Original Research Article

Physicochemical and Sensory Evaluation of Biscuits Produced from Composite Flour of Wheat and Fermented Cowpea Hull

ABSTRACT

Aims: This study investigated the physicochemical and sensory properties of biscuits made from a composite flour of wheat and fermented cowpea hull.
Study design: Mixture Design was adopted for this study.
Place and Duration of Study: Department of Food Science and Technology, NnamdiAzikiwe University,Awka, Anambra State, Nigeria, between January 2023 and March, 2024.
Methodology: Cowpea hulls were cleaned, soaked, boiled, dehulled, and fermented with *Rhizopusoligosporus* for 48 hours. The resulting hulls were dried, milled, and blended with wheat flour in varying ratios (95:5, 90:10, 85:15, 80:20, 75:25, and a 100% wheat control). The composite flours were then used to produce biscuits, which underwent proximate, physical, and sensory evaluations using a 9-point hedonic scale.
Results: Results showed that the inclusion of fermented cowpea hull significantly increased moisture (9.75-11.55%), ash (1.59-2.85%), crude protein (10.75 - 12.05%), fat (0.96 - 1.95%), and crude fibre (4.55 - 5.30%) content, while carbohydrate content decreased (72.37-66.31%). Physically, the biscuits exhibited an increase in thickness (4.40 - 5.55 mm) and weight (9.64 - 11.85g), but a decrease in height (4.85 -3.90 cm) and breaking strength (3.70 - 2.65). Sensory evaluations indicated that higher levels of fermented cowpea hull negatively impacted the biscuits' quality in terms of colour (7.25 - 6.15), taste (7.45 - 6.25), aroma (7.15 - 6.75), flavour (7.60 - 6.40), and overall acceptability (7.50 - 6.60). The biscuit with 5% fermented cowpea hull was the most acceptable (7.05), after the control sample made with 100% wheat (7.50).
Conclusion: This study demonstrates that nutritionally enhanced biscuits can be produced using a blend of wheat and fermented cowpea hull, though the inclusion should not exceed 10% as to maintain high sensory acceptability.

Keywords:Cowpea, acceptability, biscuit, Rhizopusoligosporus, protein, taste.

1. INTRODUCTION

The term "biscuit" originates from the Latin phrase *"biscoctus,"* meaning twice cooked [1]. For centuries, h have been producing and consuming biscuits and other baked goods. These items are commonly enjoy before meals and as snacks after meals across various nations, being widely accepted and eaten by people of all kinds [2]. Biscuits are typically offered in semiformal settings with tea or coffee and are also used as weaning food for infants. Their per capita consumption is steadily increasing. Biscuits are popular across both rural and urban areas and among all age groups. Their widespread popularity can be attributed to their low cost compared to other baked goods and their easy availability [3]. Biscuits have a low moisture content, which helps prevent microbial spoilage and gives them a long shelf life. They are convenient food items and are among the most popular baked goods consumed by all social classes in Nigeria. Their popularity can be attributed to their

Comment [c1]: Give space(single tab) for first starting affordability compared to other processed foods, good nutritional value, variety of flavours, ease of access, and extended shelf life [4]. Biscuits are primarily made from wheat flour, fat, sugar, water, and various other ingredients to enhance their sensory qualities [5]. Wheat flour, essential for making pastries and bakery goods, is seldom cultivated in Nigeria. Consequently, importing it elevates the production costs of biscuits and renders our tropical crops underutilized [6]. Research is being conducted on using composite flour for making biscuits and other bakery products. Biscuits, as a popular ready-to-eat snack, are characterized by their widespread consumption, relatively long shelf life, convenience, and good eating quality [7]. The extended shelf-life of biscuits enables large-scale production. Their appealing taste makes them a suitable candidate for protein fortification and other nutritional enhancements. The current trend in the bakery industry is to develop fortified biscuits and other products using composite flours. The increasing popularity of these bakery products is attributed to their improved nutritional value and their potential application in feeding programs and emergency situations like famine or natural disasters [8]. Composite flour is a blend of various flours derived from roots, cereals, and legumes, which may or may not include wheat flour [9]. For example, [10] demonstrated that biscuits produced from a blend of 50% plantain and wheat flour are similar in quality to those made entirely from wheat flour. Using composite flour offers benefits for countries like Nigeria, as it lessens reliance on imported wheat flour and promotes the utilization of locally sourced agricultural products in flour production.

