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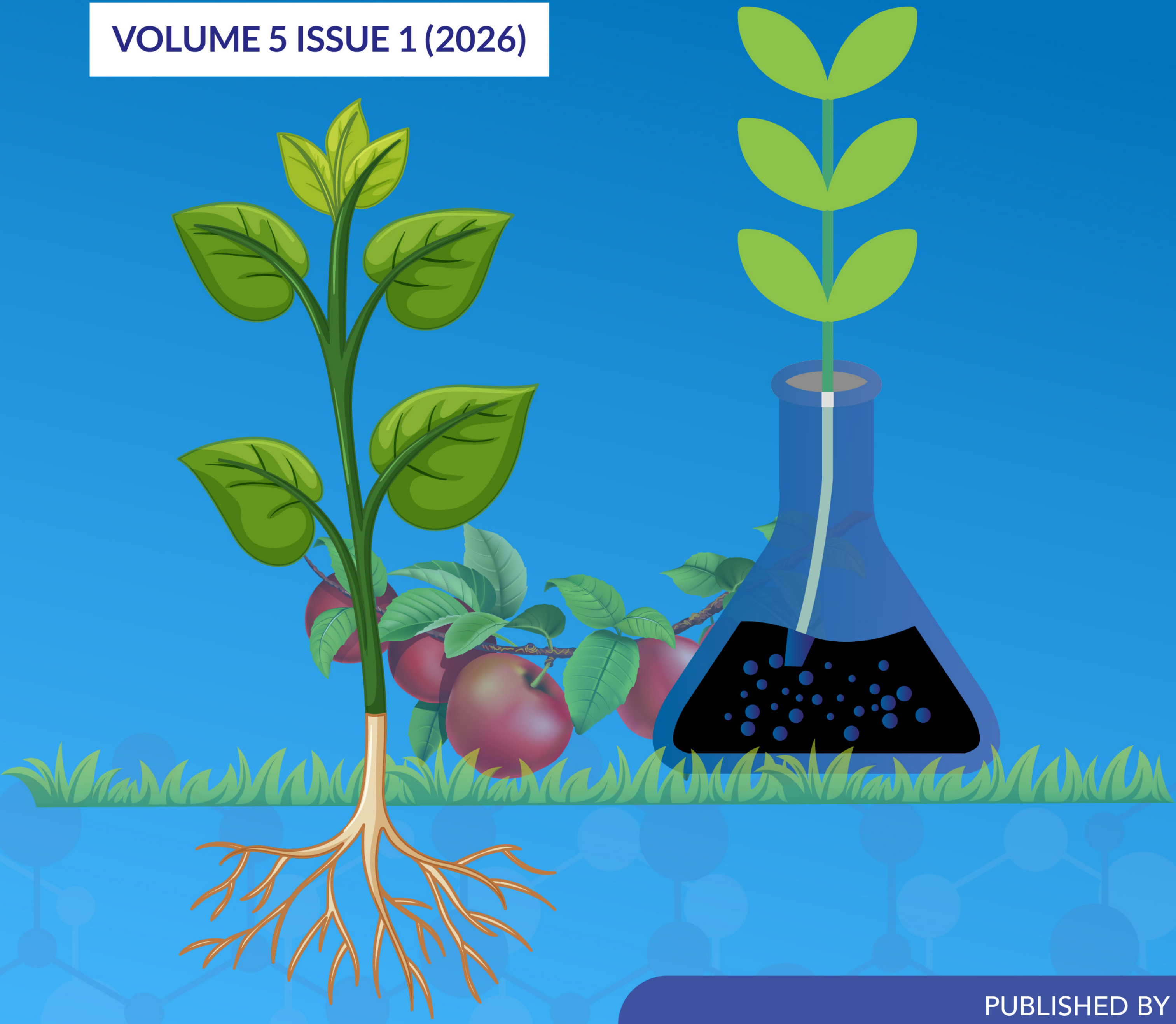

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Partially Replaced Gluten Biscuit: Nutritional and Consumer Acceptability

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ABSTRACT

Driven by a heightened awareness of health issues associated with gluten consumption, there is an increasing demand for gluten-free food products. This trend has been particularly pronounced due to the increasing prevalence of conditions such as Celiac disease and Non-Celiac Gluten Sensitivity (NCGS), impacting millions of individuals globally. This study investigated the development of gluten-free biscuits using cassava, soybean, and sorghum flours to address the nutritional and consumer acceptability gaps in gluten-free products. The study also aimed to assess the sensory attributes and nutritional composition of gluten-free biscuits prepared from locally available and cost-effective flours. Sensory analysis revealed high consumer acceptability for gluten-free biscuits, particularly in taste, texture, and overall appeal, with scores averaging above 7 on a 9-point hedonic scale. Proximate analysis indicated that soybean-enriched biscuits contained 14.5% protein, significantly higher than the 8.2% found in wheat-based biscuits, while sorghum contributed 5.8% dietary fiber compared to 2.3% in the control. Cassava provided a carbohydrate content of 72.4%, ensuring energy density. The study's findings shows the potential of leveraging underutilized crops to address health concerns, reduce reliance on wheat flour, and promote agricultural sustainability. This research offers a practical framework for creating nutritious and desirable gluten-free biscuits that cater to evolving dietary preferences and promote inclusivity in food production.

