**Techno-functional and sensorial properties of biscuits produced with toasted African Bush Pear (*Dacryodes Edulis*) Seed, Acha (*Digitaria Exilis*) and Grasshopper (*Zonocerus Variegatus*)**

**ABSTRACT**

This study investigated the potential of incorporating toasted African Bush Pear, Acha, and grasshopper as nutritious and sustainable ingredients in biscuit production. The acha, African Bush Pear flour and grass hopper were mixed in the ratio of 100:0:0, 91:5:4, 86:10:4, 81:15:4, 87:5:8, 83:5:8, 83:5:12, 79:5:16, respectively, to produce blend biscuits. The blend biscuits were analysed for nutrient composition, functional and sensory properties using standard methods. The swelling and water absorption capacity increased from 3.11 to 4.02 and 2.05 to 2.52mg/100g with increase in African Bush Pear flour and decreased from 3.49 to 3.38 and 2.27 to 2.12mg/100g with increase in added grass hopper powder. The physical properties: spread ratio and break strength increased from 10.60 to 11.70 and 4600 to 5200g with increase in the added African Bush Pear flour. However the break decreased from 4700 to 4500g with increase in the added grass hopper. Sample D(containing 86% acha, 10% African Bush Pear and 4% grasshopper) demonstrating the highest break strength (5200.00g).The proximate composition: crude protein, fat and crude fiber increased from 28.67 to 32.74, 25.10 to 25.550 and 18.24 to 18.62%, respectively, with increase in added ube seed flour. Mineral content of the blend biscuit: iron and sodium, decreased 4.371 to 3.821, 9.909 to 9.694mg/100g, while zinc znd magnesium increased 3.165 to 5.282 and 0.324 to 3.337mg/100g with increase in added African Bush Pear flour. These findings underscore the viability of toasted African Bush Pear, Acha, and grasshopper as innovative ingredients in biscuit formulations. They enhance nutritional value, sensory appeal, and dietary diversity while offering a sustainable approach to diversifying baked products, supporting the development of healthier, eco-friendly options.

***Key words****:* Quality evaluation, biscuits, Africa bush pear, Acha (*Digitaria Exilis)* and

grasshopper (*Zonocerus Variegatus)*

**INTRODUCTION**

Biscuit may be regarded as a form of confectionary, dried to very low moisture content. Consumption of whole grains is an excellent source of dietary fibre and nutraceutical that are of benefit in the management of obesity and diseases such as diabetes (Jideani and Jideani, 2011). The consumption of cereal foods such as biscuit has become very popular in Nigeria especially among children. Most of these cereal foods are poor in protein content and protein quality (Alobo, 2001). Enrichment of cereal-based foods with other protein sources such as oil seeds and has received considerable attention (Ayo *et al.,* 2007; Dhingra and Jood, 2002; Elkhalifa and El-Tinay, 2002; Ayo and Gaffa, 2002; Ayo and Olawale, 2003).

Legumes are high in lysine, an essential limiting amino acid in most cereals (Ayo et al., 2024). The production of good quality biscuit would depend on selecting the correct flour for each type and appropriate processes involving steps such as mixing, aeration and fermentation, machining including laminating, baking, cooling and packaging (Okaka and Okaka, 2005).

The introduction of composite flour into the bakery world has brought about different changes into baked products. Some of the oldest popular cereal grains of Digitaria spp., Digitaria exilis (acha) and Digitaria iburua, (iburu), also known as fonio or hungry rice are indigenous grains of West Africa (Jideani, 2012). Acha and iburu proteins have composition similar to that of white rice (Ogbonnaya, 2009: Jideani and Jideani, 2011), but having relatively higher sulphur amino acids (methionine and cystine) content (Ayo et al., 2024c, Afam, 2012). These and other attributes of acha and iburu show the uniqueness of the grains and their potential in contributing significantly to whole grain diets. Acha grain can also be grounded into flour to produce biscuit (Jideani, 2012).

Acha, one of the cereals belongs to the family Graminae and the sub – family Poaceae. Acha (Digitaria exilis) originated in West Africa. The plant Acha, belongs to the monocotyledonous family the graminae family. As an annual grass, it is about 45cm height with tiny, slightly elongated, yellow grains. It grows on poor sandy soil, which often will not support the growth of some of the more popular cereals. (Ayo, *et al.,* 2018).

It is an important crop in Southern Mali, Western Burkina Faso, Eastern Senegal North East Nigeria and Southern Niger. D. exilis is commonly called Acha, hungry rice or fonio. It was adopted by growers as a marginal grain and forage crop due to its tolerance to soil stress and seasonal droughts. Digitaria is a large genus and includes two cultivated West African species, which include Digitari exilis and Digitaria Ibura, the former being very close to the Wild West African specie Digitaria Longiflora. White fonio is the most widely used and can be found in farmer field froms Senegal to Chad (Pablo, *et al.,* 2003). It is grown particularly on the upland plateau of Central Nigeria as well as neighbouring regions, which include Togo and Benin Republic (Hubert*,* 2010).

