Nutritional Composition, Physical and Sensory Properties of Cookies from Wheat, Acha and Mung Bean Composite Flours

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Abstract: Wheat flour, acha flour and mung bean flours were blended into different ratios and used to produce cookies. The flours were blended into six different ratios of wheat : acha : mung beans as follows: 100:0:0 (sample A) control, 80:10:10 (B), 70:15:15 (C), 60:20:20 (D), 50:30:20 (E) and 50:20:30 (F). Proximate composition of the flour blends and cookies were determined. Some selected minerals and vitamins were determined and physical and sensory properties of the cookies samples were evaluated. The protein, ash, fibre and fat contents of all the samples increased with increasing substitution of wheat flour with acha and mung bean flours. Moisture and carbohydrate contents decreased with increased substitution of the wheat flour with acha and mung beans. Protein and ash increased from 13.03 to 19.66% and 2.56 to 3.53% respectively, showing significant difference between the different flour blends. The minerals and vitamins (calcium, iron, zinc, and vitamins A and C) increased with corresponding increase in the level of substitution of wheat flour with acha and mung beans. There was significant difference between the control and the blended samples. The break strength and weight of cookies decreased (1.9kg to 1.57kg and 13.55g to 9.31g) with increasingly acha and mung bean levels while the diameter increased (4.44 to 5.85) and consequently, the spread ratio increased from 4.95 to 8.05. There were significant differences in the break strength, weight and spread ratios of all the samples. Sensory evaluation scores showed that cookies made with 70% wheat, 15% acha and 15% mung beans can favourably compare with the control. It is recommended that the beany flavour of mung beans be removed, in order to produce cookies that can be accepted at higher levels of substitution of wheat flour with acha and mung beans.

Keywords: Cookies, Composite Flour, Acha, Mung Beans, Wheat

1. Introduction

Cookies are popular snacks widely consumed all over the world by people of all ages [1-2]. Cookies are traditionally made from soft wheat and are nutritious and convenience foods with long shelf life. The major attraction of cookies is the wide variety of types that are possible. The nutritional value of cookies varies with the type of cereal used. Cookies are known to generally contain 18.5% fat, 78.23% carbohydrates, 1.0% ash, 7.1% protein and 0.85% salt [3].

Acha (Digitaria Exilis) is a cereal, traditionally consumed whole as “tuwo”, couscous, “gwate”, acha jollof and kunun acha [4]. Acha is reported to have a high pentosan (3.3%), hence, a high water absorption capacity that could be utilized in baking [5]. Acha is rich in micronutrients like iron and iodine (28.5mg/100ml and 22.9mg/100ml respectively) and has about 73% carbohydrate [6]. Acha is considered as health grains in a sense that they are often consumed whole and are gluten-free [7]. Acha is uniquely rich in methionine and cystine and evokes low sugar on consumption; an advantage to diabetics [8-9].

Mung beans (Vigna radiata) are legumes that are small, ovoid in shape and green in colour. They are also known as green gram or golden gram and contain about 24% protein [10]. Mung bean is incorporated with cereals which contain high concentration of methionine and cysteine to enhance its
Mung bean is also rich in vitamin A, B₁, B₂, niacin, vitamin C, potassium, phosphorus and calcium and could be used in combination with other flours [11-12]. Thus, utilization of mung beans in cookies could avail the consumers a protein rich food product.

Wheat grains are relatively low in total protein and generally low in lysine and certain other amino acids, which could be supplemented by the use of acha and mung beans in cookies production. The most obvious result of such blending is that the mixture is higher in protein than the cereal component alone. The legumes usually improve the quality of cereal protein by supplementing them with limiting amino acids such as lysine and sometimes tryptophan and threonine. On the other hand, legumes which are deficient in methionine can be supplemented by cereal grains which are not deficient in the amino acid [13]. Thus production of cookies from composite flours of wheat, acha and mung bean could provide nutrient rich and affordable product that would solve the problem of food insecurity and malnutrition. Savings could also be made from the non -use of the expensive animal food proteins and non- importation of wheat which is not produced in tropical regions due to climatic reasons. The main objective of this paper is to produce nutritious, healthy and affordable cookies from wheat, acha and mung bean flour blends to prevent malnutrition and enhance food security.

