



Nutrient Composition and Sensory Properties of Biscuit from Mushroom-Wheat Composite Flours

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Authors' contributions

This work was carried out in collaboration between all authors. Author MOO headed the project. Author MB conducted the study, the analysis and interpretation. Author MB drafted the manuscript. Authors MOO and VNE were involved in the early work and assisted with the interpretation of the results. Both authors MOO and VNE were involved in the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript.

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ABSTRACT

The nutrient composition and the acceptability of biscuit from composite flours of wheat and *Pleurotus sajur-caju* (PSC) mushroom were evaluated. *Pleurotus sajur-caju* (PSC) mushroom was dried, processed into flour and used to substitute wheat flour as composite flour. The composite flour was at 0, 5, 10, 20 and 30% level of mushroom addition, the resulting mixtures were then used to produce biscuits. The proximate composition, minerals, physical (spread ratio, weight, thickness) and sensory properties of the composite biscuit were evaluated. The protein content increased from 13.04% in the control (100% WF) to a range of 13.41% - 15.55%. in the biscuits; crude fibre increased from 2.10 to 2.16 - 2.93 %.; ash content increased from 1.52% to a range of 1.87 - 3.85%, while crude fat and carbohydrate reduced from 21.71 to 19.05 - 20.58% and 61.63 to 58.62 - 61.58% respectively. As the ratio of mushroom level increased, the mean, thickness, diameter, weight as well as the spread ratio increased. The result of the mineral analysis revealed that the sodium and potassium were the predominant mineral elements in the biscuit samples and the mineral composition increases with level of mushroom addition. There was no significant difference in the overall acceptability of the control (100% WF) and 5% mushroom substitution samples. This shows the viability of producing nutritious biscuits with desirable nutritional qualities from mushroom-wheat up to 10% mushroom substitution level.

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1. INTRODUCTION

Bakery based products including cookies are among top ten items popularly consumed by consumers in Nigeria. Extensive studies have been done using various types of legumes, cereal and plant dietary fibre in bakery based products in attempting to enhance nutritional qualities and dietary fibre [1]. The effect of utilization of legumes flour as a source of protein in bakery products, chickpea and broad bean flours as well as isolated soy protein isolates has been reported previously [2]. In general the nutritional, physical and sensory characteristic of biscuits depends on both the physicochemical properties of the legumes used in the formulation and processing method employed for preparation of the legume flour. Recently, researchers found that dietary pigeon pea (*Cajanus cajan L.*) grain has potential value as an economic source of protein and is widely consumed after appropriate processing into biscuits [3]. Another study found that replacing wheat flour with acha flour, substantial improvement in the protein and fibre contents can be achieved without affecting physical and sensory properties [4,5]. It is expected that by partially replacing wheat flour with oyster mushroom powder into biscuit formulation, an improvement of nutritional composition especially dietary fibre without affecting sensorial properties can be achieved. This research on the incorporation of mushroom as a supplement in biscuit formulation was conducted with the focus to establish an alternative means of utilization of mushroom through investigation of its quality characteristics.

2. MATERIALS AND METHODS

2.1 Sources of Materials and Preparation

Soft wheat flour and other baking ingredients such as canola oil, salt, baking powder, salt, aspartame, flavour, and egg white (albumin) were purchased at Igele market, Ondo while the *Pleurotus sajor-caju* mushroom was obtained from Shukrah farm, in Ondo, Ondo State, Nigeria.

2.2 Processing Methods

2.2.1 Production of mushroom flour

Mushroom powder was prepared as illustrated in Fig. 1. Fresh mushrooms were cleaned, cut into

slices (about 3 mm thickness) and dry at 60°C for 8 h. Dried mushroom sample were ground separately in an electric grinder and sifted through an 80 mesh screen to obtain fine powders. The obtained powder were cooled and hygienically packed and stored in airtight container for further use.