Acha is considered as one of the nutritious of all grains; its seeds contain 8.79% protein and may be up to 11.89% in some black fonio sample. The grains are rich in amino acids; leucine (9.8%), methionine (5.6%) and valine (5.8%) and cysteine which are vital to human health but deficient in today’s major cereals (Jenkins, *et al.,* 2008). Acha grains contain substantial minerals (mostly iron, calcium and phosphorus) about 5% dry matter. The grains are commonly used in the production of local foods (‘Couscous’, ‘gwate’ or ‘Tuwo’) in some countries in West Africa and could be mixed with other cereal flours to make cookies, as candy and fermented beverages. Acha grain could be a substitute for semovita and other wheat products such as spaghetti and other pastas (Ayo, *et al.,* 2017. Jideani, *et al.,* 2012).

Acha contains approximately 70-80% carbohydrates, contains about 8-10% protein and provides around 10% of the daily recommended intake per 100g serving. It is rich in B vitamins, especially niacin (B3) at about 2-4 mg per 100g and folate (B9) at about 30-40 mg per 100g and contains iron (about 4-8 mg per 100g), calcium (about 10-20 mg per 100g), magnesium (about 60-80 mg per 100g), and zinc (about 1-3 mg per 100g) and naturally gluten-free.

Grasshoppers are group of insects belonging to the suborder Caelifera. They are amongst what are possibly the most ancient living groups of chewing herbivorous insects, dating back to the early Triassic around 250 million years ago (Caelifera, 2017).

Grasshoppers are typically ground-dwelling insects with powerful hind legs which allow them to escape from threats by leaping vigorously. Their front leg is shorter and used for grasping food. As hemimetabolous insects, they do not undergo complete metamorphosis; they hatch from an egg into a nymph or "hopper" which undergoes five moult, becoming more similar to the adult insect at each developmental stage. The grasshopper hears through the tympanal organ which can be found in the first segment of the abdomen attached to the thorax; while its sense of vision is in the compound eyes, the change in light intensity is perceived in the simple eyes (ocelli) (Nuwer, 2023).

Grasshoppers are exceptionally high in protein, with content ranging from 60-70% of dry weight, contains about 10-15% fat, with beneficial omega-3 and omega-6 fatty acids. It is rich in Vitamin B12 (about 5-10 μg per 100g) and Vitamin A (about 100-200 IU per 100g) and high in iron (about 10-20 mg per 100g), zinc (about 10-15 mg per 100g), magnesium (about 30-50 mg per 100g), and potassium (about 250-400 mg per 100g).

Ube also called African pear or bush pear is a native fruit of West Africa. It is popularly called Ube in the South Eastern part of Nigeria. It is mainly eaten with roasted or cooked corn. It is pink in color when unripe but turns dark purple when it is ripe. It has a butter-like nature when roasted or dipped in hot water and it is enjoyed by all (Adaobi, 2018).

Ube seeds, derived from the African pear (Dacryodes edulis), are highly valued for their rich nutritional profile. These seeds are a significant source of essential nutrients that contribute to various health benefits. Here is a comprehensive analysis of their nutritional composition: be seeds can be consumed in various ways. They are often roasted, boiled, or ground into a paste. The seeds can be added to soups, stews, or porridge, enhancing the nutritional value of these dishes. Their rich, nutty flavor makes them a versatile ingredient in both savory and sweet recipes.

Ube seeds contain approximately 15-20% protein by weight. This high protein content makes them an excellent source of plant-based protein, essential for growth, repair, and maintenance of body tissues.These seeds are rich in fats, comprising about 20-25% of their weight,. The fats are primarily healthy monounsaturated and polyunsaturated fats, which are beneficial for cardiovascular health. The presence of omega-3 and omega-6 fatty acids in these seeds helps in reducing inflammation and supporting brain function.Ube seeds provide a complete amino acid profile, including all essential amino acids that the body cannot synthesize on its own. This makes them a valuable component of a balanced diet, particularly for vegetarians and vegans.

Ube pulp contains approximately 80-85% carbohydrates, it provides around 10-15% of the daily recommended intake of dietary fiber per 100g serving, is a good source of Vitamin C (about 15-20 mg per 100g) and Vitamin E (about 0.5-1 mg per 100g). Contains calcium (about 30-50 mg per 100g), magnesium (about 20-30 mg per 100g), and potassium (about 300-400 mg per 100g).

The aim of this study is to evaluate the quality of biscuits produced from toasted Ube seeds, Acha, and grasshopper.

**2.0 MATERIALS AND METHODS2.1 Materials**

Ube seed (African bush pea), acha and grasshopper were purchase from Lafia international market, Nasarawa State, Nigeria and processed into respective flour using Food laboratory, Department of Home Science and Management, Nasarawa State University, Keffi Shabu-Lafia Campus.

