palm on sensory qualities of composite biscuit*.

| Sample | Acha (g) | Malted BGN (g) | Date palm (g) | Color | Taste | Flavor | Texture | Crispiness | Overall acceptability |
|---|---|---|---|---|---|---|---|---|---|
| XKL | 60.0 | 10.0 | 30.0 | $6.6^{a} \pm 1.9$ | $6.5^{a} \pm 2.0$ | $6.2^{ab} \pm 2.3$ | $6.2^{a} \pm 2.2$ | $6.2^{a} \pm 2.3$ | $7.3^{a} \pm 1.8$ |
| ZWY | 60.0 | 17.5 | 22.5 | $5.7^{ab} \pm 2.4$ | $6.1^{ab} \pm 1.9$ | $5.8^{abc} \pm 2.4$ | $5.8^{ab} \pm 2.0$ | $5.7^{ab} \pm 2.5$ | $5.8^{bc} \pm 1.9$ |
| BMC | 75.0 | 10.0 | 15.0 | $5.4^{b} \pm 2.2$ | $5.4^{bc} \pm 1.9$ | $5.1^{c} \pm 2.4$ | $5.2^{b} \pm 2.4$ | $4.9^{b} \pm 2.5$ | 5.2c $\pm$ 2.1 |
| ESL | 62.5 | 20.0 | 17.5 | $5.7^{ab} \pm 2.1$ | $5.5^{bc} \pm 1.9$ | $5.4^{bc} \pm 2.2$ | $6.0^{ab} \pm 2.1$ | $5.8^{ab} \pm 2.4$ | $5.7^{bc} \pm 1.9$ |
| VHQ | 60.0 | 25.0 | 15.0 | $5.8^{ab} \pm 2.0$ | $5.3^{bc} \pm 2.3$ | $5.2^{c} \pm 2.1$ | $6.1^{ab} \pm 1.9$ | $5.7^{ab} \pm 2.0$ | $5.8^{bc} \pm 2.0$ |
| FPA | 62.5 | 12.5 | 25.0 | $6.0^{ab} \pm 2.1$ | $6.0^{abc} \pm 2.0$ | $6.2^{ab} \pm 2.0$ | $5.9^{ab} \pm 1.9$ | $5.9^{a} \pm 2.2$ | $6.0^{b} \pm 1.9$ |
| TRJ | 60.0 | 15.0 | 25.0 | $6.2^{ab} \pm 1.9$ | $6.6^{a} \pm 1.7$ | $6.4^{a} \pm 1.8$ | $6.2^{a} \pm 2.4$ | $6.3^{a} \pm 1.9$ | $6.5^{b} \pm 1.9$ |
| DGI | 75.0 | 10.0 | 15.0 | $6.1^{ab} \pm 2.2$ | $5.6^{bc} \pm 1.9$ | $5.4^{bc} \pm 2.3$ | $5.5^{ab} \pm 2.3$ | $6.3^{a} \pm 1.8$ | $5.8^{bc} \pm 1.7$ |
| ONU | 67.5 | 10.0 | 22.5 | $5.8^{ab} \pm 2.1$ | $6.1^{ab} \pm 2.2$ | $5.4^{bc} \pm 2.3$ | $6.1^{ab} \pm 2.0$ | $5.7^{ab} \pm 2.1$ | $6.0^{b} \pm 1.8$ |
| WBM | 67.5 | 17.5 | 15.0 | $5.8^{ab} \pm 2.2$ | $5.4^{bc} \pm 2.0$ | $5.1^{c} \pm 2.1$ | $6.0^{ab} \pm 2.2$ | $6.0^{a} \pm 2.1$ | $6.0^{b} \pm 1.9$ |
| SRE | 60.0 | 25.0 | 15.0 | $5.7^{ab} \pm 2.3$ | $5.2^{c} \pm 2.3$ | $5.1^{c} \pm 2.5$ | $5.7^{ab} \pm 2.3$ | $5.5^{ab} \pm 2.1$ | $5.7^{bc} \pm 2.2$ |
| AHJ | 65.0 | 15.0 | 20.0 | $5.8^{ab} \pm 2.4$ | $6.0^{abc} \pm 2.3$ | $5.6^{abc} \pm 2.4$ | $5.8^{ab} \pm 2.0$ | $6.1^{a} \pm 2.2$ | $6.4^{b} \pm 1.9$ |

* BGN = Bambara groundnut; Values are mean ± standard deviation. Values followed by different letters on each column are significantly different ($p < 0.05$).