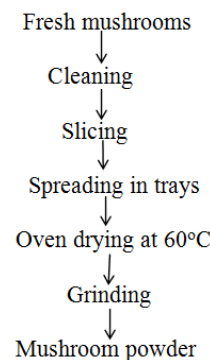


Fig. 1. Flow chart of the preparation of mushroom powder

2.2.2 Formulation of blends

Biscuits samples were produced using the flour blends in the ratio of (0:100); (10: 90); (20: 80); (30: 70) and (40:60) mushroom flour and wheat flour and the modified recipe for digestive biscuits as described by [5,6].

2.2.3 Production and preparation of biscuits

Biscuit was produced by modifying the method described by [7]. The oil and aspartame were initially mixed until fluffy in a Kenwood mixer (model HM 430). Egg white and skimmed milk were added while mixing continues for about 40 min. Appropriate flour, baking powder, nutmeg, vanilla flavour and salt were slowly introduced into the mixture. Thereafter, consistent dough was formed after thoroughly mixing with water. The dough obtained was kneaded on a smooth clean board for about 5 min, thinly rolled on a wooden board with rolling pin to uniform thickness of 5 mm and cut out to desired shapes of uniform sizes. The cut out dough pieces were placed on greased baking tray and baking was carried out at 160°C for 15 min. The biscuits were cooled hygienically and packaged in airtight polythene, kept at 4°C until needed for sensory evaluation and other analyses. Biscuits samples from wheat flour (white) served as control. The flow chart for the biscuit production is as shown Fig. 2.

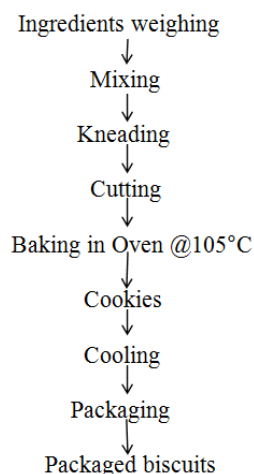


Fig. 2. Flow chart for mushroom-wheat biscuit production

Source: [Oluwamukomi et al., 2011]

2.3 Determination of the Physical Characteristics of Biscuits

The diameter was measured with a calibrated ruler as described by [8]. The thickness (mm) of the biscuits was measured by stacking six biscuit on top of one another and taking the average value. The weight of the biscuits was measured using weighing balance (Mettler). The spread ratio was calculated as weight/thickness [8].

2.4 Determination of Proximate Composition

The proximate analysis (moisture, crude fat, crude fibre, crude protein, ash content and carbohydrate) were carried out in triplicates using the methods described by [9].

2.5 Calorie Content Determination

Atwater factors were used to estimate the energy values of the samples. It has been reported that 1g of carbohydrate gives 4 kcal (16.7KJ); 1 g protein also gives 4 kcal (16.7KJ) while 1g fat gives 9 kcal (37.4KJ) [10] as reported by [11].

2.6 Mineral Analysis

About 2.0 g of the sample was placed in a dish and heated gently on a Bunsen burner in a fume cupboard until the charred mass ceased to emit smoke and it was transferred to a muffle furnace at 550 °C. Heating was continued until all the carbon was lost. The dish and the ash were transferred to a desiccator to cool after which 0.1 M HCl was added to the ash. It was then filtered through acid washed using Whatman number 43 filter paper into 100 ml volumetric flask and made up to mark using distilled – deionized water. Minerals such as Ca, Fe, Mg, Mn, Zn, Cu, Pb and Cd were determined using an atomic absorption spectrophotometer. Na and K were determined with a flame photometer, while P was determined by Vanadomolybdate method [9].

2.7 Sensory Characteristics

Sensory Evaluation of the samples were carried out using forty (40) trained panellist selected from two communities from the two purposely selected local government, comprising Ondo East and Ondo West Local Government Areas of Ondo State, Nigeria for consumer acceptance and preference. The mushroom-biscuit samples of various proportions were evaluated for colour, texture, aroma, crispness, overall acceptability and taste.