INTRODUCTION

In recent years, the demand for gluten-free food products has undergone a remarkable surge, driven by a heightened awareness of health issues associated with gluten consumption. This trend has been particularly pronounced due to the increasing prevalence of conditions such as Celiac disease and Non-Celiac Gluten Sensitivity (NCGS), impacting millions of individuals globally. Celiac disease, identified in approximately 1% of the global population, stands as an autoimmune condition necessitating strict adherence to a gluten-free diet (Puerta *et al.*, 2022). The imperative for such dietary restrictions arises from the potential adverse effects of gluten on the immune system, leading to intestinal damage and a spectrum of health complications (Kaur *et al.*, 2022; Puerta *et al.*, 2022). The rise in NCGS further contributes to the complexity of gluten-related disorders, presenting symptoms similar to Celiac disease but lacking its distinctive immunological response (Roszkowska *et al.*, 2019). Diagnosing NCGS poses a significant challenge due to the limited understanding of its underlying mechanisms, emphasizing the critical need for effective diagnostic approaches to address associated health risks (Roszkowska *et al.*, 2019; Rotondi Aufiero *et al.*, 2018). The collective awareness of gluten-related health risks, particularly in the context of Celiac disease and NCGS, has not only fueled the demand for gluten-free products but has also transformed this dietary choice into a lifestyle preference for a broader consumer base (Palmeter, 2020). This includes individuals embracing fitness regimens and those actively pursuing health-conscious lifestyles.

This burgeoning demand has triggered a substantial expansion of the gluten-free market across various food categories, with a particular emphasis on baked goods like biscuits. Responding to this consumer shift, manufacturers in the food sector have embarked on innovative endeavors, creating a diverse array of gluten-free substitutes that not only meet dietary requirements but also offer palatable and nutritious options (Palmeter, 2020; Winter, 2018). The sustained growth of this market underscores the enduring significance of gluten-free food products in contemporary culture.

The development and promotion of safe and wholesome substitutes, exemplified by gluten-free biscuits, serve multifaceted purposes. Firstly, for individuals contending with wheat allergy, NCGS, or celiac disease, the availability of safe substitutes ensures a diverse diet without compromising health (Di Cairano *et al.*, 2018). Sustaining overall health demands the incorporation of nourishing gluten-free alternatives, particularly crucial for children whose growth is contingent on a balanced diet (Xhakollari & Canavari, 2019). Beyond health considerations, the introduction of gluten-free alternatives fosters inclusivity, enabling individuals with gluten-related health issues to actively participate in social activities without feeling isolated or compromising their well-being (Kaur *et al.*, 2022). In a broader societal context, the availability of wholesome gluten-free substitutes aligns seamlessly with public health initiatives as it not only diminishes the incidence of associated health problems but also

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advocates for informed dietary choices (Xhakollari *et al*., 2019). Also, the heightened market demand for gluten-free items, notably biscuits, signifies a broader societal shift towards health consciousness and an enhanced understanding of gluten-related disorders. Manufacturers investing in the development of superior, wholesome gluten-free biscuits not only cater to a niche market but also position themselves for substantial financial rewards (Kalle Hirvonen, 2024). In doing so, they assume a pivotal role in shaping the trajectory of the food sector, placing emphasis on accessibility, safety, and health for all consumers

Understanding the nutritional composition and consumer acceptability of non-gluten biscuits is paramount. The components utilized in non-gluten formulations was closely examined in this study, with an emphasis on how they affect fiber content, key nutrients, and overall nutritional value. A comparison with conventional gluten-free biscuits will also shed light on the possible health advantages of choosing non-gluten alternatives. The functional characteristics of non-gluten biscuits such as taste, texture, and shelf stability was a major focus of research. The acceptance of non-gluten biscuits by consumers is critical to their success (Arslan *et al*., 2019). Through sensory analysis, factors impacting preferences such as taste, texture, and overall satisfaction was assessed. Manufacturers can refine formulations to meet a range of tastes and expectations with the help of insights into consumer perceptions and preferences. As the market for gluten-free products continues to expand, understanding the potential of non-gluten biscuits in meeting consumer needs becomes pivotal (Arslan *et al*., 2019; Conte, 2018). This research will shed light on market trends, consumer behaviors, and the broader implications for the food industry. Manufacturers, entrepreneurs, and stakeholders will gain valuable insights into the market dynamics of non-gluten biscuits, shaping their strategic decisions and product development initiatives.

The exorbitant cost of wheat flour not only imperils the economic sustainability of biscuit production but also places limitations on the accessibility of these products to a more extensive consumer base. In the midst of these challenges, a pronounced research gap emerges, specifically regarding the development of non-gluten biscuits (Oke *et al*., 2022). These biscuits will not only meet the nutritional requirements and functional attributes expected of traditional biscuits but also strive to ensure consumer acceptability. This is particularly crucial as the study focuses on utilizing locally available and cost-effective flours. The research endeavors to address this void by delving into alternative flour sources, optimizing biscuit formulations, and systematically assessing the overall feasibility and acceptability of non-gluten biscuits. Through these concerted efforts, the study will offer a sustainable solution to the economic, agricultural, and health challenges entangled with the prevailing dependence on expensive wheat flour.

MATERIALS AND METHODS

Source of materials

The grains (soya beans and sorghum) were bought from the Crop Research Institute (CRI) of the Council for Scientific and Industrial Research (CSIR) farm at Fumesua in the Ashanti Region. Additionally, the necessary ingredients was purchased at the Bantama market in Ghana's Ashanti area. Equipment used were measuring spoons and cups, baking sheets, ingredients bowls, sieve, oven, piping bag, metal spoon, wooden spoon, mixing bowls, wooden spoons and dish paper.