**3.2 Preparation of Materials**

 **Production of** African Bush Pear flour**:** Ube seeds was sorted, cleaned, sun dried, toasted( to produce a slightly nutty flavour), milled and sieved to produced ube seed flour.

**Production of acha and grasshopper flour:**  Acha flour was produced as described by Olapade et al. (2012). The acha grains were sorted, cleaned, destoned, and oven-dried (for 4 hours and 50 minutes at 400C), milled (Attrition mill), sieved (0.3-micron sieve) to produced acha flour, and packaged in plastic.

Nandwani (2017) description was used in the production of grasshopper. Grasshoppers was washed, blanched( to reduce possible microbial contamination) oven dried (50oC), milled, sieved to obtain grasshopper flour and packed in a plastic material.

**Production of Biscuits:** The recipe as shown in Table 1 was adopted for biscuit production. The Ayo et al. (2024) description for biscuit production was adopted for the production.

**TABLE 1: Recipe Table (5%) for biscuit production**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Materials** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** |
| Acha Flour | - | 100 | 91 | 86 | 81 | 87 | 83 | 71 |
| African Bush Pear flour | - | - | 5 | 10 | 15 | 5 | 5 | 5 |
| Grasshopper powder | - | - | 4 | 4 | 4 | 8 | 12 | 16 |
| Sugar | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Baking powder | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Salt | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Water | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Wheat | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**2.2 Methods**

**2.2.1 Determination of physical properties of the blend biscuits**

The physical properties (length, height, spread ratio, weight ratio, and break strength) of the blend biscuit was determined as described by **Ayo et al. (2024).**

**2.2.2 Functional Properties Analysis**

The sample Functional properties (water absorption capacity (WAC), oil absorption capacity, and swelling capacity) of the flour blends were analyzed.

**Water absorption capacity and Bulk density**

Water absorption capacity was determined using the method of Adebowale *et al*. (2005). Ten millilitres of distilled water was added to 1.0 g of each sample in beakers. The suspension was stirred using a magnetic stirrer for 5 mins. The suspension obtained was thereafter centrifuged (Bosch Model No TDL-5, Germany) at 3555 rpm for 30 mins and the supernatant was measured in a 10 mL graduated cylinder. The density of water was taken as 1.0 g/cm3. Water absorbed was calculated as the difference between the initial volume of water added to the sample and the volume of the supernatant.

**Oil absorption capacity**

Oil absorption capacity was determined as described by Adebowale *et al*. (2005). Ten millilitres of distilled water were added to 1.0 g of each sample in beakers. The suspension was stirred in Lab line magnetic stirrer for 5 mins. The suspension obtained was thereafter centrifuged (Bosch Model No TDL-5, Germany) at 3555 rpm for 30 mins and the supernatant was measured in a 10 mL graduated cylinder. Oil absorbed was calculated as the difference between the initial volume of oil added to the sample and the volume of the supernatant.

**Swelling capacity**

Swelling capacity was determined as described by Adepeju *et al*. (2014). Sample (1 g) was weighed into 50 mL centrifuge tube. Distilled water (30 mL) was added and mixed gently. The slurry was heated in water bath (Gallenkomp, HH-S6, England) at 95°C for 30 mins. During heating, the slurry was stirred gently to prevent clumping of the sample. The tube containing the paste was centrifuged (Bosch Model No TDL-5, Germany) at 3000 x g for 10 mins and the supernatant was decanted immediately after centrifugation. The tubes were dried at 50°C for 30 mins, cooled, and then weighed (W2). Centrifuge tubes containing sample alone were weighed prior to adding distilled water (W1).

**2.2.3 Sensory Analysis**

Sensory evaluation of the various products produced was carried out to determine the acceptability of the products. Sensory parameters such as appearance, aroma, taste, texture, and overall acceptability was assessed.

The sensory quality of products was assessed by a panel of 20 untrained individuals who were familiar with millet sorghum, rice and acha products. The panel includes students and members of staff of the Nutrition Department, Nasarawa State University, Keffi Lafia Campus.

These samples was served in clean plates. Each of the panellists was requested to assess each sample based on the different sensory parameters and to indicate their degree of likeness (preference) for each sample on a questionnaire that was provided. The Nine point Hedonic scale (1 denoting strongly dislike and 9 denoting extremely) as described by Ayo et al. (2017) was used

**2.2.4 Statistical Analysis**

The data collected were subjected to statistical analysis using SPSS Version 25.0. Analyses of Variance (ANOVA) was used to determine the differences at 5% level of significance. Differences in the means was separated using Duncan test.

