**Proximate and Sensory Properties of Biscuits from Wheat and Processed African Yam Bean Seed Composite Flour**

**Abstract**

Baked products such as biscuits are important snacks that are sold in ready-to-serve form. Proximate and sensory properties of biscuits from wheat and processed African yam bean seed composite flour biscuits were evaluated. African yam bean seeds were processed by soaking (24 h, ambient), boiling (100oC, 30 min) and roasting (130oC, 30 min).They were processed into flour following standard methods. Optimal mixture model was used for the experimental design. The variables were wheat flour (50–100g/100g), boiled African yam bean flour (20–50g/100g), soaked African yam bean flour (20–50g/100g) and roasted African yam bean flour (20–50g/100g) with a total of thirteen samples (A-M). Proximate compositions as well as sensory attributes of the biscuits samples were evaluated following standard methods. Results showed that the moisture content of the composite biscuits ranged from 9.58% M (50%Wheat flour: 0%BAYBF: 0% SAYBF: 50% RAYBF) to 12.69% (60%Wheat flour: 0%BAYBF: 40% SAYBF: 0% RAYBF). Crude protein content of the samples ranged from 8.24% A (100%Wheat flour: 0%BAYBF: 0% SAYBF: 0% RAYBF) to 18.29% I (50%Wheat flour: 0%BAYBF: 50% SAYBF: 0% RAYBF). Fat content of the composite biscuit samples ranged from 4.84% F (80%Wheat flour: 0%BAYBF: 20% SAYBF: 0% RAYBF to 8.79% for sample M (50%Wheat flour: 0%BAYBF: 0% SAYBF: 50% RAYBF). Ash content of the samples ranged from 1.86% F (80%Wheat flour: 0%BAYBF: 20% SAYBF: 0% RAYBF) to 2.95% I (50%Wheat flour: 0%BAYBF: 50% SAYBF: 0% RAYBF). Crude fiber content of the samples ranged from 1.84% A (100%Wheat flour: 0%BAYBF: 0% SAYBF: 0% RAYBF) to 2.95% I (50%Wheat flour: 0%BAYBF: 50% SAYBF: 0% RAYBF) and sample M (50%Wheat flour: 0%BAYBF: 50% SAYBF: 50% RAYBF).Carbohydrate content of the samples ranged from 57.57% I (50%Wheat flour: 0%BAYBF: 50% SAYBF: 0% RAYBF) to 70.48% A (100%Wheat flour: 0%BAYBF: 0% SAYBF: 0% RAYBF). Sensory properties of the composite biscuit samples evaluated showed that sample K (70%Wheat flour: 0%BAYBF: 0% SAYBF: 30% RAYBF) was highly rated in all the sensory attributes examined.

**Keywords**: African yam bean, Biscuits, Composite flour, Proximate properties, Sensory properties

**Introduction**

Biscuits are among the most consumed bakery products worldwide due to their convenience, long shelf life and appealing sensory attributes(Adebowale, 2012). “Biscuits are of good values, contributing valuable quantities of iron, calcium, protein, calorie, fiber and some of the B-vitamins to our diet and daily food requirement Biscuits are one of the most popular bakery products made from cereals that are consumed by nearly all the people in the world. They are snacks produced from palatable dough that transformed into appetizing product through the application of heat in the oven” (Kure *et al,* 2013*)*. “They are made from flour, sugar, milk, flavouring agents and other chemical additives. Sometimes bakery products are used as vehicles for the incorporation of different nutritionally rich ingredients” (Sudha *et al.,* 2007).

“Wheat flour (*Triticum aestivum*), the main ingredients for biscuit production is imported by countries with unfavorable climates for growing wheat. This importation has placed a considerable burden on foreign exchange reserves of the economies of such importing countries. This has led to the development and use of composite flours for production of biscuits, breads and pastry products. Composite flour has been defined as a mixture of several flours obtained from roots and tubers, cereals, legumes etc, with or without the addition of wheat flour” (Adeyemi and Ogazi, 2014). Wheat (*Triticum aestivum)* is perhaps the most popular cereal grain, for the production of bread and especially for the production of biscuits and other pastries. Wheat produces white flour. In addition, the unique properties of wheat protein alone can produce biscuit dough’s of the strength and elasticity required to produce low density cookies and biscuit of desirable texture and flavor. The wheat grain consists of an outer fibrous covering – the pericarp and testa which is hard and indigestible and an inner lining aleurone layer which contains a higher proportion of protein than carbohydrate an embryo attached to a small structure, the scutellum, at the lower end of the grain and the endosperm, comprising 85% of the whole grain from which the flour is derived. The nutritive value and composition of wheat varies with the variety of the seed, the nature of the soil and climate. Wheat is composed of starch 65-75%, protein 8-10%, water 10-14%, fat 1-2%, fibre 1.5-2.5%, Ash 0.4-1.0% and food energy of 334 calories (Ihekoronye and Ngoddy, 1985).