**Table 3.** Linear mixture model parameters for biscuit sensory qualities as affected by acha, malted BGN and date palm flours.

| Response variables | Model p-value | Regression, $R^2$ | Adjusted regression, $R^2$ | Adequate precision | Lack of fit p-value |
|---|---|---|---|---|---|
| Color | 0.056 | 0.473 | 0.356 | 4.552 | 0.871 |
| Taste | <0.0001 | 0.944 | 0.932 | 20.596 | 0.2686 |
| Flavor | 0.022 | 0.574 | 0.479 | 6.361 | 0.465 |
| Texture | 0.022 | 0.574 | 0.479 | 6.361 | 0.465 |
| Crispiness | 0.245 | 0.269 | 0.106 | 2.920 | 0.977 |
| Overall acceptability | 0.014 | 0.613 | 0.527 | 6.319 | 0.656 |

colonies. Microbial analysis of the biscuits during storage was done for the day of production (0 day), (2 days) and then weekly for four weeks for bacteria and fungi.

### 2.14. Data analysis

Sensory data were reported as mean ± standard deviation of triplicate measurements. Multivariate analysis of variance (MANOVA) was conducted on the sensory data to establish differences between the baking trials. Means were separated where differences existed ($p \leq 0.05$) using Duncans multiple range tests (IBM SPSS version 25).

## 3. Results and discussion

### 3.1. Adequacy of the linear mixture model

Table 2 details the mean sensory scores of the biscuits as affected by acha, malted BGN and date palm flours. The linear mixture model parameters for the biscuits sensory attributes are detailed in Table 3. The linear mixture model for taste, flavor and overall acceptability significantly ($p < 0.05$) explained the effect of the components on the sensory quality of the biscuits. The correlation coefficient was 0.574, 0.613 and 0.944, respectively, for flavor, overall acceptability and taste. The adequacy precision was greater than 4 and the lack of fit was not significant. Hence, the linear mixture model could be used to navigate the design space.

### 3.2. Effect of acha, malted BGN and date palm flour on the biscuit sensory properties

The hedonic rating for color (5.4–6.6), taste (5.2–6.6), flavor (5.1–6.4), texture (5.1–6.7), crispiness (4.9–6.3) and overall acceptability (5.2–7.3) are shown in Table 2. The panelists rated the biscuits from neither like nor dislike to like slightly, except for the overall acceptability that was moderately liked. Significant differences ($p \leq 0.05$) existed in all the sensory attributes. Sample XKL (60:10:30 acha: malted BGN: date palm fruit) had the highest color mean of 6.6 while sample BMC (75:10:15% acha: malted BGN: date palm fruit) had the least mean of 5.4. The date palm incorporation of 30% made the color of the biscuit most acceptable. Date palm fruits are reported as good source of dietary fibre [73.1 g/100 g], antioxidants, mainly carotenoids [80400 μmol/100 g] and phenolics [3942 mg/100 g] (Al-Farsi and Lee, 2008). Hence, that acceptable color may be from the carotenoids and the phenolics. Color is an essential parameter in judging baked cookies that not only reflect the quality of raw materials but also provide information about the formulation and quality of the product (Ikpeme-Emmanuel et al., 2010).

The mean score for taste ranged from 5.2 - 6.6 with sample TRJ (60:15:25 acha, malted BGN, date palm fruit flour) having the highest value while sample SRE (60:25:15 *acha*, malted BGN, date palm fruit flour) had the least. These samples had an increased proportion of date palm flour. The increased rating for taste may be due to the expected increased sugar content from the date palm flour. Flavor is the main criterion that makes the product liked or disliked (Obadina et al., 2013). The flavor of the biscuits varied significantly ($p \leq 0.05$) among different proportions. The biscuit TRJ prepared from 60:15:25 acha, malted BGN, date palm fruit flours had the highest flavor score of 6.4 while biscuit WBM (67.5:17.5:15 acha, malted BGN, date palm fruit flour) had the least value of 5.1. It is not surprising that increased date palm flour increased consumer acceptability of the biscuits for taste and flavor. Date flesh is low in fat and protein but rich in sugars mainly fructose and glucose as well as a high source of energy [314 kcal/100 g] (Al-Farsi and Lee, 2008). The acceptable taste and flavor could be from the sugars, high fiber and energy from the date palm which may give a feeling of satiety.