Flour preparation

The cassava roots (freshly harvested) was peeled manually with a knife, washed with tap water, and chipped using a manual chipper into 2–3 cm sizes. The chips were dried in a solar dryer at 50–55 °C for 3 days, milled, screened through a mesh sieve, and packaged in a plastic container before analysis.

The sorghum and soyabean flour was prepared by the method reported by Houssou and Ayernor (2002). Sorghum and soya bean grains was sorted and thoroughly cleaned. The sorted and cleaned whole sorghum grains was milled in a disc attrition mill locally made and be allowed to pass through a 250 m opening. The flour that was obtained was sieved using a 0.25 mm sieve and was packaged in a cellophane bag until used stored at 4°C in a refrigerator to prevent spoilage

Participants

This study made use of fifty willing panelists who was chosen from the students and staff of Bantama SDA SHS in Ghana's Ashanti region. Student participants must be over the age of 15, in good health, and willing to participate in a battery of sensory tests. Condition, as well as being open to participating in a range of sensory assessments.

Samples preparation

Non-gluten biscuits was made and presented on sample platters labeled with codes specific to each sample. Samples was presented in random order and given a three-digit code made up of random numbers to prevent bias. To further eliminate the after taste, prepared cucumber was utilized.

Biscuits Production

A modified method by Berno *et al*. (2018) was used to create and produce three distinct types of non-gluten biscuits and a control. Table 1 illustrate the specifics. Cream will be prepare with fat and sugar until it is fluffy. The liquid ingredients were added to the cream and mix well. All the dry ingredients were added to the flour, sift, cut and fold into the cream. The mixture were piped onto a baking sheet lined with dish paper and baked in a traditional oven at 75 ºC for approximately 15 to 30 minutes (Bajaj, India). After that, they will be cooled and packed in polypropylene bags for further analysis (Aidoo *et al*., 2022).

Table 1: Biscuits Formulation

Ingredients	Control	SP1	SP2	SP3
Wheat flour (%)	100			
Sorghum flour (%)		30	30	33
Soybean flour(%)		20	30	33
Cassava flour(%)		50	40	34
Margarine(g)	150	150	150	150
Sugar (g)	100	100	100	100
Milk (ml)	62	62	62	62
Vanilla Essence(ml)	5	5	5	5
Egg (g)	50	50	50	50
Baking powder (g)		2.5	2.5	2.5

NUTRITIONAL ANALYSIS

Proximate Composition

Moisture content, Ash content, Protein content, fat content, and carbohydrate content was ascertained using the standard methods. Proximate analysis is the process of estimating a food's essential ingredients using techniques that enable a reasonably rapid and accurate assessment of different food fractions, typically without the use of expensive equipment or chemicals. Protein, fat, moisture, ash, and carbohydrate levels are determined using a range of methods, including extraction and Kjeldahl. The given cereal-legume mix's protein, fat, moisture, ash, and carbohydrate contents were ascertained using AOAC Methods.

Determination of Moisture Content – (AOAC, 2005)

A petri dish was emptied and was dried in the oven, chilled, and its weight was recorded. The material (biscuits) was weighed and distributed equally over the bottom of the petri dish in an amount of about five grams (5g). The dish was cooked for 4 hours at 105 °C in a forced draft oven. After cooling the dish and sample in a desiccator, the sample's weight will then be collected after drying, and the moisture content was computed as a percentage of moisture lost. The formula used to determine the moisture content (MC) was

%MC = ([Weight of dish + Sample (before)] – Weight of dish + Sample (after)] x 100)/Weight of sample

Determination of Crude Fat – (AOAC, 2005)

The gluten-free biscuit sample was weighed into a thimble containing non-absorbent cotton and packed with around 5 g of the sample. The sample-containing thimble was set within the Soxhlet equipment' extractor. Weighing was done with a clean, dried Soxhlet flask and around 200 cc of petroleum ether, the extraction solvent. To assist in condensing the organic solvent, the Soxhlet apparatus was set up and cold" water was allowed to flow through the condenser. The apparatus was left to operate for six hours, after which the Soxhlet flask containing the fat extraction was removed and dried for one hour in an air oven at 105 °C. It will then be weighed after cooling in a desiccator. Using the equation, the fat content was estimated as a percentage of crude fat = (%FC = ((Weightofflask + Oil) - Weightofemptyflask x 100)/ WeightofSample)

Determination of Total Ash content – (AOAC, 2005)

A porcelain crucible was weighed and its base be labeled with a pencil after it has already been lit and cooled. The gluten-free biscuit was weighed into the crucible at a weight of around 2 g. The crucible was positioned with tongs in a muffle furnace set at 550 °C and left to burn up for two hours. The ash will then be weighed after cooling in a desiccator to room temperature. The following equation was used to determine the ash" content as a percentage of total ash:

%AC = ([Weight of crucible + Sample (before)] – Weight of crucible + Sample (after)] x 100)/Weight of sample

Determination of Crude Fibre – (AOAC, 2005)

2g of the defatted sample (gluten-free biscuit) (Ws) was placed in a round bottom flask with around 100 mL of 1.25% H_2SO_4 and was allowed to boil for 30 minutes. The material was filtered and rinsed with warm water for 30 minutes. 100 mL of 1.25% NaOH will then be poured over the residue after it has been put into the flask. After another 30 minutes of boiling, filtering, and washing with warm distilled water and 80% alcohol, the remaining material was left behind. The residue will then be subsequently left to dry for two hours at a temperature of around 130 °C in a hot air oven before cooling in a desiccator for roughly 30 minutes. The dry fiber weight was measured in a pre-dried crucible (W1), and the sample was burned for two hours at 550°C before cooling. When the crucible and ash (W2) are cooled, the following formula was used to calculate:

%CF = (([Weight of crucible + Sample (before)] - Weight of crucible + Sample (after)] x 100))/(Weight of sample)

%CF = W2 - W1 x 100/Ws

Determination of Crude Protein – (AOAC, 2005)

A digestion tube was filled with around 1 g of the material, and two catalyst tablets and 15 mL of concentrated H_2SO_4 was placed over the sample (gluten-free biscuit) (Kjeltabs). The sample will then be subsequently digested in the Kjedahl digester for roughly 2 hours at a temperature of 420 °C. Following digestion, 10 ml of the digest was removed and diluted to a level of 100 ml in a volumetric flask. 200 cc of distilled water and 50 mL of 40% NaOH was added to 20 ml of the diluted digest. With the "water circulation pump of the condenser turned on, the Kjeltec distillation setup was placed at a temperature of 150–200 °C. In a conical flask filled with 30 mL of 4% boric acid, two to three drops of mixed indicator was added. The flask will then be attached to the distillation equipment. The distillate was collected into a conical flask and titrated against 0.1 N HCl in an amount between 100 and 150 ml (standardized solution). The following equations was used to compute the percentage of crude protein as well as the percentage of protein content relative to a blank:

Kjeldahl Nitrogen % = ([(Titre of sample - Titre of blank) x N(HCl) x 14.01] x 100)/(Weight of sample x 10)

"%" CrudeProtein="%" KjeldahlNxF

Where,

N = Normality of standardized HCl
14.01 = Molecular weight of Nitrogen
10 = Factor to convert mg/g to percent
Titre = Volume of standardized acid used to titrate a test
F = Conversion factor to Protein
(5.70 for wheat, 6.38 for dairy products, and 6.25 for other feeds)

Carbohydrate and energy determination

The carbohydrate content of the sample was determined by difference.

The carbohydrate content was calculated as indicated below:

Carbohydrate (%) = 100 – (% moisture + % fat + % protein + % ash + % fibre)

Consumer Acceptability Study

The sensory evaluation panelists was obtained from semi-trained panelists who was selected from seventy panelists who was randomly picked from the students and staff of SDA Senior High School to access the biscuits. On a 9-point hedonic scale, where 1 represents "dislike extremely" and 9 represents "like extremely," they was asked to score the biscuits based on their color, taste, flavor, texture, crispiness, and general acceptability. A blind taste test was employed to help eliminate any perceptions participants might have of the product.

Statistical Analysis

SPSS version 26 was used to analyze data from the sensory and nutritional analysis.

RESULTS AND DISCUSSIONS

Sensory attributes of biscuits produced with sorghum flour, cassava flour and soya bean flour

The biscuits used in this study were developed from varying compositions of cassava, sorghum and soya bean flours and sensory analysis conducted to assess the consumer preferences. A hedonic scale was adopted to rank the rate of acceptance after each panel member assesses the product. The biscuits were with different formulations were labelled as Sample 1 (30% sorghum, 20%soya beans and 50% cassava flour), sample 2 (30% sorghum, 30% soya beans and 40% cassava flour), sample 3 33% sorghum, 33% soya beans and 34% cassava flour) and 100% wheat flour as the control.

Table 2: Descriptive Statistics for Appearance, Flavour, Taste, Texture, and Overall Acceptability of different biscuit samples

Sample	Appearance	Flavour	Taste	Texture	Overall Acceptability
CONTROL	5.88 ± 1.19^{b}	5.84 ± 1.10^{a}	5.92 ± 1.18^{b}	5.54 ± 1.15^{a}	6.3 ± 1.11^{b}
SAMPLE 1	5.5 ± 1.30^{ab}	5.64 ± 1.08^{a}	5.72 ± 1.29^{ab}	5.26 ± 1.32^{a}	5.72 ± 1.39^{a}
SAMPLE 2	5.32 ± 1.63^{a}	5.44 ± 1.20^{a}	5.26 ± 1.52^{a}	5.12 ± 1.56^{a}	5.66 ± 1.38^{a}
SAMPLE 3	5.92 ± 1.21^{b}	5.84 ± 1.13^{a}	5.66 ± 1.39^{ab}	5.36 ± 1.56^{a}	6.06 ± 1.25^{ab}

All values in the same column with the same superscript are not significantly different ($p>0.05$)

Appearance

The results of the descriptive tests are presented in Table 4.1 above. The results indicated that Sample 3 has the most preferred with respect to appearance. This was correlated by a mean value of 5.92±1.21 which was the highest recorded for all samples. Sample 2 recorded a mean value of 5.32±1.63 was the least preferred in appearance.

It can be deduced from Table 4.1 that, Sample 3 which is the most preferred varies significantly from Sample 2 but not sample 1 and the control sample. This shows that sample 3 can be used to mimic the control sample. The findings show a high preference for the Sample 3 by the panelists, which had a composition of 33 % sorghum flour, 33% g soya bean flour and 34% cassava flour. It was most preferred possibly because of the evenness of the formulation used in making the biscuits.