2. Materials and Methods

2.1. Source of Raw Materials

Mungbean (Vigna radiata) seeds were purchased from the Langtang market in Langtang North Local Government area of Plateau State. Acha (Digitaria exilis) and wheat grains were purchased from the Gindiri market in Mangu Local Government Area of Plateau State. The other ingredients like margarine, sugar, baking powder and eggs were bought at the North bank market in Makurdi, Benue State. All chemicals used were of analytical grade.

2.2. Preparation of Samples

2.2.1. Preparation of Mung Bean Flour

Mung beans were manually cleaned by hand picking the chaff and the stones. The cleaned mung beans were washed with water in order to remove the adhering dirt. The mung beans were left to soak in water for about 10 minutes. The soaked seeds were pounded gently in a mortar to dehull them. The dehulled mung beans were air dried and milled using an attrition mill. The flour was sieved to pass through a 0.4mm mesh size and packaged in polyethylene bags and kept at room temperature for later use.

2.2.2. Preparation of Acha Flour

Acha flour was produced using the method of [14]. Acha grains were winnowed to remove chaff and dust. Adhering dust and stones were removed by washing in water (sedimentation) using local calabashes. The washed and destoned grains were dried in a cabinet drier at 45°C to a moisture content of about 12%. The dried grains were milled using attrition milling machine and the flour sieved to pass through a 0.4mm mesh size. The acha flour was packaged in air tight containers for use.

2.3. Formulation of Composite Flour

Composite flour of acha, mung beans and wheat was prepared as shown in Table 1. One hundred percent wheat flour was the control and designated as sample A. Sample B consisted of 80% wheat, 20% acha and 20% mung beans. Sample C consisted of 70% wheat, 15% acha and 15% mung beans. Sample D was 60% wheat, 20% acha and 20% mung beans. Samples E and F consisted of 50% wheat, 30% acha, 20% mung beans and 50% wheat, 20% acha, 30% mung beans respectively. The blends were thoroughly mixed using a Kenwood blender to achieve uniform blending.

| Sample | % wheat | % acha | % mung beans |
|--------|---------|--------|--------------|
| A      | 100     | 0      | 0            |
| B      | 80      | 10     | 10           |
| C      | 70      | 15     | 15           |
| D      | 60      | 20     | 20           |
| E      | 50      | 30     | 20           |
| F      | 50      | 20     | 30           |

2.4. Baking of Cookies

Cookies were prepared using the method of [2] as shown in Figure 1. The flour blends, salt and baking powder were mixed together. Another separate mixing bowl was used to mix, the butter, sugar and eggs until the mixture became creamy. The creamy mixture was poured into the flour and mixed thoroughly. Water was added and mixed to obtain dough. The dough was cut into different sizes and baked at 180°C for 15 minutes. The cookies were removed and allowed to cool before packaging in air tight containers.

Source: Chinma et al, (2012).

Figure 1. Flow Chart for the Production of Cookies.
2.5. Analyses

2.5.1. Determination of Proximate Composition of Flour Blends and Cookies

The method of [15] was used to determine the moisture, ash, fat, crude fibre, protein contents of the flour and cookies. The method of [16] was used in determining the carbohydrate content by difference, thus the total sum of the percentage of moisture, ash, fat, crude fibre and protein was subtracted from hundred.

2.5.2. Determination of Minerals and Vitamins of the Cookies

The mineral elements; iron, zinc and calcium were determined by Atomic absorption Spectrophotometer (AA800 Perkin-Elmer, Germany) using the method [15]. The Vitamin A (β-carotene) and vitamin C were also determined using the method [15].

2.5.3. Determination of the Physical Properties of Cookies

The breaking strength of cookies was determined using the method of [17]. Cookies of known thickness were placed centrally between two parallel metal bars. Weights were added on the cookie until the cookie snapped. The least weight that caused the breaking of the cookie was regarded as the break strength of the cookies.