**3.0 Results and Discussion**

**3.1 Functional Properties of Biscuits Produced from Acha,** African Bush Pear **Flour, and Grasshopper Powder Blends**

The functional properties of the biscuits, presented in Table 2, reveal key trends in swelling capacity, water absorption capacity, and oil absorption capacity. The swelling capacity ranged from 3.04 ± 0.51 in the control (0:0:0) to 4.14 ± 0.07 (71:5:16) blend, indicating that the addition of African Bush Pear flour and Grasshopper powder enhances the dough's ability to expand and retain moisture. The water absorption capacity also increased significantly, from 1.80 ± 0.09 g/ml in the control to 2.52 ± 0.06 g/ml in the 86:10:4 blend. This suggests that the inclusion of these ingredients improves the biscuits' moisture retention, which is essential for texture and shelf life. Conversely, the oil absorption capacity varied moderately, ranging from 1.54 ± 0.08 g/ml in the control to 1.84 ± 0.30 g/ml in the 71:5:16 blend, indicating that the fat absorption was relatively stable but increased with the blend's complexity, contributing to flavour and mouthfeel.

The oil absorption capacity varied from 1.54 ± 0.08 g/ml in the control (0:0:0) to 1.84 ± 0.30 g/ml in the 71:5:16 blend. The increase in oil absorption capacity could indicate a richer flavour profile, as fats are crucial for taste and mouthfeel. However, managing oil absorption is important for health, particularly in diets aimed at reducing saturated fat intake. High oil absorption can contribute to increased caloric content, potentially leading to obesity and related health issues (Mozaffarian, 2016). Thus, a balanced approach in formulations is essential for maintaining healthful dietary options.

The water absorption capacity significantly increased from 1.80 ± 0.09 ml in the control to 2.52 ± 0.06 ml in the 86:10:4 blend. This improvement suggests that the addition of African Bush Pear flour and Grasshopper powder enhances the moisture-retaining abilities of the biscuits, which can promote digestive health and improve stool bulk (Tiwari *et al.,* 2020). Foods that can retain higher water content are also typically associated with lower caloric density, making them favourable for weight management strategies (Tiwari *et al.,* 2020).

The swelling capacity also showed a notable increase, from 3.04 ± 0.51 g/ml in the control to 4.14 ± 0.07g/ ml in the 71:5:16 blend. Higher swelling capacity is linked to increased satiety, potentially aiding in appetite regulation and reducing the likelihood of overeating (Kaur *et al.,* 2019). This attribute is beneficial for consumers seeking to manage their weight effectively.

**TABLE 2: Functional properties of Biscuit produced from with toasted** African Bush Pear**, acha and grasshopper**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sample****A:U:G** | **Swelling Capacity (g/ml)** | **Water Absorbing Capacity (g/ml)** | **Oil Absorbing Capacity (g/ml)** |
| **0:0:0** | 3.04c ± 0.51 | 1.80e ± 0.09 | 1.54c ± 0.08 |
| **\*100:0:0** | 3.11c ± 0.08 | 2.05d ± 0.17 | 1.56c± 0.12 |
| **91:5:4** | 3.29b ± 0.70 | 2.17c ± 0.33 | 1.79a ± 0.20 |
| **86:10:4** | 3.30b ± 0.79 | 2.52a ± 0.06 | 1.66b ± 0.14 |
| **81:15:4** | 4.02a ± 0.33 | 2.27b ± 0.32 | 1.54c ± 0.08 |
| **87:5:8** | 3.49b ± 0.25 | 2.02d ± 0.20 | 1.65b ± 0.04 |
| **83:5:12** | 3.38b ± 0.65 | 2.25b ± 0.30 | 1.82a ± 0.17 |
| **79:5:16** | 3.14c ± 0.07 | 2.12c ± 0.29 | 1.84a ± 0.30 |

*Average mean score with the same alphabets on the same column are not significantly different p=0.5*

*\*100:0:0 !00% wheat flour, \*\*100:0:0 A=Acha, U=* African bush pear *flour, G = Grasshopper powder*

**3.3. Physical Properties of biscuits produced from acha,**African Bush Pear **flour, and grasshopper flour blends**

The physical properties (weight, spread ratio, weight ratio, and break strength) of the flour blend biscuits are shown in Table 3. The effect of the African Bush Pear and grass hoper were significant on the quality of the produced biscuit. The length of the biscuits increased from 9.10 ± 0.12 cm in the control to 10.50 ± 0.41 cm in the 83:5:12 blend, indicating that the incorporation of Ube flour and Grasshopper powder positively affects the dough’s extensibility. The height generally remained consistent, ranging from 2.00 ± 0.22 cm in the control to 2.70 ± 0.44 cm in the 83:5:12 blend. The spread ratio showed a significant increase, from 6.15 ± 0.07 in the control to 12.97 ± 0.14 in the blend with 83:5:12, suggested an enhanced spread ability as more African bush pear flour and grasshopper powder were added. The break strength also improved significantly, increasing from 2500.00 ± 4.03 g in the control to 5200.00 ± 3.82 g in the 86:10:4 blend, indicating that the biscuits gained structural integrity with the addition of African bush pear flour and grasshopper powder.

