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Proximate and mineral analysis of the mushroom biscuits

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Abstract

Mushroom is a rich source of nutrients and is widely consumed in Asian countries. Biscuits can be easily fortified with mushroom-rich flour to provide convenient foods to supplement protein in the diet. The research study evaluated the proximate and mineral analysis of the most widely used mushroom cultivated in Chattogram and developed mushroom biscuits. The mushroom varieties (*Pleurotus ostreatus, Pleurotus sajor-caju, Agaricus bitorquis,* and *Ganoderma lucidum*) were collected and dried, then taken to the laboratory for proximate and mineral analysis by following standard assay methods. Results demonstrated that the moisture, total solids, protein, fat, carbohydrate, fibre, ash, and energy content of different types of mushrooms ranged from 53.10 to 90.10%, 9.90 to 47.00%, 3.23 to 19.70%, 0.47 to 4.20%, 4.21 to13.02%, 0.51 to 3.90%, 1.28 to 6.18 and 34.78 to 172.37 (kcal/100 g), respectively. The highest sodium, phosphorus, and copper content value was found in *Agaricus bitorquis*. Magnesium content was found to be the highest in *Pleurotus ostreatus.* Potassium, calcium, chloride, iron, and zinc were the most elevated in *Ganoderma lucidum*. In mushroom biscuits, the moisture, ash, protein, fat, fibre, carbohydrate, and energy value ranged from 4.03 to 3.89%, 3.47 to 4.11%, 12.15 to 13.43%, 5.43 to 5.83%, 4.71 to 5.09%, 67.03 to 70.35% and 374.15 to 378.87 (Kcal/100 g), respectively. From the sensory and microbiological point of view, mushroom biscuits exhibited significant acceptability and stability. Mushrooms and mushroom-based products are valuable food sources for human needs, able to meet day-to-day nutritional requirements as a portion of food and help the country's economy.

1. Introduction

Fungi from the family *Agaricaceae* produce mushrooms, which have a white, fleshy fruit body. Mycelium, a tiny body of fine threads, grows on the substratum or below the soil's surface. At the turn of this century, commercial cultivation was pioneered in Europe. The protein in edible mushrooms is precious and inexpensive (Nasiri *et al*., 2013). There are over 2,000 different types of mushrooms out there, but only about 25 of them are commonly consumed. The most widely eaten mushroom is an *Agaricus bisporus*, the most widely cultivated. China produces more than one million tonnes annually, making it the world's largest mushroom producer (Kapahi, 2018). Mushrooms are considered valuable and nutritious foods due to their diverse nutrient profiles. In addition to the medicinal fibres and nutrients found in edible mushrooms, these fungi are also low in carbohydrates, making them suitable for the diets of people with diabetes. Ingestible mushrooms have been studied and found to have many health benefits for humans (Valverde *et al*., 2015). According to studies done on various edible mushroom species, mushrooms have a higher protein content than fruits and vegetables. Mushrooms are a good source of several B vitamins and vitamin D and contain some unsaturated fatty acids. They have the highest protein content of any vegetable and are also rich in B vitamins, particularly niacin, and riboflavin. Every type of edible mushroom is affluent in potassium relative to other minerals. Potassium, sodium,

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phosphorus, calcium, and magnesium are the most abundant minerals in mushrooms; copper, zinc, iron, molybdenum, and cadmium are present but in lower concentrations (Gucia *et al*., 2012). From relatively specific conditions, like skin diseases, to more complex pandemic diseases like AIDS, mushrooms have been used in medicine for centuries (Wani *et al*., 2010). Mushroom fruit body, mycelium, and culture broth contain numerous bioactive compounds with promising biological effects, such as terpenoids, steroids, phenols, alkaloids, lectins, and nucleotides. Besides their specific nutrients, mushrooms are a functional food (Rathee *et al*., 2012).