Food products appearance often influences consumer perception even before tasting the food product. In most baked goods, appearance is mainly influenced by color, surface texture, and size, all of which are impacted by the ingredients used in making the product. Wheat flour produces a pale golden color and a smooth surface in baked goods and this is due to its gluten content and well-defined starch granules. Also, Gluten proteins in wheat flour contribute to uniform dough expansion during baking, resulting in an even texture and appealing appearance and this could have influenced why the control sample scored highly in appearance. Cassava is a starchy tuber, and its flour is mostly white and gluten-free, which may impact the appearance of the biscuit. It usually lacks the elasticity that gluten provides, leading to a denser structure, which has less volume than wheat-based doughs. This can cause biscuits with cassava to have a less appealing appearance if the structure collapses or does not expand as uniformly as wheat-based ones. Sorghum has a slightly darker, reddish-brown hue because of it anthocyanin and tannin content. The presence of these pigments can influence the biscuit's color, making it look darker or more mottled than typical wheat biscuits, which may be perceived as less appealing. Soybeans have a cream or light yellow color and a high protein content, which may lead to uneven browning if not balanced with other starches. Soybean flour also lacks gluten, which affects the biscuit's ability to form a smooth and uniform surface. The blend in Sample 3 may have balanced the individual appearances of each flour type, producing a look closer to wheat-based biscuits. Sample 2, with higher sorghum content, could have appeared darker or less uniform, which might explain why it scored the lowest.

As reported Bolarinwa *et al.* (2016) , a decrease in the sorghum level in the sorghum-soy mixture resulted in the decrease in appearance in the sample. In sample one, was preferred compared to sample 2, and sample 3 was more preferred compared to all the others in terms of appearance. The increase likeness in appearance of sample 3 can be attributed to the increase in sorghum concentration despite the concentration of the cassava being decreased and the soy being increased.

Flavor

Sample 3 recorded the highest mean value of 5.84±1.13 for flavor making it the most preferred in flavor whiles Sample 2 had its mean value being the least preferred, this is a results of the flour formulations. The flavor preferences of the samples and control were not significantly different from each other under $p>0.05$. Flavor is an essential sensory attribute influenced by the volatile compounds released during baking and the natural flavors of each ingredient. Wheat has a mild, neutral flavor, which is generally well-accepted in bakery products. It lacks strong bitter or beany notes, making it good for blending with other ingredients and for creating flavors that are similar and appealing to most consumers. Cassava flour has a mild, slightly sweet taste due to its high starch content, which usually works well in baked products. However, when used in high amounts, cassava may lack the depth and complexity of flavor present in wheat products, as it lacks gluten and associated proteins that contribute to flavor development during baking. Sorghum has a distinct earthy and sometimes slightly bitter flavor due to the presence of tannins, which can influence the overall taste profile of the biscuit, especially in higher quantities. The bitterness is more pronounced in varieties of sorghum with higher tannin content, and this could be off-putting to some consumers, as seen in the lower flavor scores for Sample 2. Soybean has a beany flavor that can be observed in most baked goods, especially if not masked by other ingredients. Its high protein content can sometimes contribute to a bitter aftertaste when exposed to heat, which may impact the biscuit's overall flavor if used in large proportions. The Sample 3 blend (33% sorghum, 33% soybean, and 34% cassava flour) appears to have struck a balance, masking undesirable flavors from each individual flour. Sample 2, with equal parts sorghum and soybean, may have had too much of the earthy bitterness from sorghum and the beany notes from soybean, resulting in a lower flavor score.

Sample 3 had high values for flavor which could also be attributed to the occurrence of maillard reactions due to the increase in the amount of soy and sorghum which are good sources of proteins. The proteins and the carbohydrates reacts at high temperatures leading to a formation of brown coloration and development of flavors. This generated more flavour compared to the others. The control also had high ratings due to the occurrence of maillard reaction between the carbohydrates and the protein (gluten) (Oluwafemi *et al.*, 2017).

Taste

The control sample was the most preferred among the other samples in terms of taste since it recorded the highest mean value being 5.92±1.18 and Sample 2 was least preferred in taste because of the flour formulation and it recorded the lowest mean value, 5.26±1.52.

The control sample exhibited a significant difference from Sample 2 but not Samples 1 and 3 as determined by the one-way ANOVA under $p>0.05$. Taste, as distinct from flavor, usually refers to the balance of sweetness, bitterness, and any other primary taste sensations that is present in the biscuit. Wheat has a neutral taste, allowing the sweetness from added sugar in biscuits to come through clearly. It also adds up to a balanced mouthfeel without overpowering flavors, which consumers generally find palatable. Cassava is mildly sweet and can enhance the sweetness of the biscuit. However, in high amounts, cassava lacks the complexity that gluten contributes, which can impact mouthfeel and reduce the overall perceived “fullness” of taste. The taste of sorghum includes earthy and sometimes bitter notes, as mentioned earlier. These notes can interfere with sweetness, creating a taste profile that some consumers may find less appealing in higher proportions. Soybean is known for its slightly beany and sometimes bitter taste. The high protein content of soybean flour can also contribute to a taste that may be too intense or off-putting if not balanced with other milder flours.

The control sample was likely preferred for taste due to its neutral profile and the absence of bitterness or beany flavors. Sample 1 and Sample 3, which had moderate cassava content, likely provided a more balanced taste compared to Sample 2, which had more sorghum and soybean that may have introduced bitterness and affected overall taste. The panelists preferred the taste of the control sample (made from 200 g wheat) more possibly due to familiarity with several breads made from wheat in the markets. This findings agree with Okpalanma *et al.* (2020) and who recorded the high ratings for the control sample.