The texture of the biscuit was significantly affected by the rise in the level of malted BGN flour as well as the date palm flour. . The biscuit, XKL

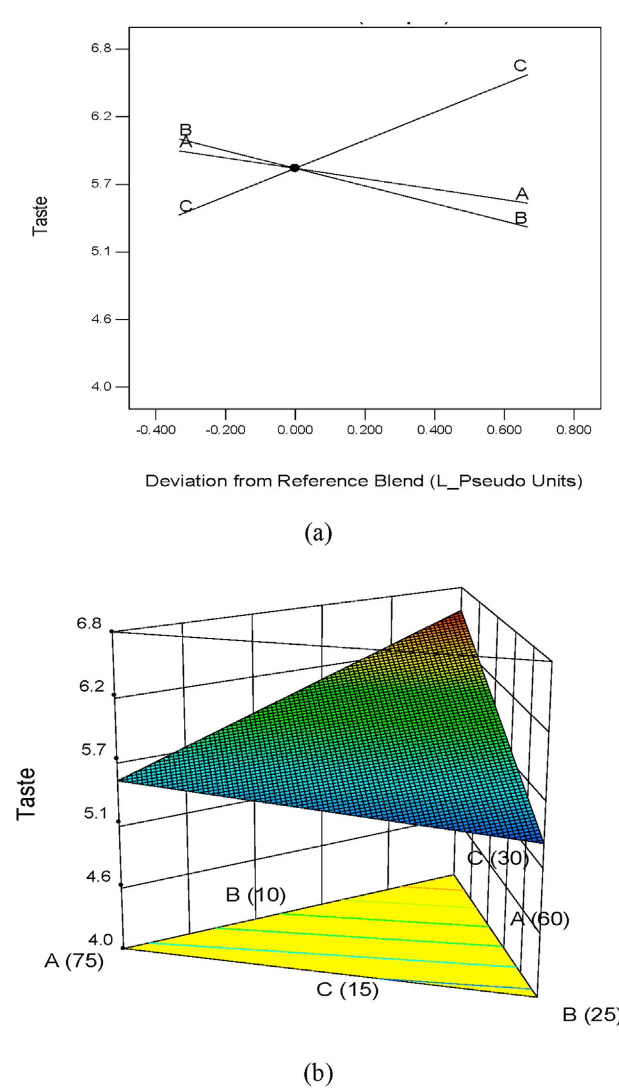


**Figure 1.** Trace (Piepel) plot (a) and response surface (b) for the effect of acha (A), malted BGN (B) and date palm (C) flours on the taste of the biscuits.