“African yam bean (AYB) botanically known as (*Sphenostylis stenocarpa)* is an underutilized grain legume in Nigeria. It is an important legume in Africa; a lesser-known legume of the tropical and subtropical areas of the world which attracted research in recent times” (Azeke *et al*, 2005). “African yam bean is high in protein that play important role in human nutrition and makes an excellent source of supplementing proteins in the diets. These compositions gave African yam bean its high nutritive and health value” (Iwueke, 2016). The broad objective of the study is; to carryout proximate and sensory properties of biscuits from wheat and processed African yam bean composite flour. This study will help to enlighten consumers and food processors on new areas of application of lesser-known legumes in industrial food processing.

**2.0 Materials and Methods**

**2.1 Sources of Materials**

Wheat flour and raw African yam bean seeds and baking ingredients were purchased from Relief Market in Owerri Municipal Local Government Area of Imo State, Nigeria. Equipments used which included: baking oven, stainless plates, weighing scale, flour mixer and baking trays were made available by the Department of Food Science and Technology, Imo State University Owerri, Nigeria.

**2.2 Sample preparation**

**2.2.1 Preparation of Flour from Boiled African Yam Bean Seeds**

Two kilogram (2kg) of the African yam bean seeds was sorted, weighed and boiled for 30minutes in a boiling water. It was drained, dehulled and oven dried at 60oC for 3h. After oven-drying, the sample was cooled, milled using attrition mill (MODEL 594), sieved with muslin cloth and packaged (Adeyemi, 2020). The sample was labelled as boiled African yam bean (AYB) flour (Figure 1)

**2.2.2 Preparation of Soaked African Yam Bean Flour**

According to Adeyemi (2020), two kilograms (2kg) of the African yam bean seeds was sorted, weighed, soaked for 24hours at ambient condition, drained, dehulled, oven dried at 60oC for 6h for each of the samples was cooled, milled using attrition mill (MODEL 594) sieved using muslin cloth, packaged and (Figure 2 ).

**2.2.3 Preparation of Roasted African Yam Bean Flour**

Two kilogram(2kg) according to Adeyemi (2020) of the African yam bean seeds was, sorted, weighed, roasted at 130oC for 30minutes, dehulled, milled using attrition mill (MODEL 594) sieved using muslin cloth, packaged and labeled (Figure 3).

 **RAW AFRICAN YAM BEAN SEED**

 Sorting

 Weighing

 Boiling (30mins at 100OC)

 Draining

 Dehulling

 Oven drying (60OC , 3h)

 Milling (using attrition mill)

 Sieving (0.02nm mesh size sieve)

 **Boiled African yam bean flour**

**Figure 1:** Flow chart for the production of Boiled African yam bean flour samples (Source: Adeyemi, 2020)

 **RAW AFRICAN YAM BEAN SEED**

 Sorting

 Weighing

 Soaking in water (27OC, 30 min)

 Draining

 Dehulling

 Oven drying (60OC, 3h)

 Milling (using attrition mill)

 Sieving (0.02nm mesh size sieve)

 **Soaked African yam bean flour**

**Figure 2:** Flow chart for the production of Soaked African yam bean flour samples (Source: Adeyemi, 2020).

 **RAW AFRICAN YAM BEAN SEED**

 Sorting

 Weighing

 Roasting (70OC, 30 min)

 Dehulling

 Milling (using attrition mill)

 Sieving (0.02nm mesh size sieve)

 **Roasted African yam bean flour**

**Figure 3: Flow chart for the production of Roasted African yam bean flour samples (Source: Adeyemi, 2020)**

 **Experimental Design**

This was as shown in Table 1.