The nutritional value of mushroom food products may rise if they are used in manufacturing products like biscuits (Van Toan and Thu, 2018). Mushroom flour fortified with flour could also be a good option for people with diabetes and choleric metabolisms. As a result, local farmers may be encouraged to start growing mushrooms for commercial purposes. Mushrooms have a lot of nutritional value that could be used better if their commercial production potential were realized. Biscuits and other bakery products are consistently ranked among Bangladeshi consumers' top five most frequently purchased goods (Islam and Ullah, 2010). Typically made with flour, biscuits are baked goods that can be eaten. You can think of biscuits as a type of candy that has been dried until it has a shallow moisture content. Biscuits are a great example of a ready-to-eat, low-cost food product that still incorporates fundamental principles of nutrition and digestion. These are gaining in popularity across Bangladesh, not just in the cities. To improve the nutritional value of baked goods, mushrooms, which are readily available but underutilized due to their low dietary profile, could be used (Friedman, 1996). Due to their high protein content (up to 40% on a dry weight basis), vitamin content (especially vitamin B-complex), and mineral content, mushrooms have a lot of upsides (Farzana and Mohajan, 2015). For this reason, mushrooms can be dehydrated and ground into a powder for added nutrition in breads, biscuits, and other baked goods.

2. Materials and methods

2.1 Collection of mushrooms

These mushrooms were purchased from a supermarket in Chattogram, Bangladesh, and their scientific names are *Pleurotus ostreatus*, *Pleurotus sajor -caju*, *Agaricus bitorquis* and *Ganoderma lucidum*.

2.2 Proximate analysis of mushrooms and mushroom biscuits

Using the Association of the Official Analytical Collaboration (AOAC) International standards, mushroom samples' moisture, protein, fat, and ash content were determined in triplicate. Oven drying to a constant weight at 105°C was used to determine the relative humidity (AOAC, 2000). Using the Kjeldahl method (6.25N), the amount of crude protein present was determined. The Soxhlet apparatus extracted total lipid using the AOAC (2000) methodology. In a muffle furnace, ash was heated to a constant weight via gravimetric measurement at 550°C (AOAC International, 2000).

2.2.1 Moisture

After thoroughly drying the crucibles, 5 g of the sample was added. After that, the crucible was dried at 105°C in a thermostatically controlled air oven for 24 hrs. The following formula was used to derive the percentage of moisture present in the food samples from their weights:

$$\%\text{ Moisture}=\frac{\text{Loss of the weight of}}{\text{Initial sample weight of sample}}\times 100$$

2.2.2 Protein

Using a Kjeldahl digestion flask, 2 g of the sample was mixed with 3 g of digestion mixture and 25 mL of H_2SO_4. A Kjeldahl digester/distillation apparatus heated it for 4 hrs. The percentage of protein in the sample was calculated using protein factor 6.25.

$$\%\text{ Nitrogen}=\frac{(T_s\text{-}T_b)\times\text{Normality of acid}\times\text{meq. }N_2}{\text{Weight of the sample (g)}}\times 100$$

Where T_s = Titer value of sample (mL), T_B = Titer value of Blank (mL), meq. of N_2 = 0.014, % Protein = % Nitrogen × 6.25

2.2.3 Fat

The typical AOAC International method was used to analyze the samples for fat content (AOAC International, 2020). The presence of fat was expressed as follows:

$$\text{Fat}=\frac{\text{Loss of ether soluble materials}}{\text{Weight of sample}}\times 100$$

2.2.4 Ash

Ash concentrations were calculated using the AOAC International method (AOAC International, 2020). This technique completely burns away any organic material before weighing the ash left over. The ash content was calculated using the following equation:

$$\%\text{ Ash content}=\frac{\text{Weight of ash}}{\text{initial weight of sample}}\times 100$$

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2.2.5 Crude fibre determination