Fig. 3. Biscuit prepared from different blends of wheat and mushroom flour

Key: A = 100% WF; B = 95% WF: 5% MF; C = 90% WF: 10% MF; D = 80% WF: 20% MF; E = 70% WF: 30% MF

2.8 Statistical Analysis

The experimental results were expressed as mean \pm standard deviation (SD) of three replicates. Data obtained were statistically analysed using one way Analysis of Variance (ANOVA), a tool in Statistical Packages for Social Scientists (SPSS 18.0). The level of significance was set at $p < 0.05$. Means were separated with Duncan's New Multiple Range Test (DNMRT).

3. RESULTS AND DISCUSSION

3.1 Influence of *Pleurotus sajur-caju* (PSC) Mushroom on Physical Characteristics of Biscuits

Physical characteristics such as diameter, thickness, weight, and spread ratio were affected by the increase in the level of mushroom flour addition in the composite biscuits.

The effect of replacing 5%, 10%, 20% and 30% of wheat flour *Pleurotus sajur-caju* mushroom flour on the physical properties of biscuits was studied and the result obtained are presented in Table 1. No significant differences ($P \leq 0.05$) were observed in the diameter, thickness, weight, and spread ratio of Mushroom biscuits produced from 5%, 10% and the control samples, same goes between the 20% and 30% samples as well except for thickness, in which slight difference was observed. The diameters ranged from 3.43 - 3.97 cm, thickness ranged from 0.53 - 0.57 mm, the weight of the mushroom biscuit ranged from 3.35 g - 4.67 g while Spread ratio of the biscuits ranged from 6.44 - 7.0. The least data were obtained in sample A, which is the control while the highest values were obtained in sample E for all the parameters at 30% level of inclusion. The values of the physical parameters obtained in this study

were lower than those reported by [3], for sorghum biscuit enriched with defatted soy-bean; thickness values were comparable to those obtained by [12] in the incorporation of whole wheat flour with moringa leaves and cocoa powder; spread ratio value were comparable to the values reported by [13] while the values of diameter and weight were comparable to the values reported by [7] in wheat-cassava composite biscuit. As the ratio of mushroom increased, the mean diameter, thickness, weight as well as spread ratio of Mushroom biscuits increased. The increase in the values corresponds to those reported by [7,14] on diameter and spread ratio but differs in terms of thickness and weight in cookies produced from wheat and brewers' spent grain. The weight increase of the composite biscuit with increased addition of *Pleurotus ostreatus* mushroom could be attributed to high bulk density of mushroom flour than wheat flour. Increase in spread ratio with decrease in wheat flour showed that the starch polymer molecules are more tightly bound with granules and swelling is limited in the biscuit with wheat flour when heated. The changes in diameter and thickness reflected the spread ratio which is consistently increased from 6.44 in control to 7.00 in composite biscuit as a result of 30% level of substitution. Based on this, 30% level of substitution is therefore considered as the most desirable, this however, contradict the result of the sensory valuation in which 5% level of substitution is the most acceptable. There is a relationship between the spread – ability, height, thickness and the breaking strength of the differently enriched biscuits, the thinner the biscuit the lesser its ability to withstand stress/load [15]. The lowest values obtained for sample (A) (100% wheat flour biscuits) could be as a result of the higher gluten content it contain in comparison with others, which forms an elastic network, holding the gluten strands such that there is contraction in the final baked products [16,17].