**Table 1: Experimental Design**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Samples** | **Wheat flour (%)** | **Boiled African yam bean flour** **(%)** | **Soaked African yam bean flour (%)** | **Roasted African yam bean flour****(%)** |
| A | 100 | 0 | 0 | 0 |
| B | 80 | 20 | 0 | 0 |
| C | 70 | 30 | 0 | 0 |
| D | 60 | 40 | 0 | 0 |
| E | 50 | 50 | 0 | 0 |
| F | 80 | 0 | 20 | 0 |
| G | 70 | 0 | 30 | 0 |
| H | 60 | 0 | 40 | 0 |
| I | 50 | 0 | 50 | 0 |
| J | 80 | 0 | 0 | 20 |
| K | 70 | 0 | 0 | 30 |
| L | 60 | 0 | 0 | 40 |
| M | 50 | 0 | 0 | 50 |

**Table 2: Recipe for biscuit Production**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **sample****codes** | **wheat flour** **(%)** | **BAYBF** **(%)** | **SAYBF** **(%)** | **RAYBF** **(%)** | **sugar** **(g)** | **Margarine** **(g)** | **salt(g)** | **baking powder****(g)** | **Milk (g)** |
| A | 100 | 0 | 0 | 0 | 30 | 30 | 1 | 5 | 10 |
| B | 80 | 20 | 0 | 0 | 30 | 30 | 1 | 5 | 10 |
| C | 70 | 30 | 0 | 0 | 30 | 30 | 1 | 5 | 10 |
| D | 60 | 40 | 0 | 0 | 30 | 30 | 1 | 5 | 10 |
| E | 50 | 50 | 0 | 0 | 30 | 30 | 1 | 5 | 10 |
| F | 80 | 0 | 20 | 0 | 30 | 30 | 1 | 5 | 10 |
| G | 70 | 0 | 30 | 0 | 30 | 30 | 1 | 5 | 10 |
| H | 60 | 0 | 40 | 0 | 30 | 30 | 1 | 5 | 10 |
| I | 50 | 0 | 50 | 0 | 30 | 30 | 1 | 5 | 10 |
| J | 80 | 0 | 0 | 20 | 30 | 30 | 1 | 5 | 10 |
| K | 70 | 0 | 0 | 30 | 30 | 30 | 1 | 5 | 10 |
| L | 60 | 0 | 0 | 40 | 30 | 30 | 1 | 5 | 10 |
| M | 50 | 0 | 0 | 50 | 30 | 30 | 1 | 5 | 10 |

**Key:**

Sample BAYBF = Boiled African yam bean flour

Sample SAYBF = Soaked African yam bean flour

Sample RAYBF = Roasted African yam bean flour

**2.2.4 Preparation of the Biscuits**

Biscuit was prepared with slight modification of (Cookery, 2018) method. Wheat flour and boiled African yam bean flour were formulated according to dilution in Table 2. Wheat flour and roasted African yam bean flour, Sugar, margarine baking powder and salt were added and mixed until a stiff paste (batter) was obtained. The batter was rolled on a floured board using rolling pin to a thickness of 0.2-0.3cm. The rolled batter was cut into shapes and arranged on greased trays and baked at 200oC for 30minutes, cooled and packaged (Figure 4).

**Composite flour, margarine, flavor, baking powder, salt, egg and sugar**

Mixing

Shaping

 Baking (200OC, 30min)

De-panning

Cooling

 **Composite Biscuits**

**Figure 4**: Flow chart for production of wheat - African yam bean Composite Biscuits

**2.3 Proximate Analysis of Biscuits**

The standard method of AOAC (2010) was used to determine the proximate compositions of the biscuit samples.

**2.3.1 Moisture Content Determination**

Two grammes (2g) each of the grated samples was weighed into previously weighed dry crucible. The samples was oven dried in an oven (Astel Hearson England model 262) at 105 OC for 2 h .The crucibles with their contents was cooled in a desiccators and reweighed, then put back into the oven and the operation was repeated until a constant weight was obtained. The loss in weight represents the moisture content and calculated with the following formula.

% Moisture content = Weight loss x 100 Eqn. (1)

 Weight of sample 1

**2.3.2 Ash Content Determination**

Two grammes portion of each sample was weighed into a clean, dried crucible and placed on the muffle furnace set at 550 OC. The sample was allowed to ash to a whitish grey colour and cooled in a desiccators. Then finally it weighed to get the weight W3. The weight of the ash was calculated from the difference in weight.