The AOAC International (2000) method was used to quantify crude fibre. Crude fibre primarily comprises the insoluble carbohydrate fraction of cellulose, hemicellulose, and lignin. A fat-free food sample is boiled in a dilute acid solution (1.25% H_2SO_4) for 30 mins, then boiled in a dilute alkali solution (1.25% NaOH) for 30 mins, all while maintaining a constant volume, and the ash is then subtracted from the residue to estimate the digestible fat content. The crude fibre was calculated using the following equation:

$$\text{Crude fibre \%} = \frac{\text{Weight of residue with crucible - the weight of ash with crucible}}{\text{Weight of the sample (moisture and fat-free)}} \times 100$$

2.2.6 Determination of total carbohydrates

It was expressed as a numeric difference between 100 and the sum of all other nearby elements. As a result, the formula below was used to determine it:

% CHO = 100% - % (Protein + Fat + Fibre + Ash + Moisture content).

2.2.7 Determination of energy value

The samples' calorie count was calculated using the standard James formula, multiplying the samples' protein, carbohydrate, and fat contents by 4, 4, and 9, respectively (Matin *et al*., 2019b).

Energy Value = (Crude protein × 4) + (Total carbohydrate × 4) + (Crude fat × 9)

2.3 Mineral analysis

2.3.1 Sample preparation

To conduct biochemical assays, a commercially available biochemical kit (Randox) was used (Akther *et al*., 2020).

2.3.2 Determination of sodium

Sodium, magnesium, and uranyl acetate form a precipitate. Ferrocyanide reacts with an excess of uranyl ions in an acidic medium to produce a brownish hue. A sample's sodium content negatively correlates with the hue produced. The sodium content was calculated with the following formula:

$$\text{Sodium in} \frac{\text{mmol}}{\text{L}} = \frac{\text{(A) sample}}{\text{(B) Standard}} \times \text{Standard conc.} \left(\frac{\text{mg}}{\text{dl}}\right)$$

2.3.3 Determination of calcium

The calcium ions form a violet complex with an O-Cresol phthalein complex in an alkaline medium. The colourimetric method: O-Cresol phthalein complex one, without deproteinization. The calcium content was calculated with the following formula:

$$\text{Concentration in} \frac{\text{mg}}{\text{dl}} = \frac{\text{(A) sample}}{\text{(A) standard}} \times \text{Standard conc.} \left(\frac{\text{mg}}{\text{dl}}\right)$$

2.3.4 Determination of potassium

Fine turbidity of potassium tetraphenyl boron is produced when sodium tetraphenyl boron reacts with potassium. The intensity of turbidity is proportional to potassium concentration. The potassium content was calculated with the following formula:

$$\text{Potassium} \frac{\text{mg}}{\text{dl}} = \frac{\text{(A) sample}}{\text{(A) standard}} \times \text{Standard conc.} \left(\frac{\text{mg}}{\text{dl}}\right)$$

2.3.5 Determination of magnesium

The method relies on the complex's absorption wavelength change brought about by the specific binding of calmagite, a metallochromic indicator, and magnesium at alkaline pH. The magnesium content was calculated with the following formula:

$$\text{Magnesium} \frac{\text{mg}}{\text{dl}} = \frac{\text{(A) sample}}{\text{(A) standard}} \times \text{Standard conc.} \left(\frac{\text{mg}}{\text{dl}}\right)$$

2.3.6 Determination of phosphorous

The phosphorous was determined via the following calculation:

$$\text{Phosphorus concentration} \frac{\text{mg}}{\text{dl}} = \frac{\text{(A) sample}}{\text{(A) standard}} \times \text{Standard conc.} \left(\frac{\text{mg}}{\text{dl}}\right)$$

2.3.7 Determination of chloride ion

The chloride ions combine with free mercuric ions and release thiocyanate from mercuric thiocyanate. The chloride ion content was calculated with the following formula:

$$\text{Chloride in} \frac{\text{mmol}}{\text{L}} = \frac{\text{(A) sample}}{\text{(A) standard}} \times \text{Standard conc.} \left(\frac{\text{mg}}{\text{dl}}\right)$$