Table 1. Physical characteristics of oyster mushroom biscuits

Biscuit samples	Weight (g)	Thickness (cm)	Diameter (cm)	Spread ratio
A = 100% WF	3.35 ^b \pm 0.03	0.53 ^b \pm 0.02	3.43 ^c \pm 0.10	6.44 ^b \pm 0.32
B = 95% WF: 5% MF	3.52 ^b \pm 0.05	0.55 ^{ab} \pm 0.02	3.58 ^{bc} \pm 0.31	6.54 ^{ab} \pm 0.39
C = 90% WF: 10% MF	3.59 ^b \pm 0.10	0.55 ^{ab} \pm 0.01	3.64 ^{bc} \pm 0.01	6.70 ^{ab} \pm 0.17
D = 80% WF: 20% MF	4.29 ^a \pm 0.52	0.56 ^a \pm 0.02	3.83 ^{ab} \pm 0.02	6.84 ^{ab} \pm 0.19
E = 70% WF: 30% MF	4.67 ^a \pm 0.23	0.57 ^a \pm 0.01	3.97 ^a \pm 0.08	7.00 ^a \pm 0.15

Data represent mean \pm standard deviation of three replicates, values with different superscripts along the same column are significantly different ($p < 0.05$).

Key: WF = Wheat flour, MF = Mushroom flour

Table 2. Proximate Composition of Wheat flour, Mushroom flour and mushroom-wheat composite biscuit (% dwb.) and Energy Value (Kj/100g)

Parameters	Moisture content	Crude protein	Crude fibre	Crude fat	Ash	CHO	GEV
WF	-	14.76	1.61	0.82	0.53	82.28	395.54
MF	7.35 ^b ± 0.00	24.23	30.12	2.59	7.35	35.71	263.07
A	4.79 ^e ±0.03	13.04 ^d ± 0.03	2.10 ^d ± 0.03	21.71 ^a ± 0.44	1.52 ^c ± 0.15	61.63 ^b ± 0.06	2135.57 ^b ± 3.61
B	4.98 ^d ±0.02	13.41 ^c ± 0.07	2.16 ^d ± 0.05	20.58 ^b ± 0.06	1.87 ^d ± 0.02	61.58 ^a ± 0.05	2088.68 ^d ± 5.42
C	6.71 ^c ±0.05	13.46 ^c ± 0.06	2.27 ^c ± 0.07	20.51 ^b ± 0.01	2.81 ^e ± 0.00	60.95 ^c ± 0.03	2173.89 ^a ± 5.90
D	8.35 ^b ±0.02	15.47 ^b ± 0.02	2.56 ± 0.01	20.39 ^b ± 0.03	3.47 ^b ± 0.08	58.11 ^e ± 0.00	2114.76 ^c ± 0.77
E	9.63 ^a ±0.04	15.55 ^a ± 0.03	2.93 ^a ± 0.01	19.05 ^c ± 0.14	3.85 ^a ± 0.05	58.62 ^d ± 0.02	2119.63 ^c ± 1.06

Data represent mean ± standard deviation of three replicates, values with different superscripts along the same column are significantly different ($p < 0.05$).

Key: WF = Wheat Flour, MF = Mushroom Flour, A= 100% wheat biscuit (Control), B = 95% WF: 5%MF, C=90 % WF: 10 %MF, D = 80 % WF: 20 %MF, E = 70 % WF: 30 %MF, GEV = Gross Energy Value, CHO = Carbohydrate

3.2 Proximate Composition of Mushroom Biscuits (%db)

The result of the proximate analysis of mushroom biscuits obtained from different ratios of *Pleurotus sajur-caju* flour and wheat flour composite biscuits were as shown in Table 2. The moisture content of the samples ranged between 4.79 - 9.63 %. The moisture contents of the samples A (control); B (5%); C (10%); D (20%) and E (30%) were 4.79%, 4.98%, 6.71%, 8.35% and 9.63% respectively. The least moisture content was found in the control biscuit followed by that of the 5% mushroom- wheat composite biscuit in which there was no significant difference between the two and the highest moisture content was found in the sample E (30% mushroom- wheat composite biscuit). These values were within the range (5 – 10%) set by the Protein Advisory Group [18] reported as not having adverse effect on the quality attributes of the product [15]. The lower the moisture contents of a product, the better the shelf stability of such product [19], because low moisture ensures shelf stability in dried products. Thus, low moisture content in confectionaries such as biscuit is of advantage as it will bring about reduction in microbial spoilage and prolonged storage life if stored inside appropriate packaging materials under good environmental condition. The values obtained in this study favourably compares with those reported by [15] for different types of commercial biscuits [20] in wheat-potato composite biscuit and [21] in wheat-sweet potato composite biscuit.