The physical properties of the biscuits, as shown in Table 3 revealed significant changes in length, height, spread ratio, weight ratio, and break strength. The length increased from 9.10 ± 0.12 cm in the control to 10.50 ± 0.41 cm in the 83:5:12 blend. This indicates that the incorporation of African bush pear flour and Grasshopper powder positively affects the extensibility of the dough, potentially influencing portion sizes and consumer perception of the product.

The spread ratio also showed a marked increase, from 6.15 ± 0.07 in the control to 12.97 ± 0.14 in the 83:5:12 blend. A higher spread ratio enhances the textural qualities of the biscuits, making them more appealing and easier to handle during preparation. According to Zhang et al. (2018), improved spread ability is associated with greater consumer acceptability, encouraging the consumption of nutrient-rich foods.

Additionally, the break strength increased from 2500.00 ± 4.03 g in the control to 5200.00 ± 3.82 g in the 86:10:4 blend. This enhancement in structural integrity indicates that the biscuits are more robust and can withstand handling, which is crucial for their marketability.

**TABLE 3: Physical properties of Biscuit Produced with Toasted** African Bush Pear**, Acha and Grasshopper**

| **Sample****A:U:G** | **Length(mm)** | **Height(mm)** | **Spread Ratio** | **Break Strength(g)** |
| --- | --- | --- | --- | --- |
| **0:0:0**  | 9.10c ± 0.12 | 2.00d± 0.22 | 6.15e±0.07 | 2500.00e ± 4.03 |
| **\*100:0:0**  | 11.70a ± 0.02 | 2.00d ± 0.36 | 10.60d±0.14 | 4600.00b ± 3.39 |
| **91:5:4**  | 11.90a± 0.34 | 1.60e ± 0.01 | 10.90d±0.14 | 4100.00c ± 3.82 |
| **86:10:4**  | 11.00b ± 0.43 | 2.00d ± 0.47 | 11.46c±0.14 | 5200.00a ± 3.82 |
| **81:15:4**  | 10.40b ± 0.61 | 2.00d ± 0.33 | 11.70b±0.14 | 4500.00b ± 4.10 |
| **87:5:8**  | 10.60b ± 0.22 | 2.30c ± 0.56 | 11.88b±0.14 | 4400.00b ± 3.89 |
| **83:5:12**  | 10.50b ± 0.41 | 2.70a ± 0.44 | 12.80a±0.14 | 4360.00b ± 4.00 |
| **79:5:16**  | 10.50b± 0.60 | 2.50b ± 0.30 | 12.97a±0.14 | 4300.00c ± 3.89 |

*Average mean score with the same alphabets on the same column are not significantly different p=0.5*

*\*100:0:0 !00% wheat flour, \*\*100:0:0 A=Acha, U=* African Bush Pear *flour, G = Grasshopper powder*

**2.3 Proximate composition of Biscuit Produced with Toasted** African Bush Pear**, Acha and Grasshopper**
The proximate analysis provides insights into the macronutrient composition of the biscuit samples, highlighting variations in their nutritional value. The proximate composition of the flour blends is shown in Table 4.

The moisture content ranges from 5.33% in sample B to 6.22% in Sample H. A higher moisture content, like that in sample H, may reduce shelf life due to increased susceptibility to microbial growth, while lower moisture levels, as in sample B, enhance storage stability. The ash content, indicative of total mineral content, varies significantly, with sample H having the highest ash content (2.15%), suggesting a higher mineral presence. Sample C has the lowest ash content (0.35%), implying fewer minerals. Sample C exhibits the highest crude protein (34.87%), making it a potential choice for consumers seeking protein-rich snacks. Sample B (28.62%) and Sample E (30.60%) also have high protein levels, while Sample H has the lowest (22.56%). Fat content, which contributes to energy density and flavour, is highest in Sample A (31.80%) and lowest in Sample E (24.22%). Crude fibre, essential for digestion, ranges from 16.86% in Sample A to 19.60% in Sample E. High fibre content in Sample E could make it a better choice for individuals seeking digestive health benefits. Carbohydrate content, crucial for energy, is highest in Sample C (23.52%) and lowest in Sample H (11.19%). Sample C emerges as the most energy-dense option.

Moisture content ranged from 5.3 to 6.22%. These values are consistent with those reported by Olaoye et al. (2006), who emphasized the importance of low moisture content in enhancing the shelf life of bakery products. The relatively low moisture content in all samples suggests good storage stability, reducing susceptibility to microbial spoilage. However, Sample H, with the highest moisture content, may be slightly more prone to microbial activity, as highlighted by Paul et al. (2024)
The crude protein content was highest in Sample C (34.87%) and lowest in Sample H (22.56%). These findings are comparable to Olagunju et al. (2020), who found that biscuits made with legume-based flours exhibited elevated protein levels. This highlights the potential for protein fortification in biscuits as a strategy to address protein-energy malnutrition.