2.3.8 Determination of iron

The iron is dissociated from the transferring-iron complex in a weakly acid medium. Liberated iron is reduced into the bivalent form by means of ascorbic acid. Ferrous ions give Ferrozine a coloured complex. The intensity of the colour formed is proportional to the iron concentration in the sample. The iron content was calculated with the following formula:

$$\text{Iron in} \frac{\mu g}{dl} = \frac{\text{(A) sample - (A) sample blank}}{\text{(A) standard}} \times \text{Standard conc.} \left(\frac{\text{mg}}{\text{dl}}\right)$$

2.3.9 Determination of copper

Chloride ions combine with free mercuric ions and release thiocyanate from mercuric thiocyanate. The thiocyanate released combines with the ferric ions to form a red-brown ferric thiocyanate complex. The copper content was calculated with the following formula:

$$\text{Copper in} \frac{\text{mmol}}{\text{L}} = \frac{\text{(A) sample}}{\text{(A) standard}} \times \text{Standard conc.} \left(\frac{\text{mg}}{\text{dl}}\right)$$

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2.3.10 Determination of zinc

The zinc (Zn) concentration determined via the following formula. The zinc content was calculated with the following formula:

$$\text{Zn in } \frac{\mu g}{dl} = \frac{\text{(A) sample - (A) sample blank}}{\text{(A) standard}} \times \text{Standard conc. } \left(\frac{mg}{dl}\right)$$

2.4 Development of mushroom biscuits

2.4.1 Preparation of mushroom powder

First, fresh mushrooms were washed in clean water to prepare mushroom powder. The mushrooms were chopped up into little bits. The mushrooms were then transferred to a tray and dried in a cabinet dryer (Genlab 1000-L, UK) for 24 hrs at 60°C. A Mixer grinder was then used to grind the dried mushrooms (Panasonic MX-AC300). The plastic bag containing the mushroom powder was placed in the fridge for later use.

2.4.2 Formulation of mushroom biscuits

Various trials were carried out to formulate the mushroom biscuits as shown in Table 1.

2.4.3 Processing of mushroom biscuits

A mixer was used to whip the oil and sugar into a light and airy consistency (model HM 430). The biscuits were cooled hygienically before being sealed in airtight polythene and stored at room temperature until needed for sensory attributes and other analyses (Wakchaure, 2011). The standard was white wheat flour biscuits.

2.4.4 Sensory attributes of mushroom biscuits

A unique scorecard was made for the purpose of evaluating mushroom biscuits. Product quality attributes were taken into account when creating the scorecard. Appearance/colour, flavour, taste, and general acceptance are some of the quality attributes described. The panel used visual analog scales to rate each sample's characteristics. Like significantly = 9, Like very much = 8, Like moderately = 7, Like slightly = 6, Neither like nor dislike = 5, Dislike slight = 4, Dislike moderate: 3, Dislike very much: 2, and Dislike extremely = 1. Most preferred features were given a score of 9, while the least preferred features received a score of 1. This rating does not reflect how consumers feel about the product, but it provides guidelines for what to look for in a high-quality item.

2.4.5 Microbiological quality of the mushroom biscuits

The total viable count was performed using plate count agar medium following the published standard procedure (Matin *et al*., 2019a). Colony counting was carried out using a digital colony counter, and the total viable count was expressed as colony-forming units per ml (CFU/mL). The yeast and mould count was performed using previously published methods (Matin *et al*., 2018). The results were expressed as the presence or absence of yeast and mould growth.

2.5 Statistical analyses

The statistics were done by IBM SPSS Statistics 23 was used for data organization, classification, and storage. One-way analysis of variance tests was applied to these data sets to determine the existence of statistically significant variation at the 95% confidence level. The significance level used in the study was 5% ($P = 0.05$).

3. Results

3.1 Proximate analysis of mushroom

Proximate analysis results for mushrooms are shown in Table 2. Energy, protein, fat, carbohydrates, fibre, and ash content ranged from 34.78 to 172.37 (kcal/100 g) for various mushrooms, while moisture content varied from 53.10 to 90.10%.