Wheat(*Tritium aestivum)*, is globally recognized as a paramount economic grain, with a history dating back 10,000 years [11]. Its remarkable adaptability to various regions stems from its extensive genetic diversity [12]. In addition to being the main source of starch and energy, it also contains substantial levels of protein, vitamins, phytochemicals, and dietary fiber, all of which contribute to human health. Wheat is primarily utilized in both whole and refined flour forms for making various bakery products [13]. Wheat flour finds extensive application in the production of various goods such as pasta, food concentrates, and confectionaries on an industrial level. Ash content and moisture play crucial roles in determining the quality and suitability of wheat flour for various food products [14]. Ensuring the quality and safety of wheat flour is a matter of public importance, given its significance for human health and addressing hunger. Thus, there is need for effective and convenient approach for improving its nutritional quality for snack like biscuity [15]. Wheat flour, serves as the primary component in producing baked goods like biscuits, constituting over 50% of global caloric consumption. The wheat kernel comprises minerals, proteins (8-16%), fats (1-3%), and fiber (12-15%) [16].Cowpea, also known as *Vigna unguiculata*, is a significant legume widely cultivated in tropical and subtropical regions globally. In African nations such as Nigeria and Ethiopia, it serves as a versatile food source, with its tender leaves, fresh pods, and grains being commonly consumed. During the production of fried cow pea balls (*Akara*) and steamed Cowpea paste (*Moimoi*), cowpea hulls are generated as byproduct which are most times discarded [17]. Cowpea hulls in their natural state contain substances like phytic acid, tannins, trypsin inhibitors, gluten, oxalates, etc. [17]. The hull from leguminous seedscontainantinutrients.These anti-nutrients can be minimized through food processing methods like soaking and fermentation [18]. The fermentation processes couldinvolve~~bacteria –~~ lactic acid bacteria or fungi – *Rhizopusoligosporus*[18]. Fermentation is known to improve flavour, boost nutritional value, extend shelf life, and eliminate harmful or anti-nutritional components in food products [19]. According to [20] ~~these~~ benefits are due to the production of organic acids, such as lactic and acetic acids, which lead to a decrease in pH. Additionally, research by [21] demonstrated that fermenting buckwheat flour with L. plantarum can be utilized to create functional food products. Fermentation using *Rhizopusoligosporus* has been extensively studied for its nutritional benefits, including enhanced protein digestibility and the characteristics of fermented food products often vary significantly compared to the original ingredients hence the aim to ferment cowpea hulls with *Rhizopusoligosporus* and use it in biscuit production.

2. MATERIAL AND METHODS

2.1 Sources of Material

Commercial wheat flour (Golden Penny, Flour Mills of Nigeria Limited) and cowpea hulls, sourced from roadside vendors selling *Akara* balls and moi-moi, along with other baking ingredients like granulated sugar and salt (Dangote, Nigeria), sodium bicarbonate (baking powder), milk powder (Peak), baking fat, and eggs (layers), was purchased from Eke Awka market in Anambra State. The *Rhizopusoligosporus*(Ragi Tempe, RaprimaInokulum Tempe, PT., (0.4 g/kg drained grain) was obtained from Aneka FermentasiIndustri, Sandung 40553 – Indonesia.All these raw materials were packaged in low-density polyethylene bags and transported to the Food Processing Laboratory of the Department of Food Science and Technology at Nnamdi Azikiwe University, Anambra State, Nigeria, for further processing.

~~2.2Sample Preparation~~

~~2.2.1~~ Preparation of fermented cowpea hull

The hulls will be soaked twice for 12 h with the removal of soaked water after each soaking period. Then they are cooked for 45 min (1kg/6l), drained and cooled. To prevent the growth of microorganisms and to maintain the pH of the convenient growth of *Rhizopusoligosporus*, pH will be adjusted using vinegar of grapes at 285 ml per 100 g of the substrate [22]. The cowpea hull was divided into three portions inoculated with *Rhizopusoligosporus* (0.4g/kg cowpea hull)

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then packaged in a low-density polyethylene perforated bags (50µm) and allowed to ferment (29◦C) in an incubator for 72 h then dried at 70◦C for 14 h, after which it was milled and stored in a glass jar.