Fat content varied significantly, with Sample A having the highest fat content (31.80%). High fat levels improve the energy density and flavour of biscuits, as noted by Singh et al. (2012). However, excessive fat can increase the risk of cardiovascular issues, necessitating moderation in consumption.

Crude fibre, ranging from 16.86 to 19.60%, was notably high in Sample E. High fibre content is beneficial for digestion, as supported by studies by Paul et al. (2024), which emphasized the role of dietary fibre in reducing risks of chronic diseases such as diabetes and colon cancer.
Sample C had the highest carbohydrate content (23.52%), consistent with findings of Kiin-Kabari (2020), who noted that biscuits are a significant source of quick energy. However, high carbohydrate levels should be balanced with adequate fibre to avoid rapid spikes in blood sugar levels.

### Table 4: Proximate composition of Biscuit Produced with Toasted African Bush Pear, Acha and Grasshopper

| **Sample Code** | **% M.C** | **% Ash** | **% C.P** | **% FAT** | **% C.F** | **% CHO** |
| --- | --- | --- | --- | --- | --- | --- |
| **\*0:0:0**  | 5.50d ± 0.15 | 0.45f ± 0.03 | 21.43h ± 0.42 | 31.80a ± 0.67 | 16.86d ± 0.22 | 15.32e ± 0.35 |
| **\*\*100:0:0**  | 5.33e± 0.12 | 1.60b ± 0.05 | 28.62e ± 0.50 | 25.10c ± 0.45 | 18.29b± 0.28 | 19.06d ± 0.41 |
| **91:5:4**  | 5.73c± 0.11 | 0.97d± 0.12 | 31.74c± 0.34 | 25.57b± 0.18 | 17.98c± 0.15 | 21.28c± 0.14 |
| **86:10:4**  | 6.13b ± 0.18 | 0.35f ± 0.02 | 34.87b ± 0.62 | 26.05b ± 0.55 | 17.67c ± 0.30 | 23.52a ± 0.53 |
| **81:15:4**  | 6. 55a± 0.15 | 0.72e± 0.11 | 35.75a± 0.34 | 25.52c± 0.15 | 18.62b± 0.44 | 22.13b± 0.15 |
| **87:5:8**  | 5.78c ± 0.14 | 1.05d ± 0.04 | 30.60 d± 0.48 | 24.22d ± 0.47 | 19.60a ± 0.25 | 18.75d ± 0.39 |
| **83:5:12**  | 6.00b± 0.18 | 1.65b± 0.14 | 26.56f± 0.18 | 24.86d± 0.15 | 18.82b± 0.14 | 14.97f± 0.17 |
| **79:5:16**  | 6.22b ± 0.16 | 2.15a ± 0.06 | 22.56g ± 0.45 | 25.49b ± 0.50 | 18.07b ± 0.31 | 11.19g ± 0.28 |

*Average mean score with the same alphabets on the same column are not significantly different p=0.5*

*\*100:0:0 !00% wheat flour, \*\*100:0:0 A=Acha, U=* African Bush Pear *flour, G = Grasshopper powder*

**3.5 Mineral composition of Biscuit Produced with Toasted** African Bush Pear**, Acha and Grasshopper**The mineral analysis highlights the presence of essential micronutrients across the samples: Essential for immune function, zinc levels are highest in Sample E (5.600 mg/L) and lowest in Sample A (3.032 mg/L). Sample E stands out as a significant source of zinc. Crucial for bone development and enzymatic activity, manganese content is highest in Sample C (2.892 mg/L), while Sample B has the lowest level (0.324 mg/L). Iron, vital for oxygen transport, is most abundant in Sample A (5.431 mg/L), making it suitable for addressing iron deficiencies. Sample C has the lowest iron content (3.453 mg/L). Sodium, which contributes to taste and fluid balance, is highest in Sample A (11.675 mg/L) and lowest in Sample E (8.956 mg/L). Sample A may require cautious consumption by individuals monitoring sodium intake. Iodine, essential for thyroid function, is highest in Sample E (2.012 mg/L) and lowest in Sample B (0.982 mg/L). Sample E is particularly beneficial for iodine supplementation.

Mineral analysis revealed substantial increase in zinc, manganese, iron, sodium, and iodine levels. Sample E had the highest zinc (5.600 mg/L) and sample A had the highest iron (5.431 mg/L). Zinc and iron are critical for immune function and oxygen transport, respectively Paul et al. (2024). The high levels align with findings of who stressed the importance of fortifying processed foods with zinc and iron to combat micronutrient deficiencies in developing countries.

Sample C exhibited the highest manganese levels (2.892 mg/L). Manganese is essential for bone health and enzymatic functions, as discussed by Umeta et al. (2005), the presence of manganese-rich ingredients, such as whole grains or nuts, could explain these findings.

Sample E showed the highest iodine content (2.012 mg/L). This aligns with efforts highlighted by Zimmermann (2009) to fortify processed foods with iodine to address thyroid health issues, particularly in regions with high incidences of goitre.