The protein content of the samples ranges from 13.41% - 15.55%. The protein contents of the control (A=100% wheat flour) was 13.04%, composite biscuit B (5%) was 13.41%; C (10%) was 13.46%; D (20%) was 15.47% and E (30%) was 15.55% as presented in Table 4, it was observed that the protein content of the samples increased with level of mushroom addition. Protein is one of the important biomolecules that is essential for proper body functioning, because when digested and metabolised in the body, it provides energy. The increased in protein content of the biscuit with increase in substitution level agreed with [22] in malted soy-acha biscuit; [23] in biscuit with increasing level of soybean. This is however contrary to the report of [23] who reported a decrease in protein content of wheat-plantain composite biscuit. The values obtained in this study were higher than the values reported by [7] in cassava wheat composite biscuit; [3] in plantain-spent grain composite

biscuit, [24] sorghum flour to wheat flour fortified biscuit, [22]. The high protein content might be due to the high protein content of the oyster mushroom used. The result of this study reveals that the protein content of composite biscuit would be of better quality as compared with 100% wheat flour biscuits.

The crude fibre content of the samples were; control (A=100% wheat flour) was 2.10 %, composite biscuit B (5 %) was 2.16 %; C (10 %) was 2.27 %; D (20 %) was 2.56 % and E (30%) was 2.93 %. Increase in level of PSC mushroom flour equally brought about increase in the crude fibre content of the composite biscuits from 2.10% in the control sample to 2.93% in the sample with 30% mushroom flour. The high values obtained might be due to the fact that both mushroom used in composite biscuit production were rich sources of dietary fibre which therefore increased the fibre content of the composite biscuit with increase in level of the composite flour incorporation. This agreed with the reports of [3,7,25]. However they were higher than the 1.5% maximum allowable fibre content of bread flour as stated by [26] and the 2.0% recommended by Nigerian Raw Materials Research And Development Council [27]. A high intake of dietary fibre is positively related to different physiological and metabolic effects [28]. Fibre prevents constipation, soluble fibre helps to reduce the cholesterol level in the blood, slows down digestion and sudden release of energy, thus making blood level stable. Food containing at least 3g/100 g dietary fiber (DF) can be referred to as a source of DF; it is high in DF when it contains at least 6 g/100 g dietary fibres [6]. The consumption of these biscuits will meet the WHO recommendation for dietary fibre intake of about 25 g per day [29]. The ash content increased from 1.52% to a range of 1.87 – 3.85% with the control having the least ash content while the 30% level of mushroom flour addition (3.85%) had the highest value. The high ash content of the composite biscuit might be attributed to the fact that mushroom has been reported to be a good source of minerals. The ash content of a food material could be used as an index of minerals constituents of the food. The crude fat content of the samples as showed were 21.71% for the control (A=100% wheat flour), 20.58% for composite biscuit B (5%); 20.51%; for sample C (10%): 20.39% for sample D (20%); and 19.05% for sample E (30%):. The fat composition of the samples ranged from 19.05-21.71%. Fat plays a role in determine the shelf-life of foods [30]. A high