3.2 Mineral contents different types of mushrooms

Table 3 details the mineral content of various mushroom varieties. Different types of mushrooms had varying levels of sodium, potassium, calcium, magnesium, phosphorus, chloride, iron, copper, and zinc in the blood, with readings from 463.21 to 413.12 mg/dL, 32.14 to 15.25 mg/dL, 1.81 to 0.90 mg/dL, 1.90 to 1.10 mg/dL, 13.20 to 7.40 mg/dL, 13.57 to 7.20 mg/dL,

Table 1. Formulation of mushroom biscuits.

Ingredients	Formulation 1	Formulation 2	Formulation 3	Formulation 4
Mushroom powder (g)	0	5	10	15
Wheat flour (g)	75	70	65	60
Soy flour (g)	10	10	10	10
Milk powder (g)	8	8	8	8
Egg (mL)	20	20	20	20
Sugar (g)	35	35	35	35
Sodium bicarbonate (g)	1.0	1.0	1.0	1.0
Salt (g)	0.5	0.5	0.5	0.5
Oil (mL)	20	20	20	20

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Table 2. Proximate composition of different types of mushrooms.

Parameter	*Pleurotus ostreatus*	*Pleurotus sajor-caju*	*Agaricus bitorquis*	*Ganoderma lucidum*	Level of sign.
Moisture (%)	89.80±0.05[b]	89.20±0.02[c]	90.10±0.10[a]	53.10±0.07[d]	*
Total solids	10.20±0.07[c]	10.80±0.05[b]	9.90±0.10[d]	47.00±0.15[a]	*
Protein (%)	3.49±0.03[c]	3.69±0.05[b]	3.23±0.10[d]	19.70±0.03[a]	*
Fat (%)	0.54±0.02[b]	0.58±0.07[b]	0.47±0.02[b]	4.20±0.05[a]	*
Carbohydrate (%)	4.31±0.09[b]	4.37±0.02[b]	4.21±0.11[b]	13.02±0.15[a]	*
Fibre (%)	0.58±0.04[bc]	0.69±0.03[b]	0.51±0.03[c]	3.90±0.10[a]	*
Ash (%)	1.28±0.04[c]	1.47±0.03[b]	1.46±0.11[bc]	6.18±0.08[a]	*
Energy (kcal/100 g)	36.89±0.14[c]	38.32±0.02[b]	34.78±0.06[d]	172.37±0.02[a]	*

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different (P<0.05).
* Significant at P<0.05.

Table 3. Mineral contents of different types of mushrooms.

Parameter	*Pleurotus ostreatus*	*Pleurotus sajor-caju*	*Agaricus bitorquis*	*Ganoderma lucidum*	Level of sign.
Sodium	437.69±0.03[c]	442.29±0.08[b]	463.21±0.04[a]	413.12±0.02[d]	*
Potassium	21.51±0.10[c]	15.25±0.05[d]	27.13±0.03[b]	32.14±0.04[a]	*
Calcium	1.20±0.05[b]	0.90±0.10[c]	1.78±0.04[a]	1.81±0.10[a]	*
Magnesium	1.90±0.05[a]	1.70±0.10[b]	1.10±0.05[c]	1.80±0.02[ab]	*
Phosphorus	11.70±0.05[b]	8.30±0.03[c]	13.20±0.05[a]	7.40±0.10[d]	*
Chloride	9.23±0.03[b]	9.24±0.04[b]	7.20±0.01[c]	13.57±0.06[a]	*
Iron	0.15±0.02[a]	0.13±0.01[a]	0.11±0.03[a]	0.17±0.04[a]	NS
Copper	0.02±0.01[a]	0.03±0.01[a]	0.07±0.03[a]	0.05±0.03[a]	NS
Zinc	0.31±0.03[b]	0.30±0.03[b]	0.43±0.05[a]	0.50±0.02[a]	*

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different (P<0.05).
* Significant at P<0.05, NS: not statistically significant.

Table 4. Proximate analysis of developed mushroom biscuits.