### Table 5: Mineral composition of Biscuit Produced with Toasted African Bush Pear, Acha and Grasshopper

| **Sample Code** | **Zn (mg/L)** | **Mn (mg/L)** | **Fe (mg/L)** | **Na (mg/L)** | **I (mg/L)** |
| --- | --- | --- | --- | --- | --- |
| **\*0:0:0**  | 3.03d ± 0.020 | 0.67f ± 0.015 | 5.43a ± 0.040 | 11.67a ± 0.110 | 1.34c ± 0.030 |
| **\*\*100:0:0**  | 3.16d ± 0.022 | 0.32g ± 0.012 | 4.87b ± 0.038 | 9.90c± 0.105 | 0.98e ± 0.025 |
| **91:5:4**  | 4.06c ± 0.035 | 1.60c ± 0.015 | 4.16c± 0.015 | 10.16b± 0.025 | 1.02d ±0.020 |
| **86:10:4**  | 4.96b ± 0.031 | 2.89b ± 0.025 | 3.45d ± 0.030 | 10.43b ± 0.112 | 1.06d ± 0.028 |
| **81:15:4**  | 5.28b± 0.020 | 3.33a ± 0.027 | 3.82d ± 0.029 | 9.69c ± 0.025 | 1.59c± 0.015 |
| **87:5:8**  | 5.60a ± 0.035 | 1.78c ± 0.022 | 4.21c ± 0.045 | 8.95e ± 0.108 | 2.01a ± 0.040 |
| **83:5:12**  | 4.91b± 0.015 | 1.41d ± 0.025 | 4.19c± 0.015 | 9.08d± 0.020 | 1.94b ± 0.025 |
| **79:5:16**  | 4.22c ± 0.028 | 1.04e ± 0.018 | 4.98b ± 0.032 | 9.21d ± 0.101 | 1.87b ± 0.036 |

*Average mean score with the same alphabets on the same column are not significantly different p=0.5*

*\*100:0:0 !00% wheat flour, \*\*100:0:0 A=Acha, U=* African Bush Pear *flour, G = Grasshopper powder*

**3.6 Vitamin composition of Biscuit Produced with Toasted** African Bush Pear**, Acha and Grasshopper**
The vitamin content of the flour blend biscuits is shown in Table 6. The vit A, B3 and C increased from 2.40 to 3.90, 0.59 to 1.45 and 13.14 to 13.56mg/100g with increase in the added ube seed flour and decreased from in level of vit C from 12.86 to 12. 27 but increase in B3 from 1.44 to 1.47mg/100g, respectively, with added level of grasshopper powder. The relative increase in the respective vitamins could be due to the inherent chemical compositions of the added ube and grass hopper powder. The decrease in the level of vit. C with addition of grass hopper could be attributed to its poor content of the same. Vital for vision and immune health, vitamin A levels are highest in sample H (3.891 mg/100g) and lowest in sample A (2.345 mg/100g). Sample H is the best choice for enhancing vitamin A intake. Important for energy metabolism, vitamin B3 is most abundant in Sample H (1.471 mg/100g) and least in sample B (0.587 mg/100g). Sample H supports metabolic functions effectively. These findings resonate with Aini et al. (2013), who emphasized the role of Vitamin A fortification in combating deficiencies, especially in developing countries. Vitamin B3 content was also highest in sample H (1.471 mg/100g). Niacin is crucial for energy metabolism and reducing the risk of pellagra, as noted by Bender (2003). The variability among samples suggests differences in ingredient composition, such as enriched flours.

### Table 6: Vitamin composition Biscuit Produced with Toasted African Bush Pear, Acha and Grasshopper

| **Sample Code** | **Vitamin A (mg/100g)** | **Vitamin B3 (mg/100g)** | **Vitamin C (mg/100g)** |
| --- | --- | --- | --- |
| **\*100:0:0**  | 2.35d ± 0.015 | 0.59c ± 0.010 | 13.14c ± 0.140 |
| **\*\*100:0:0**  | 2.40d ± 0.018 | 0.58c ± 0.008 | 13.16c ± 0.125 |
| **91:5:4**  | 3.12c ± 0.125 | 1.04b± 0.025 | 13.26b± 0.018 |
| **86:10:4**  | 3.77b ± 0.025 | 1.46a ± 0.020 | 13.46a ± 0.150 |
| **81:15:4**  | 3.90a ± 0.125 | 1.45a ± 0.115 | 13.56a ± 0.105 |
| **87:5:8**  | 2.54d ± 0.020 | 1.44a ± 0.018 | 12.86d ± 0.130 |
| **83:5:12**  | 2.20e± 0.018 | 1.45a± 0.018 | 12.46e± 0.025 |
| **79:5:16**  | 2.21e ± 0.022 | 1.47a ± 0.019 | 12.27f ± 0.135 |

*Average mean score with the same alphabets on the same column are not significantly different p=0.5*