amount of fat could accelerate spoilage by promoting rancidity which could lead to the production of off flavours and odours. Also diet high in fat predispose consumer to different illness such as obesity, heart disease, etc. The fat content of the biscuits initially decreased from 21.71 in the control to 19.05% in the sample with 30% mushroom level of addition. The values obtained reduced with increase in level of substitutions and are comparable with the values reported by [13]. The carbohydrate content ranged from 58.11 – 61.98%. The carbohydrate content initially increased from 61.63 obtained for the control (A) to 61.98 obtained for 5% composite biscuit (B) followed by subsequent reduction in (C) 60.95%, D (58.11) and E 58.62%. The energy value ranged between 2088.6 kJ/100 g - 2173.89kJ/100 g, values obtained were higher than the recommended value for estimated energy intake of children of age 1-24 months (479 - 1148Kj/ day) [13] but lower than the recommended value of 7500KJ/day for adult [7]. Recommended daily energy intake varies with height and age. The energy value of food is very important as it helps in determining the fuel value of food. Energy is not a nutrient but is required in the body for metabolic processes, physiological functions, muscular activity, heat production, growth and synthesis of new tissues. It is released from food components by oxidation. The calculated energy value of a food is based on its chemical composition, this explain why the value obtain differs in these respects.

3.3 Mineral Composition of Mushroom-Wheat Biscuit

The Calcium, Sodium, Potassium and Phosphorous are the predominant mineral elements present in the mushroom-wheat biscuits. The mineral composition obtained in this study shows that there was an increase in the phosphorous content of the biscuit with increase in the level of mushroom flour addition is an indication that mushrooms is a good source of minerals as revealed in Table 3. The Fe content of this study ranged from 1.68 – 2.89 mg/100 g and it is lower than the recommended daily allowance (RDA) - 10 mg of iron per day [29]. Thus it can be concluded that both the control sample and the composite biscuit are not a good source of iron. Iron is a major component of haemoglobin that carries oxygen to all parts of the body. Iron also has a critical role within cells assisting in oxygen utilization, enzymatic systems, especially for neural development, and

overall cell function. Potassium was the most abundant mineral in the biscuit followed by sodium and then Phosphorous. The potassium content of the samples ranged from 40.63 - 154.07 mg/100 g while sodium ranged from 36.15 - 65.92 mg/100g and Phosphorous ranged from 12.5 - 54.62 mg/100g. This is in line with the report that the most abundant mineral elements in biscuit are potassium and sodium [8]. The increase in the phosphorous content of the biscuit with increase in the level of mushroom flour addition is an indication that mushrooms is a good source of minerals.. Both sodium and potassium are required to maintain osmotic balance of the body fluids, the pH of the body, to regulate muscle and nerve irritability, control glucose absorption, and enhance normal retention of protein during growth [8]. Ca content ranged from 12.10 to 47.05 mg/100g and Mg ranged from 7.05 to 14.00 mg/100g. The calcium and magnesium content of the biscuits increases with increase in level of mushroom flour addition, which means that the mushroom has higher content of both calcium and magnesium than wheat. Without magnesium, calcium may not be fully utilized, and under-absorption problems may occur resulting in arthritis, osteoporosis, menstrual cramps, and some premenstrual symptoms. Manganese, copper and zinc are trace mineral elements that are essential for important biochemical functions and necessary for maintaining health throughout life. The value of copper (Cu) obtained in this study ranged from 0.04 – 0.13. The values were comparable to those reported by [13]. However these values were below the Estimated Safe And Adequate Daily Dietary Intake (ESADDI) for Cu which is 1.5– 3.0 mg/d [29], while, Zinc (Zn) ranges from 0.08 – 1.16 mg/100g. These values were comparable to what was reported by [1], but lower than the recommended value for Zn of 15 mg for men and 12 mg for women [31]. The biscuit could therefore not be taken as a good source of these trace minerals. Thus, other dietary sources must be explored to meet the daily requirements.