% Ash = Weight of ash x 100 Eqn .(2)

 Weight of original sample 1

**2.3.3 Determination of Crude Protein**

The crude protein was determined using the micro-kjedahl technique. One gramme (1g) portion of each of the samples was weighed into filter paper and added into the dry digestion Kjeldahl flask, followed by 0.12g of copper sulphate (CUSO4). And 2.50ml of concentrated sulphuric acid (H2S04) was added with 3g selenium catalyst and a few anti bumping chips. It was then heated in a flame chamber until the solution became clear (colorless). The solution was cooled to room temperature after which 80mls of distilled water was added. Then, 50mls of 2% boric acid was placed in the receiving flask under the condenser with two drops of methyl red in desiccators added. The digestion flask was heated until 100ml distillate was collected. And 10mls of the distillate was titrated with 0.649MoLH2S04 to get pink colour. The sample procedure was carried out on the blank.

 The amount of nitrogen was calculated as shown below

Weight of sample = 1.0g

Volume of H2S04 required for the titration = 2.50ml

Normality of H2S04 = 0.649

Nitrogen content of sample (%N) = Titre – Blank x Normality of acid Eqn. (3)

 Weight of sample

Crude Protein = %N x 6.25

**2.3.4 Determination of Fat Content**

This was carried out using the method of (AOAC, 2010). Clean and dried thimble was weighted (W1) and two grammes of the sample was added and reweighed (W2). The round bottom flask was filled with N-hexane at 60OC up to ¾ of the flask. Solvent extractor was fixed with a reflux condenser to adjust the heat sources so that the solvent boils gently, the samples was put inside the thimble and inserted into the solvent apparatus and extraction under reflux was carried out with N-hexane for 4 hours. The sample was removed from the boiling flask and solvent recovered flask containing oil dried and weighed. The weight of the extract was calculated by difference as expressed as percentage total lipid.

% Fat = Weight of fat extract x 100 Eqn. (4)

 Weight of sample 1

 **2.3.5 Determination of Crude fibre**

Two grammes of the samples was defatted as n fat determination and boiled for 30 minutes under reflux in 200ml of 1.25% H2S04 solution after which the sample was heated with hot water to remove the acid using a must in cloth to trap the sample. The residue was scraped back to flask and 200mls of 1.25% of NaOH solution was added and the mixture was allowed to boil for another 30minutes under reflux after which it was again, allowed to drain, transferred to a weighed crucible and dried in the oven at 105OC to a constant weight (W2).

 Finally it was incinerated to ash in a muffle furnace at 550OC, cooled in a desicator and reweighed (W3). By difference, the weight of the fibre was determined and expressed as a percentage of the sample weight analyzed.

% Crude fibre = Weight loss x 100 Eqn. (5)

 Weight of sample 1

**2.3.6 Determination of Carbohydrate Content**

 The carbohydrate content of the samples was determined by difference using the formula.

%Carbohydrate = 100 - (% Moisture% + Ash% + Protein% + % Crudefibre% + % Fat)

 Eqn. (6)

**2.4 Sensory Evaluation**

The sensory attributes of the biscuit samples appearance, taste; aroma, mouth feel and overall acceptability was evaluated using forty (40) trained panelists selected from the Department of Food Science and Technology Imo State University, Owerri, Nigeria using a nine point hedonic scale as described by Iwe (2002), as presented below:

9 = Like extremely

8 = Like very much

7 = Like very moderately

6 = Like slightly

5 = Like nor dislike

4 = Dislike slightly

3 = Dislike moderately

2 = Dislike very much

1 = Dislike extremely

**2.5 Statistical analysis**

Data obtained from analysis was subjected to statistical analysis of variance (ANOVA) with the mean value separated by Duncan’s multiple range tests at 95% level of significance using SPSS version 2022.

**3.0 Results and Discussion**

**3.1 Proximate composition of Wheat-African yam bean Composite Biscuits**

Presented in Table 3 is the proximate composition of composite biscuit samples from blends of wheat and African yam bean flour. The moisture content of the samples ranged from 9.58% for M (50%Wheat flour: 0%BAYBF: 0% SAYBF: 50% RAYBF) to 12.69% for H (60%Wheat flour: 0%BAYBF: 40% SAYBF: 0% RAYBF). The moisture contents of the biscuits in this study were within the acceptable limit of moisture content for the product (Agu, 2015). The relatively low moisture content of sample M (50%Wheat flour: 0%BAYBF: 0% SAYBF: 50% RAYBF) showed that the biscuit sample will have longer shelf life and this could be attributed to loss of moisture from flour samples used for formulation. “Reduced moisture content of the in biscuits will help to inhibit the development of contaminating micro-organisms whose growth and activities are favoured by the presence of high moisture” (Ugwu, 2014).