2.2.2 Preparation of composite flour

Blends of wheat and fermented cowpea hull (FCH) was prepared by mixing the wheat flour:FCH in the proportions of 100:0 (WAN), 95:5 (PAN), 90:10 (CAN), 85:15 (BAN), 80:20 (FAN), 75:25 (VAN) using machine food processor.

Table1: Recipe for the Biscuit production

INGREDIENTS	AMOUNTS
Flour (g)	100
Sugar (g)	25
Butter (g)	40
Egg (g)	31
Powdered Milk (g)	10
Sodium bicarbonate (g)	1
Salt (g)	1
Vanilla essence (ml)	5

Source: Effiong (2018).

2.4.1 Production of the biscuit

The formulation of ingredients (Table1) and the creamy method of biscuit production described by [23] was adopted with minor modifications. Butter and granulated sugar was creamed together for 5 minutes. Eggs and powdered milk were added and mixed until the mixture became light and fluffy. Composite flour, sodium bicarbonate, salt, and vanilla flavoring will be thoroughly combined and incorporated into the cream mixture using a bowl mixer to form a dough. The dough will be kneaded to a uniform thickness, cut into uniform diameters, then molded and placed in the freezer for 30 minutes to rest. It was baked in an oven at 180°C for 20 minutes, cooled at room temperature (27±2°C), packaged in high-density polyethylene, labeled, and stored at room temperature for further analysis.

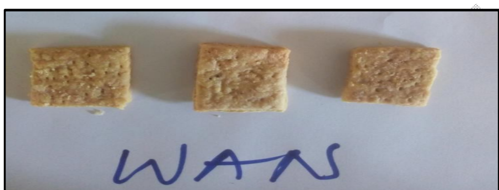

Plate 1a: wheat:fermented cowpea hull – 100:0 Plate 1b: wheat:fermented cowpea hull – 95:5

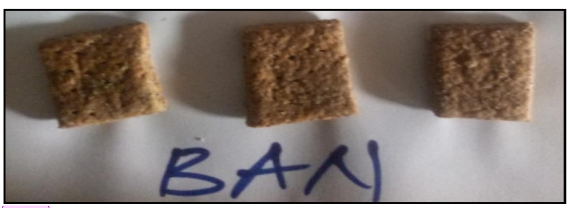

Plate1c: wheat:fermented cowpea hull – 85:15 Plate 1d: wheat:fermented cowpea hull – 90:10

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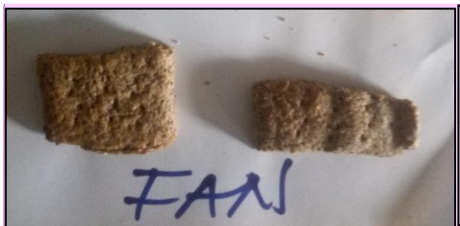	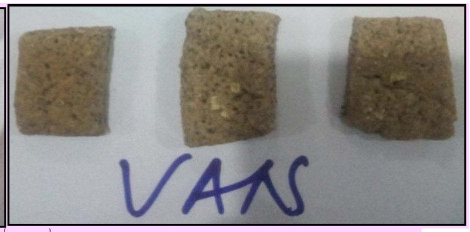
~~Plate 1e~~: wheat:fermented cowpea hull – 80:20	~~Plate 1f~~: wheat:fermented cowpea hull – 75:25

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~~2.5~~ Physical Properties

ThePhysical properties of biscuit samples were evaluated by measuring the weight, height, thickness and break strength as described by [24].

~~2.5.1~~ Thickness and Height of biscuit

The thickness and height were evaluated using vernier caliper

~~2.5.2~~ Weight of the biscuit

The weight will be evaluated using electronic weighing balance

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2.5.3 Breaking strength

The samples of unknown thickness were rested on two longitudinal beams parallel to each other spread at a distance of 2.5 cm. Another beam joining to the moving part will be brought down to break the biscuits at a crosshead speed at 10 mm/min and load cell of 10 kg. Absolute measures were taken to see that the point of contact will be equivalent from both the two parallel beams. The peak force (N) at the break, representing breaking strength, will be recorded and average values were calculated.