Texture

The descriptive statistics presented on Table 4.1 above shows that the control sample had the highest recorded a mean value, 5.54±1.15 whereas sample 2 was the least preferred among the samples.

Texture is mostly influenced by the presence of gluten and the starch content, both of which impact the structure, mouthfeel, and crunchiness of baked products. Wheat's gluten proteins provide elasticity and structure, allowing for a crumbly yet cohesive texture. This is generally preferred in biscuits, as it creates a balanced mouthfeel that is neither too dense nor too crumbly. Cassava is starchy but gluten-free, meaning it cannot form a cohesive, elastic structure like wheat. Cassava tends to create a crumbly, sometimes dense texture when used in high proportions. However, it can still provide a pleasant crunch if mixed well with other flours. Sorghum is also gluten-free and has a high fiber content, which can produce a denser, rougher texture in baked goods. Its texture properties are less ideal for soft, smooth biscuits, and it can contribute to a gritty mouthfeel if not balanced with softer starches. Soybean flour, with its high protein and fat content, can produce a dense texture and may affect the biscuit's mouthfeel by making it harder or more compact. Since it does not contain gluten, it may lead to a lack of cohesiveness in the biscuit structure.

From the table, the samples and control were not significantly different from each other as determined by the one-way ANOVA under $p>0.05$. However, differences were detected among the samples. The panelists accepted the different formulations of the samples equally even though the control sample was the most preferred. This is similar to the findings made by Okpanlama 2020 and Adekunle 2014(Adekunle and Mary, 2014; Okpalanma *et al.*, 2020; Oluwafemi *et al.*, 2017) who reported high values for taste for samples made with 100% wheat compared to other wheat substitutes . The control sample scored well for texture due to the gluten's ability to provide a balanced structure. Sample 3 appears to have created a texture closer to that of the control by balancing cassava and sorghum. Sample 2 may have been denser or less cohesive due to the combined high fiber and protein content from sorghum and soybean. The control sample had the highest value in terms of texture, this could be attributed to the presence of gluten in wheat flour that resulted in the formation of elastic dough which was hard during handling and after baking (Oluwafemi *et al.*, 2017)This causes the baked product to have the best texture.

Overall Acceptability

The control sample formulated with 200 g wheat flour had the highest mean score of 6.3±1.11 which implied that it was the most preferred in appearance, flavor, texture and taste. Sample 3 (33% sorghum, 33% soya beans and 34% cassava flour) had a mean score of 6.06±1.25 which was preferred better after the Control. It was followed by Sample 1 (30% sorghum, 20% soya beans and 50% cassava flour) of mean score 5.72±1.39and Sample 2 (30% sorghum, 30% soya beans and 40% cassava flour) of mean score 5.66±1.38 was the least preferred in the sample because of the different formulations of the flour used in baking.

Overall acceptability refers to an aggregate measure that reflects how well the product satisfies consumers based on all sensory attributes. It is a summative score that indicates the likelihood of consumer preference. As expected, the control scored the highest in overall acceptability, as consumers are generally more accustomed to the sensory properties of wheat-based biscuits. Sample 3 had a balanced composition of cassava, sorghum, and soybean flours, creating an acceptable combination of appearance, flavor, taste, and texture. This sample may have provided a similar experience to wheat biscuits, explaining its high overall acceptability. Sample 1 though slightly lower in acceptability, this sample likely had a balance between the sensory attributes that made it reasonably liked. Sample 2 scored the lowest, likely due to the combined effects of an earthy and bitter flavor profile from sorghum, the dense texture from high fiber and protein content, and the potentially uneven appearance.

More of sorghum flour, soybean flour and lesser cassava flour were used in Sample 3 as compared to the others; Sample 2 had flour compositions with more soybean and sorghum flour as compared to Sample 1 with more cassava flour. The flour composition of Sample 3 was evenly distributed which explains how it is able to mimic the control sample (made from 100% wheat flour).

The control was not significantly different from Sample 3 but the control was significantly different from Samples 1 and 2 whereas Sample 3 was also not significantly different from Sample 1 and 2. Sample 1 was disliked possibly because the composition of cassava present in the formulation was more as compared to other formulations. The specific blends of cassava, sorghum, and soybean flours affected each sensory attribute of the biscuits. The gluten-free nature and distinct flavors of these alternative flours meant that some formulations were less favorable than wheat. However, Sample 3 demonstrated that with the right balance, alternative flours could produce biscuits that approximate wheat-based products in sensory appeal.

Proximate Composition of Biscuits

It is essential to understand the proximate analysis of foods in order to know their nutritional value and to make inferences on their possible health implications. The control sample and sample 1 were analyzed for moisture, ash, protein, fat, carbohydrates and energy. The results obtained were presented in Table 4.2 below with their means and their significant differences in the nutritional profiling of the samples, which serves as an aid to consumer acceptability. These two samples were chosen for the proximate because of their high acceptance rate compared to the other samples during the sensory analysis.

Table 3: Proximate Composition of the control sample and sample 3

Sample	Moisture	Ash	Protein	Fat	Carbohydrates	Energy
CONTROL	5.22±0.03	1.35±0.01	6.39±0.22	27.77±0.14	59.27±0.40	512.54±0.58
SAMPLE 3	4.68±0.08	2.45±0.01	12.13±0.36	32.94±0.06	47.81±0.37	536.17±0.60

Moisture

From Table 4.2 the moisture contents recorded for the control sample and sample 3 were 5.22±0.03 and 4.68±0.08 respectively. Sample 3 recorded a lower moisture than that of the control sample. The higher moisture content in the control sample explains why it came out with a better texture than the sample when analyzed by the consumer panel having a mean score of 5.54±1.15 as compared to sample 3 which had a mean score of 5.36±1.56.