The weight of cookies was determined by weighing on an electronic weighing balance (Mettler PF160 Balance, Switzerland). The cookies diameter and thickness were determined using vernier callipers. The spread ratio was calculated as diameter divided by thickness [18].

2.5.4. Determination of Sensory Properties of Cookies

The cookies were coded and presented to a fifteen member panel of Judges who were familiar with the product. The samples were analyzed based on appearance, colour, flavour, taste, odour and general acceptability using a 9-point hedonic scale. The rating of the samples ranged from 1 (extremely dislike) to 9 (like extremely) according to the method by [19].

2.6. Statistical Analysis

The means and standard deviation of duplicate samples for the nutritional, chemical and sensory properties of the cookies were calculated. The data obtained was then subjected to Analysis of variance (ANOVA) [20] where significance difference existed, Tukey’s test was employed in separating the means as described by [19].

3. Results and Discussion

3.1. Proximate Composition of Flour Blends of Wheat, Acha and Mung Beans

The proximate composition of the flour blends is shown in Table 2, for 100% wheat (A); 80% wheat, 10% acha and 10% mungbeans (B); 70% wheat, 15% acha and 15% Mungbeans (C); 60% wheat 20% Acha and 20% mungbeans (D); 50% wheat, 30% acha and 20% mung beans (E) and 50% wheat, 20% acha and 30% mungbeans (F). Moisture, protein, fibre, fat, ash and carbohydrates ranged from 12.64% to 10.96%, 11.12% to 15.53%, 5.70% to 4.04%, 0.20 to 0.32%, 0.81% to 1.11% and 71.14 to 66.38% respectively for the different flour blends. The moisture content for 100% wheat flour was the highest (12.64%) and was significantly different from those of samples B and C. The moisture content of the last two samples (E and F) were not significantly different from each other (at 0.05 level) but were significantly different from samples A, B, C and D, that have higher percentages of wheat flour. This result is in agreement with [6] who reported moisture contents of 10.75% and 12.73% for dehulled mung beans and acha flours respectively. The moisture contents for all the blends are about the recommended level for safe keeping of samples by the Standards Organisation of Nigeria (SON) and shows that they will have better keeping quality as moisture content in excess of 14% in flours has greater danger of bacterial action and mould growth which produce undesirable changes in the flour [19]. The ash content of the samples increased with increase in the substitution of wheat flour with acha and mungbeans (0.81% to 1.11%). Increase in the ash content indicates that the samples with high percentage of ash will be good sources of minerals. Mung bean seeds are excellent sources of potassium (1145mg/100g), phosphorus (315mg/100g) and magnesium (132mg/100g) and also sodium, calcium and iron [21]. Carbohydrate content decreased with increased substitution of wheat flour with acha and mung beans (71.19% to 66.38%). Decrease in carbohydrate content could be due to the low carbohydrate content of mung beans flour as observed in similar works using legumes [22].

| Sample | Moisture (%) | Crude protein (%) | Crude Fibre (%) | Crude fat (%) | Ash (%) | CHO (%) |
|--------|--------------|------------------|----------------|--------------|---------|--------|
| A      | 12.64±0.11   | 11.12±0.13      | 4.04±0.08      | 0.20±0.01    | 0.75±0.06| 71.19±0.00 |
| B      | 11.98±0.03   | 11.91±0.05      | 4.25±0.02      | 0.21±0.01    | 0.81±0.01| 70.90±0.12 |
| C      | 11.93±0.09   | 13.08±0.16      | 4.45±0.30      | 0.27±0.04    | 0.95±0.06| 69.32±0.13 |
| D      | 11.37±0.12   | 14.13±0.17      | 4.86±0.27      | 0.29±0.01    | 1.02±0.04| 68.33±0.40 |
| E      | 10.96±0.07   | 14.50±0.46      | 5.17±0.09      | 0.30±0.01    | 2.06±0.01| 67.01±0.36 |
| F      | 10.96±0.01   | 15.53±0.04      | 5.70±0.01      | 0.32±0.02    | 2.11±0.01| 65.38±0.00 |