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2.6 Proximate composition of the biscuit

The proximate composition of breakfast cereals was assessed using the method outline by [25]. For determining moisure content, an oven drying method at 105°C was employed using the Gallenkamp Oven (300 plus series) from Cheshire, United Kingdom, until constant weight was attained (AOAC Method 925.10). Soxhlet extraction method using petroleum ether (LobaChemie, Mumbai, India) was employed for fat content determination (AOAC Method 920.39). Samples were incinerated at 550°C for 5 h using a muffle furnace (Hasthas, Servell Engineers, Chennai, India) to assess ash content (AOAC Method 923.03). Crude fibre was determined by treating the sample with 2.5% sulphuric acid, 2.5% NaOH, ethanol, acetone, dried at 105°C for 3 h and incinerated at 550°C for 4 h (AOAC Method 962.09). The method of Kjeldahl was used in determining crude protein with a correction factor of 6.25 (AOAC Method 984.13). The carbohydrate content was determined using the difference method.

2.7 Sensory Evaluation

This will involve assessing various biscuit samples made by a group of at least 20 partially trained panelists from the Department of Food Science and Technology at Nnamdi Azikiwe University in Awka, Anambra State. They will rate the samples on a 9-point scale, ranging from 1 (strongly disliked) to 9 (strongly liked), considering factors like color, crispiness, taste, texture, flavor, and overall appeal [26].

2.8 Statistical Analysis

The data obtained were subjected to analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS) software. Duncan Multiple Range Test will be used to detect significant differences (α=0.05) The data obtained were statistically analyzed using the analysis of variance (ANOVA) and the Duncan Multiple range test with significance level at $p < 0.05$ [27].

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3. RESULTS AND DISCUSSION

~~3.1~~Proximate composition of biscuit produced from composite flour of wheat and fermented cowpea hull.

Table2 shows the proximate composition of biscuits made from wheat and fermented cowpea hull. The findings indicated significant variances ($p<0.05$) among all the proximate parameters of the samples, except for the fiber content, which remained consistent ($p<0.05$) across all samples.

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The percentage moisture content of the biscuits ranged from 9.75-11.55%. This moisture levels indicate that the biscuit would have an appreciable shelf life. The sample with 100:0Wheat-fermented cowpea hull (WAN) had the least value while the sample with 75:25 wheat-fermented cowpea hull (VAN) had the highest moisture content. There was a significant increase (p<0.05) in the moisture content of the biscuits as the wheat was substituted with fermented cowpea hull. The moisture content of the biscuit samples shows that there was no significant differences in100:0 (WAN), 95:5 (PAN), 90:10 (CAN), 85:15 (BAN) wheat –fermented cowpea hull and between 80:20 (FAN) and75:25 (VAN) wheat-fermented cowpea hull respectively [28] suggested that the rise in moisture content might stem from a higher dry matter and increased hydrophilic interaction between the protein from the elevated cowpea level and water. [29] state that since biscuits contain less than 10% moisture, any moisture present in them won't impact their quality, as per their research findings. [30] mention that moisture content is commonly utilized as a crucial factor in assessing biscuit quality, impacting both sensory perception and physical characteristics.

By adding more fermented cowpea hull to wheat flour, the ash content in the biscuit samples significantly rose (p<0.05). Since cowpea hull is rich in minerals [31], it likely caused this increase in ash content. The ash content percentage varied from 2.09% in the biscuits containing 95:5 wheat: fermented cowpea hull (PAN) to 2.85% in the biscuit containing 75:25 wheat: fermented cowpea hull (PAW). The ash content of foods serves as a measure of their mineral composition [32]and aids in metabolizing fats and glucose, as noted by [34]. Therefore, the increased ash content in the cookies suggests they can provide essential minerals to the body.

The crude fibre content of the biscuit sample shows that the there is no significant differences (p<0.05). The range for crude fibre was from 4.55-5.30which means that all the samples were statistically the same. The control sample WAN (100:0) wheat- fermented cowpea hull had the least value of 4.55 while VAN (75:25) had the highest value of 5.30 there was regular increase of at most 10%. [34] stated that fiber supports gastrointestinal health, but excessive intake may result in trace element imbalances, potentially leading to deficiencies in iron and zinc.