Protein in foods helps in replenishing loss body tissues and supply amino acids to the human body for cellular activities and prevention of protein energy malnutrition (Obasi, 2021). Crude protein content of the samples ranged from 8.24% for sample A (100%Wheat flour: 0%BAYBF: 0% SAYBF: 0% RAYBF) to 18.29% for sample I (50%Wheat flour: 0%BAYBF: 50% SAYBF: 0% RAYBF).The crude protein content of the composite biscuit samples were significantly different (p≤0.05) from each other. Protein content of the composite biscuit samples were higher than the control sample I (50%Wheat flour: 0%BAYBF: 50% SAYBF: 0% RAYBF). This could be attributed to the addition of African yam bean (legume flour) flour in the blend. This implies that consumption of such biscuits will help to supply protein to the body which will help to reduce protein-energy malnutrition among biscuit consumers (Obasi, 2000).

Fat content of the composite biscuit samples ranged from 4.84% for sample F (80%Wheat flour: 0%BAYBF: 20% SAYBF: 0% RAYBF to 8.79% for sample M (50%Wheat flour: 0%BAYBF: 0% SAYBF: 50% RAYBF).The fat content of the composite biscuit samples were significantly different (p ≤ 0.05) from the control biscuit sample. The sample F had the least fat content which could be attributed to the 20% soaked African yam bean flour used in the biscuit formulation. The sample M (50%Wheat flour: 0%BAYBF: 0% SAYBF: 50% RAYBF) had the highest fat content which could be related to effect of roasting treatment given to the 50% roasted African yam bean flour which lead to the melting and increase in the fat content of the composite biscuit sample M (50%Wheat flour: 0%BAYBF: 0% SAYBF: 50% RAYBF). “Fat content of any food sample aids in the improvement of mouth feel and flavor. It will also help to improve the texture of food samples which increases consumers demand” (Uzozie, 2006). According to Olawole *et al*., (2022) on his report on the nutrient composition of composite biscuit from blends of wheat and acha enriched with moringa seed flour, the fat content was lower (12.64% - 14.63%).

Ash content of the samples ranged from 1.86% for sample F (80%Wheat flour: 0%BAYBF: 20% SAYBF: 0% RAYBF) to 2.95% for sample I (50%Wheat flour: 0%BAYBF: 50% SAYBF: 0% RAYBF). Ash content shows the level of minerals present in a particular food sample. The ash content of the sample I (50%Wheat flour: 0%BAYBF: 50% SAYBF: 0% RAYBF) was significantly different (p≤0.05). Also sample I (50%Wheat flour: 0%BAYBF: 50% SAYBF: 0% RAYBF) had the highest ash content when compared to the other samples. Also the ash content values obtained in this study are higher than the range 0.64% to 0.92% reported by Femi (2003) in some selected biscuit samples produced using legume seed flours. The ash content of the samples produced was lower compared with the results reported by (Ibe *et al.,* 2024) on proximate composition of cake samples from blends of Wheat-Orange fleshed Sweet Potato and *Moringa* Seed flour. This could also be in accordance with Onwuka (2014) that minerals in food are not highly affected at high processing temperatures. Ash content of food material could be used as a bench mark to assess the mineral composition of a food product. Ash content is the inorganic residue remaining, after the water and organic matter have been removed by heating in a muffle furnace or an oxidizing agent (Kin-kabari *et al.,* 2012). Ash content of food can be a reflection of the food quality in that it could be used to ascertain the level of mineral composition, though at a very high level, it could also serve as an indication of level of food adulteration or contamination (Mugendi *et al*., 2010; Peters and Olapade, 2017). From the results of this research, ash contents of all the samples under study were fairly low (> 6%).

According to Hadiza (2021) crude fiber helps in the removal of waste products from the body, thereby preventing constipation and reduction high blood glucose absorption in the body. Crude fibre in biscuits and foods helps to increase utilization of nitrogen and absorption of some other micro-nutrients needed in the human body (Olusanya, 2021). However, according to Mosisa (2017), excess of fibre leads to iron and Zinc deficiency because; they tend to bind the trace elements. The fibre contents of both the raw and processed seeds in this research were fairly low (> 10%). Crude fiber content of the samples ranged from 1.84% for sample A (100%Wheat flour: 0%BAYBF: 0% SAYBF: 0% RAYBF) to 2.95% for sample I (50%Wheat flour: 0%BAYBF: 50% SAYBF: 0% RAYBF) and sample M (50%Wheat flour: 0%BAYBF: 50% SAYBF: 50% RAYBF).