LSD 0.204 0.553 0.365 0.047 0.106 0.649

Values followed by the same superscript(s) within the same column are not significantly different at 5% probability level. Values are mean ± standard deviation of duplicate determinations.
3.2. Proximate Composition of Cookies

Proximate composition of cookies made from the different flour blends are shown in Table 3. The table showed that moisture, and carbohydrate contents decreased with increased substitution of the wheat flour with acha and mungbeans. A similar trend of decrease in moisture content was observed by [23, 24] who reported decrease in moisture in products from composite flours of cereals and legumes. The protein and ash however, increased with increased substitution with acha and mungbeans. The protein content of cookies increased significantly from 13.03% (A) to 19.66% (F). This is due to the increase in mungbean flour which is high in protein. Crude fat and crude fibre also increased as the levels of substitution of the wheat flour with acha and mungbean flours. This decrease in weight and diameter of the 100% wheat cookies (A) with the samples that were made of 80% wheat (B) and 70% wheat (C). The weight of cookies made with the different flour blends differ significantly from sample (A). Their weights decreased with increased substitution of wheat flour with acha and mungbean flours. This decrease in weight may be due to increase in fat content of the samples as indicated in the fat content of the samples and/or a decrease in the moisture content. These results are in line with [14, 27, 17, 28].

Table 3. Proximate Composition of Cookies from blends of Wheat, Acha and Mungbean.

| Sample | Moisture (%) | Crude Protein (%) | Crude Fibre (%) | Crude fat (%) | Ash (%) | Carbohydrate (%) |
|--------|--------------|-------------------|-----------------|--------------|---------|-----------------|
| A      | 13.29±0.11a  | 13.03±0.04a       | 0.66±0.08b      | 3.23±0.43b   | 2.56±0.04a| 67.23±0.40a     |
| B      | 13.24±0.18a  | 14.39±0.10a       | 0.84±0.07a      | 3.35±0.47a   | 2.77±0.23a| 65.41±0.22a     |
| C      | 12.10±0.13c  | 14.93±0.02c       | 1.44±0.03c      | 4.10±0.21c   | 2.89±0.03c| 64.54±0.22c     |
| D      | 12.08±0.13c  | 16.82±0.08d       | 1.56±0.21c      | 4.23±0.01e   | 3.16±0.01c| 61.25±0.13c     |
| E      | 11.32±0.04d  | 17.78±0.01c       | 1.97±0.54c      | 4.39±0.08f   | 3.31±0.01c| 61.23±0.55c     |
| F      | 11.05±0.06e  | 19.66±0.61c       | 2.35±0.61c      | 4.58±0.03i   | 3.53±0.62c| 58.83±0.59d     |
| LSD    | 0.296         | 0.233             | 0.341           | 0.667        | 0.210   | 1.156           |

Values followed by the same superscript(s) within the same column are not significantly different at 5% probability level. Values are mean ± standard deviation of duplicate determinations.

3.3. Minerals and Vitamins Content of Cookies

Table 4 shows some minerals and vitamins in the cookies. They are calcium, iron, zinc and vitamins A and C. All the minerals and vitamins increased as the levels of substitution of wheat with acha and mung beans increased. Calcium increased from 30.36mg/100g (A) to 52.87mg/100g (B). Iron increased from 6.98mg/100g to 39.82mg/100g, zinc increased from 2.71mg/100g to 6.06mg/100g, vitamin A increased from 0.34mg/100g to 6.06mg/100g and vitamin C also increased from 0.12mg/100g to 8.36mg/100g. The amount of calcium and iron increased greatly thereby agreeing with [3, 25] who reported increased vitamins and minerals in composite bread. Vitamin A refers to provitamin A carotenoids and the preformed retinols, plus their metabolites. A deficiency of vitamin A constitutes one of the major public health problems in developing countries. Vitamin A deficiency is the leading cause of non-accidental blindness. Children from impoverished Nations are especially susceptible because their inadequate intake and diminished stores of vitamin A fail to meet the increased needs associated with rapid growth [26].