As anticipated, as more fermented cowpea hull was used to replace wheat flour in the biscuit recipe, there was a notable increase in the protein content of the biscuit samples, showing statistical significance (p<0.05). The percentage crude protein in the formulated biscuits ranged from 10.75-12.05%. The sample with 95:5 wheat- fermented cowpea hulls (WAN) had the least protein content while the sample with 75:25 wheat- fermented cowpea hull (VAN) had the highest protein content. The higher crude protein content of the biscuits with higher levels of fermented cowpea hull yielded biscuits with higher crude protein values.

The fat content of the composite biscuit ranged from 0.96-1.95%with the lowest value being the control sample 100:0 wheat- fermented cowpea hull (WAN) and the highest value recorded by biscuits formulated with 75:25 wheat- fermented cowpea hull (VAN). The result revealed that no significant difference (p<0.05) existed in the fat content of samples with 100:0 wheat-fermented cowpea hull (WAN) (0.96%) and 95:5 wheat-fermented cowpea hull(PAN) (0.99%) although both samples differed from the rest of the samples significantly (p<0.05).The figures surpass the 1.26–3.45% range noted by [35] for wheat-African yam bean biscuits, but align with the 17.37–33.31% range for wheat-red kidney bean cookies reported by [36]. These differences may stem from the use of different ingredients. The choice between butter or margarine during biscuit production notably impacts the fat percentage in the final product [37]. [38] suggests that while fat enhances the absorption of fat-soluble vitamins, provides essential fatty acids, and contributes to flavor and sensory quality, an excessive amount of fat in food, especially in baked goods, can lead to rancidity over time.

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There was significant difference amongst all the biscuit samples with the PAN 95:5 wheat- fermented cowpea hull having the highest carbohydrate content of 71.32% aside the control biscuit (WAN) with 72.37%, while biscuit with 75:25 wheat-fermented cowpea hull (VAN) had the lowest value (66.31%). The findings indicated that adding fermented cowpea hull to the biscuits notably decreased their carbohydrate content. This reduction suggests either a lower carbohydrate level in the fermented cowpea hull or potential modification of starch during fermentation. Carbohydrates are vital for the body's energy for metabolic processes. The blend ratio of 75% wheat to 25% fermented cowpea hull showed the most improvement in proximate parameters, except for carbohydrate content, which was the lowest in this ratio.

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Table2 Proximate composition (%) of biscuit produced from wheat-fermented cowpea hull

Samples	Protein (%)	Fat (%)	Crude Fiber (%)	Ash (%)	Moisture (%)	CHO (%)
WAN	$10.75^{d}\pm0.35$	$0.96^{c}\pm0.02$	$4.55^{a}\pm0.07$	$1.59^{a}\pm0,59$	$9.75^{b}\pm0.64$	$72.37^{a}\pm0.01$
PAN	$10.95^{cd}\pm0.78$	$0.99^{c}\pm0.02$	$4.75^{a}\pm0.21$	$2.09^{a}\pm1.29$	$9.90^{b}\pm0.71$	$71.32^{b}\pm0.01$
CAN	$11.30^{bcd}\pm0.42$	$1.30^{bc}\pm0.42$	$4.95^{a}\pm0.07$	$2.19^{a}\pm1.43$	$10.15^{b}\pm0.35$	$70.11^{c}\pm0.01$
BAN	11.50±0.14	$1.45^{abc}\pm0.21$	$5.10^{a}\pm0.28$	2.25±1.49	$10.20^{b}\pm0.28$	$69.49^{d}\pm0.07$
FAN	$11.80^{ab}\pm0.14$	$1.75^{ab}\pm0.21$	$5.15^{a}\pm0.49$	2.40±1.70	$10.80^{a}\pm0.57$	$68.05^{e}\pm0.07$
VAN	$12.05^{a}\pm0.21$	$1.95^{a}\pm0.07$	$5.30^{a}\pm057$	$2.85^{a}\pm1.20$	$11.55^{a}\pm0.49$	$66.31^{f}\pm0.01$

Values are means± standard deviation of triplicate determinations. Mean values with the same superscript in the column are not significantly different (p<0.05)

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Key: **WAN**: 100:0 wheat-fermented cowpea hull biscuit; **PAN**: 95:5 wheat-fermented cowpea hull biscuit; **CAN**: 90:10 wheat-fermented cowpea hull biscuit; **BAN**: 85:15 wheat- fermented cowpea hull biscuit; **FAN**: 80:20 wheat- fermented cowpea hull biscuit; **VAN**: 75:25 wheat- fermented cowpea hull biscuit.