Parameter	Formulation 1	Formulation 2	Formulation 3	Formulation 4	Level of sign.
Moisture (%)	3.89±0.05[c]	4.03±0.03[b]	4.43±0.06[a]	4.51±0.05[a]	*
Ash (%)	3.47±0.03[d]	3.71±0.01[c]	3.85±0.02[b]	4.11±0.02[a]	*
Protein (%)	12.15±0.04[d]	12.68±0.02[c]	13.27±0.01[b]	13.43±0.03[a]	*
Fat (%)	5.43±0.01[c]	5.62±0.05[b]	5.79±0.02[a]	5.83±0.04[a]	*
Fibre (%)	4.71±0.02[c]	4.91±0.02[b]	4.94±0.03[b]	5.09±0.06[a]	*
CHO (%)	70.35±0.15[a]	69.05±0.13[b]	67.72±0.14[c]	67.03±0.20[d]	*
Energy (kcal/100 g)	378.87±0.35[a]	377.50±0.01[b]	376.07±0.34[c]	374.15±0.22[d]	*

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different (P<0.05).
* Significant at P<0.05.

0.17 to 0.11 mg/dL.

3.3 Proximate composition of developed mushroom biscuits

Proximate analysis results for four different mushroom biscuit formulations are shown in Table 4. Four different mushroom biscuit formulations yielded values for moisture, ash, protein, fat, fibre, carbohydrates, and energy that varied from 4.03 to 3.89%, 3.47 to 4.11%, 12.15 to 13.43%, 5.43 to 5.83%, 4.71 to 5.09%, 67.03 to 70.35%, and 374.15 to 378.87 kcal/100 g, respectively.

3.4 Sensory attributes of developed mushroom biscuits

The sensory attributes of four formulated mushroom biscuits are presented in Table 5. The results of appearance and colour, flavour and aroma, taste, crispness and texture, and overall acceptability score ranged from 6.6 to7.7, 7.3 to 7.9, 7.1 to 7.7, 6.9 to 8.4 and 7.3 to 8.0 for four formulated of mushrooms biscuits respectively.

Table 5. Sensory attributes of developed mushroom biscuits.

Sensory attributes	Formulation 1	Formulation 2	Formulation 3	Formulation 4	Level of sign.
Appearance and Colour	6.7±1.25[a]	6.6±0.51[a]	7.2±1.13[a]	7.7±0.94[a]	NS
Flavour and Aroma	7.4±0.84[a]	7.9±0.87[a]	7.3±0.82[a]	7.5±0.70[a]	NS
Taste	7.4±0.51[a]	7.7±1.15[a]	7.1±1.28[a]	7.1±0.73[a]	NS
Crispness & Texture	7.3±0.67[bc]	8.4±0.51[a]	6.9±0.73[d]	7.9±0.73[ab]	*
Overall acceptability	7.6±1.34[a]	7.3±0.67[a]	8.0±0.81[a]	7.8±0.60[a]	NS

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different (P<0.05).
* Significant at P<0.05, NS: not statistically significant.

3.5 Microbiological quality of developed mushroom biscuits

Their microbiological characteristics indicate the safety, quality, and shelf life of prepared mushroom biscuits. The mushroom biscuits were tested for total viable count, yeast, and mould. The results of the microbial analysis conducted on four different mushroom biscuit formulations are displayed in Table 6.

Table 6. Microbiological quality of developed mushroom biscuits.

Samples	TVC (CFU/mL)	Yeast and mould (CFU/mL)
Formulation 1	ND	ND
Formulation 2	ND	ND
Formulation 3	ND	ND
Formulation 4	ND	ND

ND: not detected, TVC: total viable count.