Table 4. Minerals and Vitamins Content of Cookies From Wheat, Acha and Mungbean Flour Blends.

| Sample | Calcium (mg/ 100g) | Iron (mg/ 100g) | Zinc (mg/ 100g) | Vitamin A (mg/ 100g) | Vitamin C (mg/ 100g) |
|--------|---------------------|-----------------|-----------------|----------------------|----------------------|
| A      | 30.36±0.95a         | 6.98±0.05c      | 2.71±0.21f      | 0.34±0.01c           | 0.12±0.02f           |
| B      | 37.36±0.35c         | 12.42±0.27a     | 3.31±0.20c      | 0.93±0.06c           | 2.19±0.07c           |
| C      | 44.93±1.06c         | 15.90±0.31c     | 4.66±0.108c     | 1.77±0.11c           | 3.66±0.03c           |
| D      | 45.42±0.52d         | 24.19±0.64c     | 5.02±0.02c      | 5.23±0.01c           | 4.56±0.30c           |
| E      | 48.12±0.53d         | 36.59±1.4g      | 5.61±0.08d      | 3.75±0.01e           | 6.69±0.16f           |
| F      | 52.87±0.34e         | 39.82±0.08e     | 6.00±0.01h      | 6.06±0.08e           | 8.36±0.06e           |
| LSD    | 1.461               | 1.650           | 0.306           | 0.1304               | 0.355                |

Values followed by the same superscript(s) within the same column are not significantly different at 5% probability level. Values are mean ± standard deviation of duplicate determinations.

3.4. Physical Properties of Cookies

The physical properties of cookies prepared from 100% wheat flour and the other flour blends are shown in Table 5. The break strength, weight, diameter and spread ratio of the cookies ranged from 1.90kg to 1.57kg, 13.55g to 9.31g, 4.55cm to 5.85cm and 4.95 to 8.05 respectively. There was no significant difference in diameter of the 100% wheat cookies (A) with the samples that were made of 80% wheat (B) and 70% wheat (C). The weight of cookies made with the different flour blends differ significantly from sample (A). Their weights decreased with increased substitution of wheat flour with acha and mungbean flours. This decrease in weight may be due to increase in fat content of the samples as indicated in the fat content of the samples and/or a decrease in the moisture content. These results are in line with [14, 27, 17, 28].

The spread ratio increased (4.95 to 8.05) with increasing the levels of acha and mungbeans increased. Mung beans and acha are rich sources of fibre [6]. High fibre is reported to enhance the health of the gastrointestinal tract by aiding normal bowel movement thereby reducing constipation problems which can lead to colon cancer. The products with high levels of protein and ash had lower levels of carbohydrates. The increase in protein of the cookies samples is an indication that supplementation of wheat flour with mung bean flour greatly improved the nutritional quality of the cookies so, the enriched cookies can be used to solve malnutrition problems like kwashiorkor and also, especially for individuals with health problems that may require protein-rich foods.
replacement of the wheat flour with acha and mung beans. Cookies from 100% wheat (A), which had the lowest spread ratio, had the highest thickness. Increase in spread ratio with increase in the replacement of wheat flour in the composite is in agreement with the works of [23] and [29] but most works, including [29], reported a decrease in spread ratio. Low spread ratio suggests that the starches in 100% wheat flour were more hydrophilic than the composite flours [30]. Cookies having high spread ratio are considered most desirable [2]. The increase in the fat content could have also affected the spread ratio [14]. Increase in spread ratio can also be an indication of poor cohesion of the network of the proteins and carbohydrates which are the principal nutrients in the products and are responsible for hardness of the products [31]. This poor cohesion could allow the outflow of some ingredients that could melt at high temperatures of baking hence increasing the spreadability of the product. The break strength of the cookies decreased (1.90kg to 1.57kg) as the percentage of acha and mung beans were increased. The control cookies (A) had the highest break strength and sample F was the most fragile.