3.2 Physical properties of biscuits produced from composite flour of wheat- fermented cowpea hull

Table3shows the physical properties of biscuit produced from composite flour of wheat and fermented cowpea hull. It was observed that incorporation of wheat and fermented cowpea hull significantly (p<0.05) affected some of the physical properties of the biscuit samples. The range of for the weight, height, thickness, and breaking strength are (9.64-11.85g), (3.90-4.85cm), (4.40-5.55mm) and (2.65-3.70mm)

The weight of the some of the samples of biscuit increased significantly (p<0.05) and ranged from 9.64 g in the control sample with 100:0 wheat- fermented cowpea hulls (WAN) to 7.57 g in the sample with 75:25 wheat-fermented cowpea hull (VAN). There was no significant difference (p<0.05) between sample PAN (95:5) and CAN (90:10) as same goes to sample BAN (85:15), FAN (80:20) and VAN (75:25) which were statistically same respectively. The weight increase observed with the addition of fermented cowpea hull to the biscuits may be due to the enhanced water binding capacity and reduced moisture loss from the biscuits containing fermented cowpea hull. A similar finding was reported in the study by [39] which investigated the impact of using honey as a sugar substitute on the physical properties of biscuits. They observed that progressively replacing sugar with honey led to an increase in the biscuits' weight.

The values for height ranged from 3.90-4.85 cm. The height of samples with 75:25 wheat-fermented cowpea hull (VAN) had the least value while the sample with 95:5 wheat – fermented cowpea hull had the most height. it was observed that there was no significant differences (p<0.05) between samples PAN(95:5) wheat-fermented cowpea hull and CAN(90:10) wheat-fermented cowpea hull as they were statistically the same. There was no consistent pattern in the changes in height, although a general decrease was noted. The differences in individual biscuit heights were influenced by variations in the molding and the compacting force applied during shaping.

The thickness of the samples was significantly different (p<0.05). The variation trend was regular for the first three as it changed for the remaining three. The thickness of the biscuit samples ranged from 4.40 to 5.55 mm with sample with 75:25 wheat-fermented cowpea hull (VAN) having the highest value (5.55 mm) while the sample with 95:5 (PAN) wheat-fermented cowpea hull had the least value (4.40 mm). Logically, as the diameter of biscuits decreases, their thickness will increase. According to [40], an increase in biscuit thickness enhances their ability to withstand pressure.

The biscuits samples' breaking strength differed significantly (p<0.05). Though there was significant reduction (p<0.05) in the breaking strength of the biscuits as the inclusion of fermented cowpea hull was increased. There was a regular trend as the inclusion ratio increased except for the PAN (95:5) wheat- fermented cowpea hull sample that has greater breaking strength than the control sample (WAN). The decrease in the breaking strength of biscuits with added fermented cowpea hull suggests that the biscuits are less hard and easier to chew. The breaking strength of the sample with 75:25 wheat-fermented cowpea hull (VAN) was the lowest (2.65 N), while the breaking strength of the sample with 95:5 wheat-fermented cowpea hull (PAN) was the highest (3.80 N). The marked decrease in the break strength of many biscuits suggests that the incorporation of fermented cowpea hulls diminished the hydrogen bonding between starch and proteins, resulting in increased crispiness.

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Table3 physical properties of biscuits produced from composite flout of wheat and fermented cowpea hull

Samples	Breaking strength(N)	Thickness(mm)	Height(cm)	Weight(g)
WAN	3.70^{a}±0.43	4.40^{e}±0.14	4.85^{a}±0.07	9.64^{b}±1.20
PAN	3.80^{a}±0.14	4.55^{de}±0.07	4.60^{b}±0.14	10.58^{ab}±0.13
CAN	3.55^{a}±0.07	4.75^{cd}±0.07	4.45^{b}±0.07	10.84^{ab}±0.07
BAN	3.35^{ab}±0.07	4.94^{c}±0.06	4.35^{bc}±0.07	10.95^{a}±0.07
FAN	3.05^{bc}±0.07	5.30^{b}±0.14	4.15^{c}±0.07	11.35^{a}±0.21
VAN	2.65^{c}±0.07	5.55^{a}±0.07	3.90^{d}±0.14	11.85^{a}±0.07