Carbohydrate content of the samples ranged from 57.57% for sample I (50%Wheat flour: 0%BAYBF: 50% SAYBF: 0% RAYBF) to 70.48% for sample A (100%Wheat flour: 0%BAYBF: 0% SAYBF: 0% RAYBF). According to Onwuka (2014) carbohydrate contributes to energy value of a food product. Carbohydrate content in baked foods is good and makes them healthy for all age groups especially those that are in need for healthy cellular activities in their body. The carbohydrate content of the samples was significantly different (p≤0.05) from each other. Also the high carbohydrate content of the sample A could be attributed to non-addition African yam bean flour in the sample A. The changes observed in the carbohydrate contents of biscuit samplesas treatment time increased could be as a result of the changes in the other proximate components such as protein and moisture contents (Okoye and Mazi, 2012).

**Table 3: Proximate compositions (%) of Wheat-African yam bean Composite Biscuits**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sample Codes** | **Moisture** | **Protein** | **Fat** | **Ash** | **Crude fiber** | **Carbohydrate** |
| A | 10.84e + 0.02 | 8.24a + 0.02 | 6.83f + 0.03 | 1.75h + 0.01 | 1.84h + 0.02 | 70.48a + 0.35 |
| B | 11.31d + 0.09 | 10.26g + 0.03 | 6.65g + 0.02 | 1.96f + 0.02 | 2.22g + 0.02 | 67.59d + 0.09 |
| C | 11.84c + 0.02 | 12.48e + 0.02 | 6.85f + 0.02 | 2.21e + 0.01 | 2.45e + 0.03 | 64.17g + 0.06 |
| D | 12.19b + 0.03 | 14.19c + 0.08 | 7.22e + 0.08 | 2.25e + 0.02 | 2.85b + 0.01 | 61.28J + 0.13 |
| E | 10.63f + 0.03 | 16.28b + 0.02 | 8.04c + 0.02 | 2.66b + 0.02 | 2.94a + 0.01 | 59.47k + 0.05 |
| F | 11.72c + 0.14 | 10.32g + 0.04 | 4.84j + 0.13 | 1.86g + 0.02 | 2.29f + 0.10 | 69.04b + 0.08 |
| G | 11.88c + 0.01 | 12.92d + 0.09 | 5.66i + 0.02 | 2.24e + 0.09 | 2.55d + 0.01 | 64.72f + 0.08 |
| H | 12.69a + 0.01 | 14.49c + 0.01 | 6.23h+ 0.03 | 2.28e + 0.02 | 2.66c + 0.02 | 61.65i + 0.05 |
| I | 10.79e + 0.02 | 18.29a + 0.01 | 7.64d + 0.03 | 2.95a + 0.03 | 2.95a + 0.03 | 57.57L + 0.07 |
| J | 9.64g + 0.04 | 10.41g + 0.38 | 6.86f + 0.01 | 2.43d + 0.02 | 2.43e + 0.02 | 68.54c + 0.06 |
| K | 10.24h + 0.03 | 11.85f + 0.12 | 7.64d + 0.03 | 2.46cd + 0.06 | 2.64c + 0.04 | 65.11e + 0.01 |
| L | 10.34f + 0.02 | 12.47e + 0.03 | 8.22b + 0.03 | 2.54c + 0.02 | 2.85b + 0.03 | 63.68h + 0.03 |
| M | 9.58h+ 0.02 | 14.27c + 0.12 | 8.79a + 0.11 | 2.65b + 0.03 | 2.95a + 0.12 | 61.75I + 0.06 |
| **LSD** | **0.0439** | **0.0926** | **0.0316** | **0.0273** | **0.0182** | **0.05709** |

**Mean values having different superscripts along the same column are significantly different (P≤0.05).**

**Key:** Wheat flour **(WF),** Boiled African yam bean flour **(BAYBF),** Soaked African yam bean flour **(SAYBF)** and Roasted African yam bean flour **(RAYBF).**