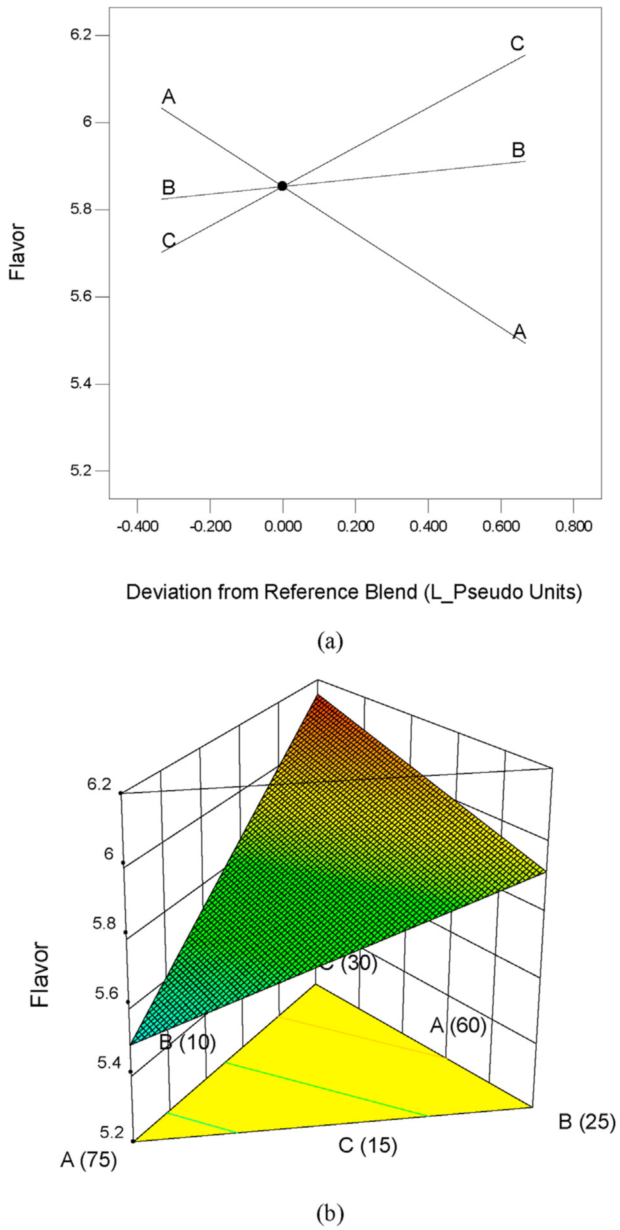


**Figure 2.** Trace (Piepel) plot (a) and response surface (b) for the effect of acha (A), malted BGN (B) and date palm (C) flours on the flavor of the biscuits.

(60:10:30 acha, malted BGN, date palm fruit flour) had the highest value of 6.2 while the lowest value was from the biscuit prepared with 75:10:15 acha, malted BGN, date palm fruit flour. The highest mean value for crispiness of 6.3 was observed in biscuit TRJ (60:15:25 acha, malted BGN, date palm fruit flour) while sample BMC (75:10:15 acha, malted BGN, date palm fruit flour) had the lowest mean value of 4.9. The crispiness is a desired characteristic that makes customers subscribe to purchasing cookie (Lucas and Rooney 2001). The overall acceptability showed that biscuit XKL (60:10:30 acha, malted BGN, date palm fruit flour) had the highest value of 7.3 while BMC (75:10:15 acha, malted BGN, date palm fruit flour) had the least (5.2). Increasing the proportion of date palm flour significantly affected the overall acceptability of the biscuits. The biscuit, XKL (60:10:30 acha, malted BGN, date palm fruit flour) was the most generally accepted. The biscuit BMC prepared with 75:10:15 acha, malted BGN, date palm fruit flour was disliked by the panelists on flavor, crispiness and overall acceptability.

The trace and response surface plots for the linear effects of acha, malted BGN and date palm flours on the biscuit taste, flavor and overall acceptability are indicated in Figures 1, 2, and 3, respectively. Increasing the date palm flour significantly increased the taste and overall acceptability of the biscuits. In contrast, increase in acha and malted BGN flours decreased the taste as well as overall acceptability of the biscuits. Increasing acha flour decreased the flavor of the biscuits. However, increasing malted BGN and date palm flour significantly increased the biscuit flavor.

### *3.3. Optimal and most acceptable biscuit formulation*

Based on the high correlation coefficient ($R^2$), taste and overall acceptability were sensory qualities used to find the optimum formulation, as shown in Table 3. The optimization goal was to maximize taste and overall acceptability. The optimum formulation was a mixture of 60% acha, 10% malted BGN and 30% date palm flours with desirability