Values are means± standard deviation of triplicate determinations. Mean values with the same superscript in the column are not significantly different (p<0.05)

Key: **WAN**: 100:0 wheat-fermented cowpea hull biscuit; **PAN**: 95:5 wheat-fermented cowpea hull biscuit; **CAN**: 90:10 wheat-fermented cowpea hull biscuit; **BAN**: 85:15 wheat- fermented cowpea hull biscuit; **FAN**: 80:20 wheat- fermented cowpea hull biscuit; **VAN**: 75:25 wheat- fermented cowpea hull biscuits

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3.3 Sensory Qualities of Biscuits Produced From Composite Flour of Wheat and Fermented Cowpea Hull

Mean sensory scores of biscuits made using wheat and fermented cowpea hull is shown in the Table4 below. The findings indicated that incorporating fermented cowpea hulls significantly (p<0.05) impacted the sensory qualities of the biscuits, with certain parameters increasing while others decreased. The sensory scores of the biscuit samples ranged from 6.25-7.45 for taste, 5.90-7.15 for aroma, 6.35-7.60 for flavour, 5.95-7.25 for colour and 6.20-7.50 for overall acceptability. The control sample exhibited the highest values for all sensory parameters, though the other samples showed results that were very similar to the control.

Means scores of taste of the biscuit samples ranged from 6.25-7.45. There were significant differences (p<0.05) in taste among samples and the taste score significantly reduced with the increasing inclusion of fermented cowpea hull in the biscuits. Sample containing 75:25wheat- fermented cowpea hull (VAN) had the lowest score (6.25) for taste whereas the control sample (WAN) had the highest score (7.25). It was observed that the sample PAN (95:5) wheat-fermented cowpea hull and CAN (90:10) wheat-fermented cowpea hull had the mean score of 6.70 as they were statistically (p<0.05) the same while sample BAN(85:15) wheat-fermented cowpea hull and FAN (80:20) wheat-fermented cowpea hull had the same mean score of 6.45.

The mean ratings for the aroma of the biscuit samples varied from 5.90 for sample BAN made with 80:20 wheat-fermented cowpea hull to 7.15 (WAN) in biscuits made with 100 % wheat control sample. There was no significant difference in samples PAN (95:5) wheat-fermented cowpea hull, CAN (90:10) wheat-fermented cowpea hull, FAN (80:20) wheat-fermented cowpea hull and VAN (75:25) wheat-fermented cowpea hull as they were statistically (p<0.05) the same. While sample BAN (85:25) wheat-fermented cowpea hull and WAN (100:0) differ from the rest of the biscuit samples. The outcome regarding the aroma was unexpected, as it fluctuated, decreasing at certain points and then increasing. Aroma refers to the sensory characteristics linked to the smell or odor of the product.

With respect to colour, the biscuit samples had mean scores ranging from 5.95-7.25. The sample containing wheat-fermented cowpea hull (FAN) had the lowest score (5.95) while the highest score (7.25) was recorded for 100:0 wheat-fermented cowpea hull (WAN) which was the control sample. Incorporating fermented cowpea hull into the biscuits significantly (p<0.05) reduced their color score. The decrease in the color rating of the biscuits when fermented cowpea hull was added could be because the dried cowpea hulls have a dark brown color, possibly from the phenolic compounds they contain. All the samples scored above average (5 - neither like nor dislike) in terms of color, suggesting that adding fermented cowpea hull did not cause them to be disliked. The panelists liked the brown colour of the biscuit and asked if the biscuits were baked in form of chin-chin. Color plays a crucial role in assessing the quality of properly prepared and baked biscuits. The distinct brown hue not only reveals the ingredients used but also indicates the product's formulation and overall quality [41].