3.4 Health Benefits of Mineral Ratio

The mineral ratio for the mushroom-wheat biscuit is as presented in Table 4. The ratio of sodium: potassium (Na: K) in the body is of great concern for the prevention of high blood pressure. A Na: K ratio of less than 1 is recommended [29]. The values obtained from the biscuits are fairly comparable. Both sodium and potassium are required to maintain osmotic balance of the body

Table 3. Mineral composition (mg/100g) of mushroom-wheat biscuit

Parameters	A	B	C	D	E
Calcium	12.10 ^e ± 0.10	22.03 ^d ± 0.03	27.06 ^c ± 0.13	38.05 ^b ± 0.06	47.05 ^a ± 0.06
Sodium	62.68 ^b ± 0.11	36.15 ^e ± 0.09	41.20 ^d ± 0.02	54.31 ^c ± 0.04	65.92 ^a ± 0.02
Potassium	40.63 ^e ± 0.12	51.63 ^d ± 0.06	63.05 ^c ± 0.06	143.05 ^b ± 0.05	154.07 ^a ± 0.14
Magnesium	7.02 ^e ± 0.19	8.05 ^d ± 0.07	10.04 ^c ± 0.03	13.04 ^b ± 0.04	14.00 ^a ± 0.00
Phosphorous	12.45 ^e ± 0.04	21.45 ^d ± 0.04	45.64 ^c ± 0.04	54.62 ^b ± 0.08	64.25 ^a ± 0.05
Iron	1.68 ^e ± 0.03	2.15 ^d ± 0.06	2.38 ^c ± 0.03	2.45 ^b ± 0.02	2.89 ^a ± 0.16
Copper	0.04 ^d ± 0.00	0.04 ^d ± 0.01	0.05 ^c ± 0.01	0.12 ^b ± 0.00	0.13 ^a ± 0.03
Zinc	0.08 ^e ± 0.00	0.53 ^d ± 0.01	0.62 ^c ± 0.03	0.95 ^b ± 0.05	1.16 ^a ± 0.05
Manganese	0.06 ^b ± 0.00	0.06 ^b ± 0.00	0.07 ^b ± 0.01	0.17 ^a ± 0.02	0.18 ^a ± 0.01

Data represent mean ± standard deviation of three replicates, values with different superscripts along the same row are significantly different ($p < 0.05$).

WF = Wheat Flour, MF = Mushroom Flour, A = 100% wheat biscuit (Control), B = 95% WF: 5% MF, C = 90% WF: 10% MF, D = 80% WF: 20% MF, E = 70% WF: 30% MF

fluids, the pH of the body, to regulate muscle and nerve irritability, control glucose absorption, and enhance normal retention of protein during growth [6]. Ca/P ratios of the biscuit samples were comparable to the recommended value of 1.0 [32]. A food material is considered good if the Ca/P ratio is above one and poor if the ratio is less than 0.5 [32]. The Ca/P ratio values obtained in this study revealed that the mushroom-wheat biscuit samples were within the range of 0.59-1.03, indicating that they would be a good source of minerals for bone formation.

3.5 Sensory Qualities

Samples of the biscuits prepared from *Pleurotus sajur-caju* mushroom and wheat composite flour are shown in Fig. 3, while the result of the sensory evaluation of the biscuit are as presented in Table 5. The panel scores for taste, colour, crispness, aroma and overall acceptability decreased with increase in level of mushroom flour inclusion. This implies that the more the mushroom flour, the lesser its acceptability. The composite biscuits A and B shows no significant difference in all the parameters for sensory evaluation, in terms of crispness and aroma, no significant difference exists between sample C and A, however, there were significant differences in other parameters.

Sensory evaluation studies showed that no significant difference occur in terms of the surface colour and appearance of the control and the biscuits produced from 5% of *Pleurotussajur-caju* (PSC) mushroom flour followed by 10% PSC flour. It was observed that both 20% and 30% level of PSC flour inclusion caused relatively dark colour. This may be due to