4. Discussion

The moisture content ranged from a high of 90.10% in *Agaricus bitorquis* to a low of 53.10% in *Ganoderma lucidum*. Nasiri *et al*. (2013) reported similar mushroom moisture content. Similarly, Zahid *et al*. (2010) found that the moisture content of five different edible mushroom species varied from 85.95 to 90.07%. Oyster (*Pleurotus ostreatus*) and Reshii (*Ganoderma lucidum*) mushrooms, two species commonly used for human consumption, contained 84% and 47% moisture, respectively, according to research conducted by Roy *et al*. (2015). Total solids ranged from a high of 47.00% in *Ganoderma lucidum* mushrooms to a low of 9.90% in *Agaricus bitorquis* varieties. According to the research of Zahid *et al*. (2010). The total solids content of five different types of edible mushrooms varied from 9.93% to 14.05%. *Ganoderma lucidum* had the highest protein content at 19.70%, and *Agaricus bitorquis* had the lowest at 3.23%. Mushroom samples had less protein than what was previously reported by Nasiri *et al*. (2013) and Nasiri *et al*. (2012). Zahid *et al*. (2010) found that the protein content of five different types of edible mushrooms varied from 3.22 to 4.83%. *Ganoderma lucidum* had the highest fat content, at 4.20%, and *Agaricus bitorquis* had the lowest, at 0.47%. Nasiri *et al*. (2013) and Nasiri *et al*. (2012) reported similar results for the fat content of mushroom samples. Zahid *et al*. (2010) found a range of 0.43-1.05% in the fat content of five different edible mushroom species. Roy *et al*. (2015) measured the fat content of two edible mushroom varieties, the oyster (*Pleurotus ostreatus*) and the Reshii (*Ganoderma lucidum*), and found that the former contained 1.05% fat and the latter had 3% fat. *Ganoderma lucidum* had the highest carbohydrate content, at 13.02%, while *Agaricus bitorquis* had the lowest, at 4.21%. Zahid *et al*. (2010) reported a higher carbohydrate content in their mushroom samples than Nasiri *et al*. (2013) and Nasiri *et al*. (2012). *Ganoderma lucidum* had the highest fibre content (3.90%), while *Agaricus bitorquis* had the lowest (0.51%). Samples of mushrooms had a higher fibre content than those reported by Zahid *et al*. (2010) but a lower fibre content than that reported by Nasiri *et al*. (2013) and Nasiri *et al*. (2012). The fibre content of two edible mushroom species was measured by Roy *et al*. (2015); the oyster mushroom (*Pleurotus ostreatus*) had 2.4%, and the Reshii mushroom (*Ganoderma lucidum*) had 3.5%. The ash content of different types of mushrooms ranged from 1.28 to 6.18%, with *Ganoderma lucidum* having the highest value at 6.18%. Nasiri *et al*. (2013) and Nasiri *et al*. (2012) reported an ash content higher than what was found in the mushroom samples we tested. According to Zahid *et al*. (2010) the ash content of five different edible mushroom species varied between 0.98 and 2.30%. The ash content of two edible mushroom species was measured by Roy *et al*. (2015); 5.5% for oysters (*Pleurotus ostreatus*) and 6.3% for Reshii (*Ganoderma lucidum*). The energy content of various mushrooms ranged from 34.78% for *Agaricus bitorquis* to 172.0 to 370.02% for *Ganoderma lucidum*. The ash energy values (in kilocalories per hundred g) of five different edible mushroom species vary from 35.51 to 50.03. (Zahid *et al*., 2010). *Agaricus bitorquis* has the highest sodium, phosphorus, and copper content of any fungus studied. *Pleurotus ostreatus* had the highest magnesium concentration of any tested species. The mineral content of *Ganoderma lucidum* was found to be highest for potassium, calcium, chloride, iron, and zinc. The nutrient content of *Ganoderma lucidum* was found to be lowest in sodium and phosphorus. The *Pleurotus ostreatus* population had the lowest copper content. It was discovered that *Agaricus bitorquis* had the lowest chloride, iron, and magnesium levels. We found *that Pleurotus sajor-caju* had the lowest zinc, calcium, and potassium levels of any of the common edible fungi tested. Zahid *et al*. (2010) found that the concentrations of sodium, potassium, calcium, magnesium, phosphorus, iron, copper, and zinc in five different species of edible mushrooms ranged from 3.18 to 37.23 mg/100 g, 19.83 to 197.24 mg/100 g, 0.12 to 0.58 mg/100 g, 27.26 to 51.21 mg/100 g, 22.20 to 62.10 mg/100 g, 1.81 to 0.81 mg/100 g, 0.14 to 0 mg/100 g. Two species of edible mushrooms were studied by Roy *et al*. (2015); the sodium, potassium, calcium, magnesium, phosphorus, iron, copper, and zinc content of these mushrooms ranged from 2.9 to 425 to 1.78 to 7.74 to 212 to 2.19 to 28 to 0.5 mg per 100 g, respectively, for oyster (*Pleurotus ostreatus*) and Reshii (*Ganoderma lucidum*).