Table 5. Physical properties of Cookies From Wheat, Acha and Mung bean Flour Blends.

| Sample | Break strength (kg) | Weight (g) | Diameter (cm) | Spread ratio |
|--------|---------------------|------------|---------------|--------------|
| A      | 1.90±0.01a          | 13.55±0.21b | 4.55±0.01b   | 4.95±0.07b   |
| B      | 1.80±0.01b          | 12.81±0.04e | 4.63±0.04e   | 5.70±0.14b   |
| C      | 1.73±0.01b          | 11.92±0.09a | 4.64±0.06a   | 5.90±0.28b   |
| D      | 1.72±0.01c          | 11.28±0.02e | 5.10±0.14e   | 7.15±0.21b   |
| E      | 1.70±0.03c          | 10.47±0.05c | 5.40±0.00b   | 7.70±0.14c   |
| F      | 1.57±0.02d          | 9.31±0.45f  | 5.85±0.07g   | 8.05±0.35e   |
| LSD    | 0.456               | 0.450      | 0.141        | 0.548        |

Values followed by the same superscript(s) within the same column are not significantly different at 5% probability level. Values are mean ± standard deviation of duplicate determinations.

3.5. Sensory Properties of Cookies

The mean sensory scores for all the quality attributes evaluated are shown in Table 6 and the scores for the cookies containing 100% wheat (A) were the highest; 80% wheat, 10% acha, 10% mung beans (B) and 70% wheat, 15% acha and 15% mung beans (C) and were not significantly different, based on general acceptability, but were significantly different from the other cookies samples (D, E and F). All the sensory attributes of the cookies decreased as the level of substitution of wheat flour with acha and mung beans increased. The cookies made with composite flours with higher percentage of mung beans had beany flavour which resulted to lower flavour ratings compared to cookies from 100% wheat. The colour of cookies became darker with increased substitution of the wheat flour with acha and mung beans; from creamy to dark brown. Generally, panelists preferred cookies formulated with 70% wheat, 15% acha and 15% mung beans (C), 80% wheat, 10% acha and 10% mung beans (B). All the cookies were however accepted with respect to all the parameters assessed using the nine point Hedonic scale.

Table 6. Sensory properties of cookies from different flour blends.

| Sample | Taste | Flavour | Colour | Texture | General accept. |
|--------|-------|---------|--------|---------|-----------------|
| A      | 8.3±0.87a | 8.5±0.83b | 8.4±0.67b | 8.5±0.76b | 8.7±0.47b |
| B      | 8.0±0.89a | 7.8±0.95c | 8.1±0.83c | 7.8±1.12c | 8.1±0.85c |
| C      | 7.4±1.35d | 7.3±1.56e | 7.4±1.19f | 7.0±1.41g | 8.1±0.95h |
| D      | 7.4±1.23i | 7.2±1.14j | 6.8±1.59k | 6.7±1.66l | 7.2±1.53m |
| E      | 6.8±1.80a | 6.5±2.91n | 5.5±1.43o | 6.3±1.56p | 7.0±1.38q |
| F      | 6.3±1.56r | 6.0±1.75s | 5.5±1.00t | 6.0±1.59u | 5.9±1.59v |
| LSD    | 0.651   | 0.582   | 0.631   | 0.657   | 0.649 |

Values followed by the same superscript(s) within the same column are not significantly different at 5% probability level. Values are mean ± standard deviation of duplicate determinations.

4. Conclusion

Cookies of acceptable quality were produced from composite flours of wheat, acha and mung beans. The cookies produced, have increased nutrient contents which are all desirable for good health and wellbeing. The study shows that supplementation of wheat with 15% acha and 15% mung beans produced well accepted cookies. The use of acha and mung beans in cookies will go a long way in enhancing nutrition, health and wellbeing of the consumers and reduce the dependence on wheat flour, thereby saving the huge foreign exchange used in importing wheat, for other projects. It will also reduce food insecurity and diversify the use of acha and mung bean.

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