The mean score of the flavour varied from 6.35-7.60, as the significant difference (p<0.0l) reduced on inclusion of fermented cowpea hull. The control sample had the highest score of 7.60 (WAN) wheat- fermented cowpea hulls while sample ban had the least score 6.35 (85:15) wheat– fermented cowpea hull. The sample PAN (95:5) wheat-fermented cowpea hull and CAN (90:10) wheat-fermented cowpea hull were statistically the same while sample BAN (85:15) wheat-fermented cowpea hull, FAN (80:20) wheat-fermented cowpea hull and VAN (75 wheat-fermented cowpea hull:25)had no significant difference respectively. The biscuit's flavor was enhanced to boost its taste and sweetness, with vanilla essence and sugar contributing to this sensory aspect.

The mean scores for the overall acceptability of the biscuits were significantly reduced (p<0.05) with the inclusion of fermented cowpea hull. The values varied from 6.20-7.50 which implies the range of like slightly to like moderately. The control sample (WAN) with 100% wheat was the sample with the highest value score of 7.50 closely followed by sample containing 95:5 wheat- fermented cowpea hull(PAN) with a score of 7.05 while samples containing 85:15 wheat-fermented cowpea hull(BAN) had the least score (6.20). As shown in Table4 below the overall acceptability of PAN (95:5) and BAN (85:15) were statistically the same as there was no significant difference between them. Same goes to FAN(80:20) wheat-fermented cowpea hull and VAN(75:25) wheat-fermented cowpea hull which were also statistically the same, thus, the overall acceptability of the biscuits which ranged from 6.20-7.50 indicates that totality of all sensory parameter were from 'like slightly' to "like moderately". The overall acceptance score is used to assess how much the panelists like the overall qualities, including color, scent, feel, and sweetness of taste.

The result of one-way ANOVA showed that there exists some significant difference (p<0.05) among some of the biscuit samples, while samples PAN (95:5) wheat-fermented cowpea hull, CAN (90:10) wheat-fermented cowpea hull, FAN (80:20) wheat-fermented cowpea hull and VAN (75:25) wheat-fermented cowpea hull statistically the same.

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Table4 Sensory evaluation of biscuits produced from composite flour of wheat and fermented cowpea hull

Samples	Colour	Taste	Aroma	Flavour	Overall Acceptability
WAN	7.25^{a}±1.89	7.45^{a}±0.83	7.15^{a}±0.98	7.60^{a}±0.94	7.50^{a}±1.00
PAN	6.85^{ab}±1.27	6.70^{ab}±1.08	6.50^{ab}±1.50	6.70^{ab}±1.42	7.05^{ab}±1.28
CAN	6.35^{ab}±1.69	6.70^{ab}±1.68	6.45^{ab}±1.50	6.70^{ab}±1.78	6.80^{ab}±1.54
BAN	6.05^{b}±1.76	6.45^{b}±1.61	5.90^{b}±1.29	6.35^{b}±1.42	6.20^{b}±1.77
FAN	5.95^{b}±1.61	6.45^{b}±1.15	6.20^{ab}±1.61	6.45^{b}±1.47	6.60^{ab}±1.27
VAN	6.15^{ab}±1.53	$6..25^{b}$±1.29	6.75^{ab}±1.55	6.40^{b}±1.23	6.60^{ab}±1.79

Values are means± standard deviation of triplicate determinations. Mean values with the same superscript in the column are not significantly different (p<0.05)

Key: **WAN**: 100:0 wheat-fermented cowpea hull biscuit; **PAN**: 95:5 wheat-fermented cowpea hull biscuit; **CAN**: 90:10 wheat-fermented cowpea hull biscuit; **BAN**: 85:15 wheat- fermented cowpea hull biscuit; **FAN**: 80:20 wheat- fermented cowpea hull biscuit; **VAN**: 75:25 wheat- fermented cowpea hull biscuit

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4. CONCLUSION

Adding fermented cowpea hulls impacted the nutritional, physical, and sensory characteristics of the biscuits. The moisture, ash, fat, fiber, and crude protein content of the biscuit showed notable increase as the carbohydrate content decreased. The weight and thickness of the biscuits show a notable increase, whereas the height and breaking strength demonstrate a decrease. The addition of fermented cowpea hull negatively impacted on the sensory characteristics of the biscuits. As the proportion of fermented cowpea hull increases, the colour of the biscuit darkened while its flavour diminished.

Comment [c34]: Add single tab space

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