*\*100:0:0 !00% wheat flour, \*\*100:0:0 A=Acha, U=* African Bush Pear *flour, G = Grasshopper powder*

**3.7** **Sensory Evaluation of Biscuits Produced from Acha,** African Bush Pear **Flour, and Grasshopper Powder Blends**

The sensory evaluation of the produced blend biscuits is summarized in Table 7. The average means scores of the aroma, taste, colour, mouth feel. Appearance and overall acceptance of the produced blend biscuits generally decreased from 7.15 to 4.35, 6.75 to 4.05, 7.35 to 5.40, and 6.45 to 5.15. 7.00 to 5.30 and 7.30 to 5.45, respectively with increase in the added African Bush Pear and grass hopper powder. The added ube seed flour and grass. hopper had significant effects on the sensory quality of the blend biscuits. Generally all the blend biscuits are acceptable (above 5.00) but the most preferred samples are 81% acha,15% African Bush Pear and 4% grass hopper powder .This demonstrated that the incorporation of Ube flour and Grasshopper powder not only improves nutritional quality but also enhances sensory attributes, increasing the likelihood of these biscuits being integrated into daily diets. Sensory attributes are critical for consumer appeal and can significantly influence perceived quality (Meilgaard *et al.,* 2015).

**Table 7. Sensory properties of Biscuit Produced with Toasted** African Bush Pear**, Acha and Grasshopper**

| **Sample****A:U:G** | **Aroma** | **Taste** | **Colour** | **Mouth feel** | **Appearance** | **Overall Acceptability** |
| --- | --- | --- | --- | --- | --- | --- |
| **\*100:0:0**  | 7.75a ± 1.05 | 8.05a ± 1.11 | 7.90a± 1.08 | 7.55a± 1.03 | 8.25a ± 1.14 | 8.15a ± 1.11 |
| **\*\*100:0:0**  | 7.15b ± 0.98 | 6.95b ± 1.02 | 7.35b± 1.00 | 6.45b± 0.89 | 7.00b ± 0.97 | 7.30b ± 0.99 |
| **91:5:4**  | 5.35c ± 0.87 | 5.80c ± 0.92 | 6.20b ± 0.89 | 6.15c ± 0.82 | 6.50c ± 0.85 | 6.00c ± 0.87 |
| **86:10:4**  | 5.55c ± 0.92 | 5.25d ± 0.84 | 6.05b ± 0.88 | 6.00d ± 0.80 | 6.35d ± 0.83 | 6.10c ± 0.81 |
| **81:15:4**  | 5.10d ± 0.83 | 4.65e ± 0.78 | 5.70c ± 0.75 | 6.05d ± 0.81 | 6.15e ± 0.80 | 5.55e ± 0.80 |
| **87:5:8**  | 5.05d ± 0.85 | 4.40e ± 0.79 | 5.50d ± 0.81 | 5.55e ± 0.88 | 5.75f ± 0.86 | 5.45f ± 0.73 |
| **83:5:12**  | 4.40c ± 0.89 | 4.25f ± 0.87 | 5.45c ± 0.90 | 5.20f ± 0.80 | 5.30g ± 0.84 | 5.40g ± 0.78 |
| **79:5:16**  | 4.35c± 0.73 | 4.05f ± 0.71 | 5.40c ± 0.74 | 5.15f ± 0.74 | 5.30g ± 0.76 | 5.45g ± 0.71 |

*Average mean score with the same alphabets on the same column are not significantly different p=0.5*

*\*100:0:0 !00% wheat flour, \*\*100:0:0 A=Acha, U=* African Bush Pear *flour, G = Grasshopper powder*

**CONCLUSION**

The incorporation of acha, Ube flour, and grasshopper powder into biscuit formulations emerges as a transformative approach to enhancing both the nutritional value and sensory appeal of traditional baked goods. The findings underscore the potential of these alternative ingredients to create healthier, more palatable options that cater to the growing demand for nutritious snacks. This study paves the way for innovative product development that can significantly impact dietary habits, contributing to improved health outcomes. Sample C is ideal for protein and energy needs, Sample E for mineral supplementation, and Sample H for vitamin enrichment. This highlights the importance of optimizing ingredient formulations to improve biscuit quality and enhance their role in meeting nutritional goals.

Future studies should delve deeper into the long-term health impacts associated with the regular consumption of biscuits enriched with acha, African Bush Pear, and Grasshopper powder. Investigating the influence on weight management, digestive health, and overall dietary quality will provide a more comprehensive understanding of their benefits.

Robust educational initiatives should be launched to inform consumers about the health benefits of these innovative ingredients. Highlighting their nutritional advantages and sensory enhancements can drive acceptance and encourage integration into daily diets.

Advocacy for supportive policies that promote the use of alternative flours and protein sources in food production can lead to broader systemic changes in food availability and health outcomes, addressing pressing public health challenges such as obesity and malnutrition.

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