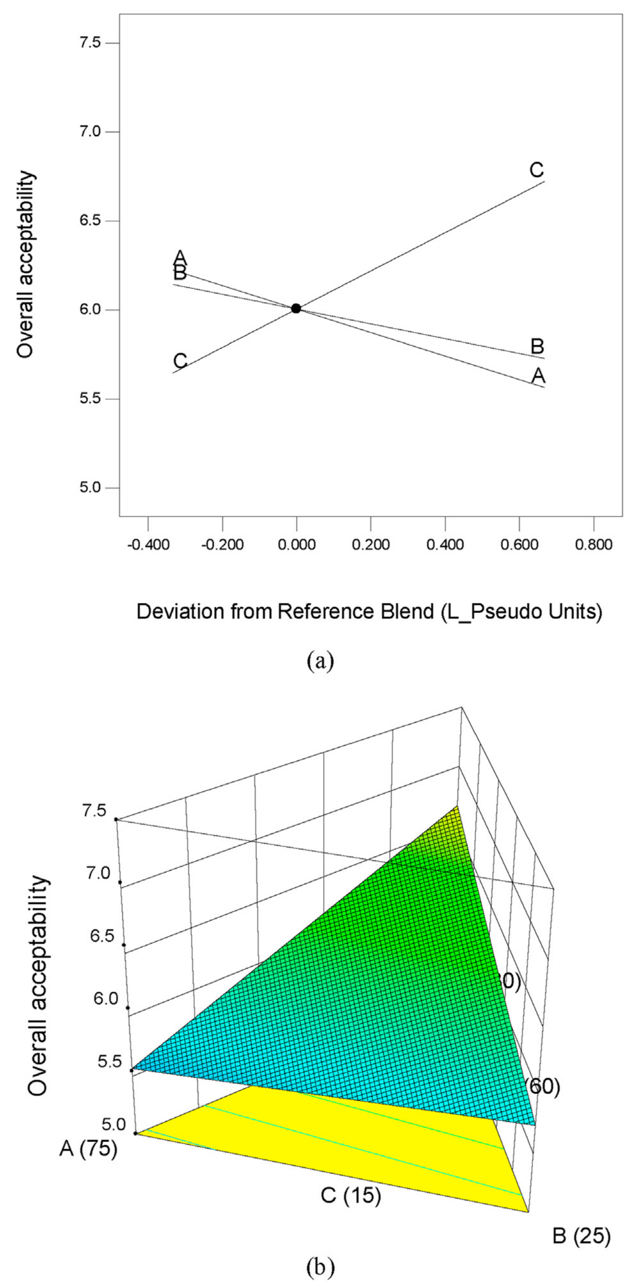


**Figure 3.** Trace (Piepel) plot (a) and response surface (b) for the effect of acha (A), malted BGN (B) and date palm (C) flours on the overall acceptability of the biscuits.

**Table 4.** Mean values of the optimal biscuit sample compared with control*.

| Sensory attribute | Biscuit | |
|---|---|---|
| | XKL | RHO |
| Color | $6.6^{a} \pm 2.9$ | $6.5^{a} \pm 2.1$ |
| Taste | $6.5^{a} \pm 1.9$ | $6.4^{a} \pm 2.0$ |
| Flavor | $6.2^{a} \pm 2.3$ | $6.5^{a} \pm 2.0$ |
| Texture | $6.2^{a} \pm 1.9$ | $6.7^{a} \pm 1.9$ |
| Crispiness | $6.1^{a} \pm 2.4$ | $5.9^{b} \pm 2.2$ |
| Overall acceptability | $7.3^{a} \pm 2.0$ | $6.8^{a} \pm 1.9$ |

* Values are mean ± standard deviation. Means values with the same superscripts along the same row are not significantly different ($p \geq 0.05$) from each another. XKL = biscuit baked with 60:10:30 acha, malted BGN, date palm fruit flour; RHO = biscuit baked with 60:10:30 acha, malted BGN flour, sugar (control).

**Figure 4.** Packaged most acceptable acha-malted Bambara groundnut composite. biscuits (XKL- 60:10:30 *acha*, malted BGN, date palm flour).

of 0.842. With this formulation the predicted taste and overall acceptability were 6.6 and 6.7 (liked moderately), respectively.

### *3.5. Comparison between the optimal biscuit sweetened with date palm flour and control biscuit with sugar*

The sensory evaluation of the most acceptable biscuit sample XKL (60:10:30 acha, malted BGN, date palm fruit flour) was compared with the control sample RHO (60:10:30 acha, malted BGN, sugar) as shown in Table 4. There was no significant difference between samples XKL and RHO except in crispiness. The biscuit sweetened with data palm flour was significantly ($p \leq 0.05$) higher (6.1) in crispiness compared to the control sweetened with sugar. Perhaps, the date palm flour being high in fibre contributed to the reduction of moisture during baking, thereby keeping the biscuits crisp.