In contrast to the 6.25 to 7.75% reported by Peter-Ikechukwu *et al.* (2018) for composite wheat-watermelon seed biscuits and the 7.70 to 8.80% reported by Adebayo and Okoli, (2017)for composite wheat-bean-sorghum biscuits, the moisture content found in this study was lower. It is also higher than the range of 3.22 to 4.39% for composite wheat-soy-cassava biscuits reported by Okpalanma *et al.* (2020). Moisture content in food products is essential as it affects texture, mouthfeel, shelf life, and microbial stability. Higher moisture can make biscuits softer and potentially more susceptible to microbial growth, but in controlled amounts, it contributes to a fresher taste. Higher moisture levels in composite biscuits are associated with shorter shelf lives, as they can encourage microbial growth that leads to spoilage (Peter-Ikechukwu *et al.*, 2018). The moisture content of a food product is a key parameter to indicate the durability and shelf life of the food. The longevity of a product is influenced by its moisture level; as noted by EA *et al.* (2018). Higher moisture contents are associated with higher water activity therefore increasing the rate of microbial activity in the food product lower moisture content generally extends shelf life.

The activity of microorganisms thereby lead to spoilage of the food product in order words, the shelf life is reduced. Moisture also affects the texture of baked goods, therefore the reduced moisture in these biscuits suggests a longer shelf life, and enough for it to give it an acceptable texture to products when baked. The lower moisture content in Sample 3 indicates a drier product. This could be due to the ingredients used cassava, sorghum, and soybean flours, which are generally lower in moisture retention compared to wheat. The lower moisture in Sample 3 could result in a crisper texture, which may appeal to consumers but also extends the shelf life by reducing the likelihood of microbial spoilage. The moisture results obtained for both the control sample and sample 3 were within the acceptable range for a composite flour however, the control sample is more susceptible to spoilage due to its higher moisture content.

Ash

The Ash content present in Sample 3 was high as compared to that of the Control which implied that the sample contains a higher concentration of inorganic materials that remains after combustion which presents the presence of minerals. That means the amount of minerals present tin Sample 3 is more than that of the Control sample. This is because of the addition of the other flour varieties, which are rich sources of minerals. The ash content in the control sample is relatively low. This is expected because refined wheat flour, commonly used in control samples, has a lower mineral content due to the removal of bran and germ during processing. Soybean has been reported to be a great source of minerals or ash (Oke *et al.*, 2022). Soybean belongs to the family of legumes which are known for their high ash value. Cassava and sorghum on the other hand do not contribute much ash as they have been reported to have very few amount of ash. This means that the bulk of the ash is being supplied by the presence of the soy flour. Sample 3 has a significantly higher ash content, indicating a higher mineral content. Sorghum and soybean flours are known to be richer in minerals than wheat flour. Soybean, in particular, contains considerable amounts of essential minerals like calcium, iron, and magnesium. Additionally, the unrefined nature of cassava flour can contribute more minerals compared to refined wheat. The higher ash content in Sample 3 means it offers more nutritional value in terms of essential minerals, which is beneficial for consumers seeking more nutrient-dense food options. This made sample 3 more nutritious compared to the control since it is enriched with a blend of cassava, sorghum and soy whilst the control is made up of only wheat.

Fat

From the Table 4.2 above, sample 3 recorded a higher fat content (32.94±0.06) as compared to the control sample (27.77±0.14). The fat content in Sample 3 was higher as compared to the control sample because it had more of the sorghum and soybean flour which contain more fat in the flour and therefore contributes to the fat content in the baked biscuit sample. This was agreeable with (Oluwamukomi *et al.*, 2011) who reported that that the enriching flour with soy increases its fat composition.

The control sample has a lower fat content than Sample 3. In wheat biscuits, fat primarily comes from added oils or butter rather than the wheat itself, which is low in fat. This moderate fat content contributes to a pleasant mouthfeel and flavor but is lower than what is found in Sample 3. Sample 3 has a notably higher fat content. This is likely due to the use of soybean flour, which is naturally higher in fat (about 18-20%) compared to wheat flour. Soybeans contain a substantial amount of unsaturated fats, including essential fatty acids, which add to the nutritional value of the product. The fat from soybean flour can also enhance the richness and flavor of the biscuit.

While the higher fat content makes Sample 3 more calorie-dense, it also provides a source of healthy fats, which are beneficial for heart health and can help improve the flavor and texture of the product. However, it may impact the shelf life if the product is not stored properly, as fats can be prone to oxidation

Fat is a vital nutrient that contributes to the flavor, mouthfeel and energy density of a food product (Honfo *et al*, 2014). The higher fat content in sample 3 therefore provides the potential to improve the organoleptic properties of the baked biscuits, which makes it more attractive to the consumer. This parameter explains why sample 3 recorded higher mean values for flavor (5.84±1.13) and appearance (5.92±1.21) as compared to that of the control sample (flavor 5.84±1.10; appearance, 5.84±1.13).