enzymatic browning, which might have given an impression of the products been over baked to the panellist hence the less liking effect. Also, the evaluation reveals that the 5% PSC biscuits had higher acceptance than the control. The higher the replacement levels of PSC, the harder the biscuits. This may be due to greater water absorption capacity. These results are comparable to the result of [13]. There was an improvement in the Aroma of the biscuits with the addition of the PSC mushroom flour. [33] reported that the addition of cocoa powder to biscuit supplemented with cassava flour enhance the flavour and colour of the biscuits. However, at 30% incorporation, the biscuits had a slightly bitter taste which may be due to high polyphenols content [12]. In terms of the overall quality and acceptance, biscuits produced from 5% level of PSC mushroom flour incorporation shows higher scores than the control, followed by biscuits produced from 10% mushroom flour incorporation, while the least acceptable was the biscuit incorporated with 30% PSC flour. The lower scores of 20% and 30% PSC mushroom flour could be due to the unattractive colour as well as the unpleasant taste. The acceptance of 5% composite biscuit was comparable to the report of [34].

Table 4. Mineral ratio of mushroom-wheat composite biscuit

Parameters	Ca/P	Na/K
A	0.97	1.54
B	1.03	0.70
C	0.59	0.65
D	0.70	0.38
E	0.73	0.43
Acceptable range	1	< 1

Table 5. Sensory scores of biscuits

Parameters	Crispness	Taste	Aroma	Colour	Overall acceptability
A	7.64 ^a ± 0.70	7.36 ^a ± 1.08	7.04 ^a ± 1.77	7.88 ^a ± 1.17	7.60 ^a ± 1.26
B	7.92 ^a ± 0.57	7.72 ^a ± 0.84	7.84 ^{a+} 0.99	8.12 ^a ± 0.60	8.08 ^a ± 0.57
C	5.96 ^b ± 1.72	5.64 ^b ± 2.27	5.60 ^b ± 2.33	6.24 ^b ± 1.56	5.68 ^b ± 1.68
D	5.24 ^b ± 1.69	5.28 ^b ± 1.70	4.96 ^b ± 1.84	4.92 ^c ± 1.78	4.64 ^c ± 2.66
E	3.68 ^b ± 1.97	3.52 ^c ± 2.02	4.68 ^b ± 2.06	3.84 ^d ± 2.44	3.24 ^d ± 2.15

Data represent mean ± standard deviation of 20 panel scores,

Values with different superscripts along the same column were significantly different ($p < 0.05$).

Key: A = 100% WF; B = 95% WF: 5% MF; C = 90% WF: 10% MF; D = 80% WF: 20% MF; E = 70% WF: 30% MF

4. CONCLUSION

The study evaluates the proximate composition, minerals, physical and sensory properties of the composite biscuit produced by substituting wheat flour with *Pleurotus sajor-caju* (PSC) flour at 0, 5, 10, 20 and 30% level of addition. The proximate composition of the biscuit composites revealed that the sample contained low moisture contents, appreciable amount of other nutritional component and moderate energy value that is required in the body for normal physiological and metabolic processes. The results of mineral composition indicates that Potassium, Calcium, Sodium, and Phosphorous are the predominant mineral elements present in the mushroom-wheat biscuits. The mineral composition obtained in this study shows that there was an increase in the mineral content of the biscuit with increase in the level of mushroom flour addition which indicates that mushroom is a good source of minerals. The samples contained nutritionally valuable minerals that are required for normal body functioning when consumed. However, manganese, copper and zinc which are essential minerals for important biochemical functions and necessary for maintaining health throughout life were found in trace. The mineral ratio for the mushroom-wheat biscuit shows that the ratio of sodium: potassium (Na: K) and Ca/P were comparable as recommended. In terms of the overall quality and acceptance, biscuits produced from 5% level of PSC mushroom flour incorporation shows higher scores than the control, followed by biscuits produced from 10% mushroom flour incorporation, while the least acceptable was the biscuit incorporated with 30% PSC flour. Based on the nutritional composition and sensory evaluation, the consumption of the mushroom-wheat flour biscuit at 5-10% mushroom flour inclusion is therefore recommended as a supplementary, low-fat, but high fibre snack food.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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