### *3.6. Quality characteristics on the most acceptable biscuit*

Some physical characteristics of the most acceptable biscuit produced with 60% acha, 10% malted BGN and 30% date palm flours (Figure 4) are weight 23.0 ± 1.8 g, height 3.0 ± 0.2 cm, spread ratio 7.7 ± 0.7, break strength 750 ± 0.5 g. The spread ratio (7.7) of the biscuit sample prepared using date palm as a sweetener was significantly ($p \leq 0.05$) lower compared to the control (18.2) (Handa et al., 2012). The reduced spread ratio was due to the date palm flour increase in the hydrophilic site available for competing for the limited free water in biscuit dough. Many other works also observed the reduction of spread ratio during biscuit baking (Singh et al., 1996; Adeola and Ohizua, 2018; Chauhan et al., 2016). The hard structure formed from the right protein in the malted BGN, date palm and carbohydrate content from acha could be due to the breakstrength increase in value (750 g). This could be beneficial during transportation as it will avoid breaking of the biscuit (Nwosu, 2013).

The proximate composition (%) of the most acceptable biscuit are fat 20.1 ± 0.1, protein 11.8 ± 0.2, ash 2.6 ± 0.1, moisture 1.2 ± 0.0, crude fiber 4.3 ± 0.1, Carbohydrate 60.0 ± 0. 6. The fat content could be a good source of energy supply to the body (Alozie et al., 2009). The level of rancidity could be high because of the high fat content of the product which could be a disadvantage in extending the shelf life of the biscuit. The high protein content of the biscuit could be from the malted BGN (Dikshit et al., 2003). The high ash content (2.6%) of the product could be a source of mineral and vitamin (vitamin A, D, F) (Al-shahib and Marshal, 2003). The moisture content of the biscuit was 1.2%. Other works on composite biscuits agreed with the low moisture content of the biscuit such as acha-soybean (Bivan and Eke-Ejiofor, 2019), amaranths-wheat (Chauhan et al., 2016), wheat-potato (Das et al., 2018), acha-wheat (Ayo et al., 2008), BGN-wheat flour (Adegbanke et al., 2019), acha-beniseed (Ayo et al., 2010), wheat-wheat-sorrel seed protein isolate-yellow cassava (Sanni et al., 2020), wheat-beniseed-unripe plantain (Agu and Okoli, 2014), wheat-African bread fruit composites (Okoye and Obi, 2017). Most spoilage microorganisms may not thrive in relatively low moisture content biscuit and the biochemical and enzymatic reactions could be minimal which could be an advantage in extending the shelf life of the product (Ayo et al., 2010). The crude fiber content (4.3%) will help digestion better in the body (Ayo and Andrew, 2016). The increased fiber content was due to the increase in date palm to 30%, confirming that date palm is a good source of dietary fiber when compared to sugar. The relatively low carbohydrate content could be from the malted BGN which decreased the carbohydrate content to 60.0%. . The carbohydrate content agreed with the discovery of Alshahib and Marshall (2003) which states that date palm contains a high percentage of carbohydrate ranging from 44 to 88%.

The microbial growth for most acceptable biscuit sample for the day of production, 2 days after production to the first week showed no growth in microorganism fungi. This could be because the product was freshly produced and packaged but growth began at the second week with $1.0 \times 10^{3}$ cfu/g for bacteria and $1.0 \times 10^{4}$ cfu/g for fungi and at the third week, it increased to $2.0 \times 10^{3}$ cfu/g for bacteria and $3.0 \times 10^{4}$ cfu/g for fungi, after the fourth week it increased rapidly. At the fourth week, the bacteria count was $4.0 \times 10^{3}$ cfu/g while the fungi count was $5.0 \times 10^{4}$ cfu/g. Counts greater than or equal to $10^{6}$ cfu/g have been reported by Centre for Food Safety (2014), as the unsatisfactory level for bakery and confectionery products. Hence, the biscuits were still within the acceptable limit. The growth observed could be due to the post-handling of the product.

## 4. Conclusion

An acceptable biscuit was formulated with 60:10:30 acha-malted BGN flour sweetened with date palm flour respectively. The formulated biscuit is rich in protein, carbohydrate, fat, ash and crude fiber. The formulation of the biscuit has also provided another means of utilizing date palm fruit. The biscuit produced has low microbial load and therefore has a long shelf life. This study shows the potential utilization of these local materials and forms a basis for new product development for the biscuit industry.

## Declarations

### Author contribution statement

Agu H. O.: Conceived and designed the experiments; Performed the experiments; Wrote the paper.

Onuoha G. O.: Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Elijah O. E.: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Jideani V. A.: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

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### Data availability statement

Data included in article/supplementary material/referenced in article.

### Declaration of interests statement

The authors declare no conflict of interest.

### Additional information

No additional information is available for this paper.

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