Protein

The results for proteins for the two samples were given as 6.39±0.22 for the control sample and 12.13±0.36 for sample 3 as presented on Table 4.2. The higher protein in sample 3 is attributable to the fact that it is composed of 33% sorghum and 33%of soya beans. Soya beans and sorghum are known to contain high levels of proteins hence the baked biscuits produced have higher proteins Bolarinwa *et al.* (2016). Wheat flour has a moderate protein content, primarily from gluten. While wheat provides protein, the amount is relatively low compared to other protein-rich flours like soybean. This explains why the control sample has lower protein content than Sample 3. The protein content in Sample 3 is nearly double that of the control, mainly due to the inclusion of soybean flour, which is high in protein (around 36-40%). Sorghum also contributes to protein content, though to a lesser extent than soybean. This increase in protein makes Sample 3 a more nutritious option for consumers looking to increase their protein intake, especially those interested in plant-based protein sources. The higher protein content also has implications for the texture and mouthfeel of the biscuit, as proteins from non-gluten sources, like soybean, may result in a firmer, denser texture compared to wheat-based products.

Similar improvements in protein content were reported by Adebowale *et al.* (2012) for sorghum-wheat composite biscuits, with values ranging from 7.06 to 11.84%; by Bolarinwa *et al.* (2016) for malted sorghum-soy, with a range of 7.28 to 11.74%; and by (Ayo *et al.*, 2018) for malted soybean-acha biscuits, which showed protein levels from 5.26 to 11.65%.

Proteins in foods are necessary for repairing body tissues, providing maintenance to the body, formation of important hormones and for growth. Consumers are usually attracted to foods that contain high amounts of proteins (Jisha & Padmaja, 2011). The higher the protein content, the better the appeal to a consumer.

Carbohydrates

The carbohydrates content in the control sample was more (59.27±0.40) than that in sample 3 47.81±0.37 because the control sample contains a greater quantity of wheat flour which has more carbohydrates present in it as compared to the formulation of Sample 3 which has more protein present. The control sample has a higher carbohydrate content, which is typical for products made from wheat flour. Wheat is high in starch, which contributes significantly to the carbohydrate content. This is expected in traditional biscuits, where carbohydrates provide energy and contribute to the structure and texture of the product. Sample 3 has a lower carbohydrate content, mainly because the higher protein and fat content from soybean flour displaces some of the starches that would be present in wheat flour. Cassava flour does add a high starch content, but overall, the blend of flours in Sample 3 results in a lower carbohydrate concentration compared to the control. The lower carbohydrate content in Sample 3 might appeal to consumers looking to reduce their carbohydrate intake, such as those on lower-carb diets or with specific dietary preferences. However, it may also make the product slightly less appealing to those seeking quick energy from carbohydrates. Other researchers that found the carbohydrate level to be decreasing with increasing substitution of the wheat support these values. (Bansal *et al.*, 2017; Oke *et al.*, 2022; Okpalanma *et al.*, 2020; Oluwamukomi *et al.*, 2011).

Energy

The Energy content recorded in Sample 3 (536.17±0.60 kcal/g) is higher as compared to that of the Control (512.54±0.58 kcal/g). This is as a result of higher values recorded for the other proximate like fat, protein, carbohydrates. The control sample has a lower caloric value due to its lower fat and protein content. While it is still energy-dense, as expected from a biscuit, its energy primarily comes from carbohydrates. Sample 3 has a higher energy content due to its elevated fat and protein levels. Fat is more energy-dense than carbohydrates or proteins, providing about 9 kcal/g compared to 4 kcal/g for carbohydrates and protein. This increased energy content makes Sample 3 more calorie-dense than the control. This appreciably increased the energy content of the sample. For consumers, the higher caloric value in Sample 3 could be seen as both a benefit and a drawback. On the one hand, it provides more sustained energy, which may be beneficial for individuals seeking nutrient-dense snacks. On the other hand, the higher caloric content may not be ideal for individuals on low-calorie diets. The energy content of the formulated mixtures for children is in accordance with the recommended energy values of 360- 400 kcal/100g 0f food (Okpalanma *et al.*, 2020).

CONCLUSION

A gluten free alternative to wheat flour was developed by formulating flours from a blend cassava flour, soy flour and sorghum flour. The three formulations samples and the control 100% wheat were analyzed in terms of both proximate properties and the sensorial properties. The sensory result revealed a that sample 2 (30% sorghum, 30% soya beans and 40% cassava flour) was the least preferred in across all the parameters (appearance, flavour, taste, texture) and an overall acceptability with a value of 5.66±1.38^{a} . Sample 1 (30% sorghum, 20% soya beans and 50% cassava flour) was the rated the second preferred sample with an overall acceptability value of 5.72±1.39^{a}. Sample 3(33% sorghum, 33% soya beans and 34% cassava flour) was the most preferred sample with an overall acceptability of 6.06±1.25^{ab}. The control sample 100% was preferred compared to its alternatives due to the familiarity of taste and other properties. There was a significance difference between sample 1, 2 and the control but there were no significance difference between the control and sample 3 under $p>0.05$. This means that sample 3 can be used to replace the control. So a flour made with the composition of sorghum, soya bean and cassava in the ratio of 33:33:34 can be used as a glutten free alternative to wheat flour.

In exception of moisture and carbohydrate compositions, sample 3 recorded high values for proximate properties compared to the control which was made from 100% wheat. The low values for moisture indicates that sample 3 will have longer shelf life compared to the control. These values also indicates that the new sample 3 has more nutrition potential compared to the control. Preparing a flour from cassava, sorghum and soya bean do not only offer a glutten free alternative but also offers longer shelf life and nutrition. This flour when made in the right proportion can be used to bake product with no significance difference in the sensorial propert

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