Sample A **=** 100%Wheat flour: 0%BAYBF: 0% SAYBF: 0% RAYBF

Sample B **=** 80%Wheat flour: 20%BAYBF: 0% SAYBF: 0% RAYBF

Sample C **=** 70%Wheat flour: 30%BAYBF: 0% SAYBF: 0% RAYBF

Sample D **=** 60%Wheat flour: 40%BAYBF: 0% SAYBF: 0% RAYBF

Sample E **=** 50%Wheat flour: 50%BAYBF: 0% SAYBF: 0% RAYBF

Sample F **=** 80%Wheat flour: 0%BAYBF: 20% SAYBF: 0% RAYBF

Sample G **=** 70%Wheat flour: 0%BAYBF: 30% SAYBF: 0% RAYBF

Sample H **=** 60%Wheat flour: 0%BAYBF: 40% SAYBF: 0% RAYBF

Sample I **=** 50%Wheat flour: 0%BAYBF: 50% SAYBF: 0% RAYBF

Sample J **=** 80%Wheat flour: 0%BAYBF: 0% SAYBF: 20% RAYBF

Sample K**=** 70%Wheat flour: 0%BAYBF: 0% SAYBF: 30% RAYBF

Sample L **=**60%Wheat flour: 0%BAYBF: 0% SAYBF: 40% RAYBF

Sample M **=**50%Wheat flour: 0%BAYBF: 0% SAYBF: 50% RAYBF

**3.3** **Sensory Properties of Wheat-African yam bean Composite Biscuits**

Presented in Table 4 are the sensory properties of the composite biscuit samples from blends wheat and African yam bean flour samples. The appearance of the composite biscuit samples analyzed ranged from 6.52 for sample H (60%Wheat flour: 0%BAYBF: 40% SAYBF: 0% RAYBF) to 8.15 for sample A (control) (100%Wheat flour: 0%BAYBF: 0% SAYBF: 0% RAYBF). The sample A (100%Wheat flour: 0%BAYBF: 0% SAYBF: 0% RAYBF) was significantly different (P ≤ 0.05) from the other samples. Appearance is an important sensory attribute of any food product because of its influence on acceptability among consumers (Falola, 2012).

Taste is the degree of sweetness, bitterness sourness and saltiness of a food product. The taste of the samples ranged from 6.37 for sample D (60%Wheat flour: 40%BAYBF: 0% SAYBF: 0% RAYBF) to 7.60 for sample A (control) (100%Wheat flour: 0%BAYBF: 0% SAYBF: 0% RAYBF). The sample A (100%Wheat flour: 0%BAYBF: 0% SAYBF: 0% RAYBF) had the highest value in terms of the taste which could be attributed to the panelists familiarity with the taste of biscuit produced with only wheat flour. Also, according to (Ayodele, 2003) sweetening agents helps in improving the taste food samples.

Aroma of the samples ranged from 5.80 for sample B (80%Wheat flour: 20%BAYBF: 0% SAYBF: 0% RAYBF) to 7.35 for sample K (70%Wheat flour: 0%BAYBF: 0% SAYBF: 30% RAYBF). The aroma of sample A, C, E, F, G, I and M are not significantly different (P ≤ 0.05) from each other. Sample A had the highest score for aroma. This could be attributed to the absence of beany flavor in the sample and consumers familiarity with wheat-based biscuits. According to Ayodele (2003), the presence of beany flavor or aroma from legumes used in composite flour formulation affects sensory properties of foods.

Texture measures the degree of hardness or smoothness and roughness of a food product especially baked food products. The texture of the samples ranged from 6.25 for sample D (60%Wheat flour: 40%BAYBF: 0% SAYBF: 0% RAYBF) to 7.61 for sample L (60%Wheat flour: 0%BAYBF: 0% SAYBF: 40% RAYBF). The sample L (60%Wheat flour: 0%BAYBF: 30% SAYBF: 0% RAYBF) had the highest value in terms of texture, while sample D had the least value in terms of texture and was significantly different (P ≤ 0.05) from each other.

Overall acceptability of the samples analyzed showed that the composite biscuit samples ranged from 6.57 for sample G (70%Wheat flour: 0%BAYBF: 30% SAYBF: 0% RAYBF) and H (60%Wheat flour: 0%BAYBF: 40% SAYBF: 0% RAYBF) to 9.67 for sample K (70%Wheat flour: 0%BAYBF: 0% SAYBF: 30% RAYBF). The high overall acceptability of the sample K could be attributed to its high values in terms of taste, aroma and overall acceptability. sample K (70%Wheat flour: 0%BAYBF: 0% SAYBF: 30% RAYBF) was significantly different (P ≤0.05) among all the samples.

**Table 4: Sensory Properties of Wheat-African yam bean Composite Biscuits**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Samples** | **Appearance** | **Taste** | **Aroma** | **Texture** | **Overall acceptability** |
| A | 8.15a + 1.31 | 7.60a + 1.76 | 6.90abcd + 1.95 | 7.43ab + 1.78 | 7.73a + 1.50 |
| B | 7.55abc + 1.15 | 6.90ab + 1.64 | 5.80d+ 1.32 | 6.52bc + 1.67 | 7.10a + 1.59 |
| C | 7.50abc + 1.46 | 7.13ab + 1.55 | 6.85abcd + 1.51 | 6.83abc + 1.64 | 7.47a + 1.19 |
| D | 6.90cd + 1.59 | 6.37b + 1.25 | 6.07cd+ 1.22 | 6.25c + 1.44 | 7.62a+ 1.23 |
| E | 6.97bcd + 1.14 | 6.37b + 1.25 | 6.55abcd + 1.41 | 6.47ab + 1.34 | 7.20a + 1.23 |
| F | 7.23bcd + 0.94 | 6.70ab + 1.16 | 6.90abcd + 1.37 | 7.05abc + 1.41 | 7.50a + 1.06 |
| G | 7.15bcd + 1.25 | 7.15ab + 1.21 | 6.90abcd + 1.64 | 6.90abc + 1.82 | 6.57a + 1.10 |
| H | 6.52d + 1.34 | 6.85ab + 1.18 | 6.23bcd+ 1.68 | 6.60abc + 1.82 | 6.57a + 1.22 |
| I | 7.17bcd + 1.24 | 6.87ab + 1.23 | 6.75abcd + 1.68 | 7.34abc + 1.31 | 7.24a + 0.84 |
| J | 7.40abcd + 1.35 | 7.37a+ 1.27 | 7.07abc + 1.42 | 6.75abc + 1.12 | 7.75a + 1.43 |
| K | 7.65abc + 0.92 | 7.43a + 1.29 | 7.35a + 1.09 | 7.05abc + 1.46 | 9.67a + 0.25 |
| L | 7.87ab + 0.95 | 7.66a + 1.22 | 7.25b + 1.74 | 7.61a + 1.28 | 7.44a + 1.23 |
| M | 6.67cd+ 1.24 | 7.05ab + 1.25 | 6.65abcd + 1.51 | 7.12abc + 1.11 | 7.53a + 1.24 |
| **LSD** | **0.27750** | **0.29857** | **0.33194** | **0.33001** | **0.93160** |

**Mean values having different superscripts along the same column are significantly different (P≤0.05).**

**Key: Wheat flour (WF), Boiled African yam bean flour (BAYBF), Soaked African yam bean flour (SAYBF) and Roasted African yam bean flour (RAYBF).**

Sample A **=** 100%Wheat flour: 0%BAYBF: 0% SAYBF: 0% RAYBF

Sample B **=** 80%Wheat flour: 20%BAYBF: 0% SAYBF: 0% RAYBF

Sample C **=** 70%Wheat flour: 30%BAYBF: 0% SAYBF: 0% RAYBF

Sample D **=** 60%Wheat flour: 40%BAYBF: 0% SAYBF: 0% RAYBF

Sample E **=** 50%Wheat flour: 50%BAYBF: 0% SAYBF: 0% RAYBF

Sample F **=** 80%Wheat flour: 0%BAYBF: 20% SAYBF: 0% RAYBF

Sample G **=** 70%Wheat flour: 0%BAYBF: 30% SAYBF: 0% RAYBF

Sample H **=** 60%Wheat flour: 0%BAYBF: 40% SAYBF: 0% RAYBF

Sample I **=** 50%Wheat flour: 0%BAYBF: 50% SAYBF: 0% RAYBF

Sample J **=** 80%Wheat flour: 0%BAYBF: 0% SAYBF: 20% RAYBF

Sample K**=** 70%Wheat flour: 0%BAYBF: 0% SAYBF: 30% RAYBF

Sample L **=**60%Wheat flour: 0%BAYBF: 0% SAYBF: 40% RAYBF

Sample M **=**50%Wheat flour: 0%BAYBF: 0% SAYBF: 50% RAYBF

**3.4 Conclusion**

The nutritional composition of the composite biscuit samples in terms of proximate composition revealed that the composite biscuit sample I (50%Wheat flour: 0%BAYBF: 50% SAYBF: 0% RAYBF) had the highest protein and sample A (100%Wheat flour: 0%BAYBF: 0% SAYBF:0% RAYBF) had the highest carbohydrate content. Sensory properties of the composite biscuit samples evaluated revealed that sample K (70%Wheat flour: 0%BAYBF: 0% SAYBF: 30% RAYBF) were generally acceptable to consumers on the basis of colour and mouthfeel.

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Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Details of the AI usage are given below:

1.

2.

3.

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