Variations in mushroom biscuit formulations showed a moisture content range of 3.89-4.03%. Formulation A had the highest moisture content, at 3.89%, and Formulation B had the lowest, at 4.03%. Different types of formulated mushroom biscuits had higher moisture content than what was reported by Farzana and Mohajan, (2015) but lower than what was reported by several other research groups (Prodhan *et al*., 2015; Bello *et al*., 2017; Ayo *et al*., 2018). Ash percentages varied from 3.47 to 4.11% between various mushroom biscuit formulations. Results showed that Formulation D had the highest ash content (4.11%), while Formulation A had the lowest (3.47%). When compared to what was reported by Farzana and Mohajan, (2015) the ash content of various samples of formulated mushroom biscuits was higher. Prodhan *et al*. (2015) and Ayo *et al*. (2018) reported that the ash content of mushroom (*Pleurotus sajor-caju*) enriched biscuits, Acha-Mushroom Flour Blend Biscuits, varied between 3.61 and 4.13% and 2.56 and 3.06%, respectively. The ash content of mushroom flour biscuits (% dwb.) was 7.35%, as reported by Bello *et al*. (2017). For various mushroom biscuit formulations, protein content varied between 13.43% and 12.15%. Protein content ranged from a high of 13.43% in Formulation D to a low of 12.15% in Formulation A. Mushroom flour biscuit (% dwb.) had 24.23% protein, as Bello *et al*. (2017) measured. Fat content results for various mushroom biscuit formulations varied between 5.43 and 5.83%. Formulation A had the lowest fat content, at 5.43%, and Formulation D had the highest, at 5.83%. Compared to the findings of Farzana and Mohajan (2015) and Ayo *et al*. (2018), as well as Prodhan *et al*. (2018), the fat content of the formulated mushroom biscuit samples was lower. According to Bello *et al*. (2017), the fat percentage in mushroom flour biscuits was 2.91% dwb. Fibre content varied between 4.71 and 5.09% among the various mushroom biscuit formulations. Formulation D contained the highest amount of fibre at 5.090.06%, while Formulation A contained the least amount of fibre at 0.51%. Comparing the fibre content of various mushroom biscuit samples, we found that it was greater than that reported by Farzana and Mohajan (2015) and Ayo *et al*. (2018), and comparable to that reported by Prodhan *et al*. (2018). Mushroom flour biscuits (% dwb.) were found to have a fibre content of 30.12% by Bello *et al*. (2017). Carbohydrate content results for various formulated mushroom biscuits ranged from 67.03 to 70.35%. Formulation A had the highest carbohydrate content, 70.35%, while Formulation D had the lowest (67.03%). Farzana and Mohajan (2015) and Ayo *et al*. (2018) reported lower carbohydrate contents for mushroom biscuits, while Prodhan *et al*. (2018) reported a similar range of values. According to Bello *et al*. (2017), the carbohydrate content of Mushroom flour biscuits was 35.71% (% dwb.). The nutritional content of mushroom biscuits varied from 374.15 to 378.87 (kcal/100 g), depending on the recipe. The highest energy content was found in Formulation A (378.87 (kcal/100 g)), while the lowest was found in Formulation D (374.15 (kcal/100 g)). Compared to what was reported by Farzana and Mohajan (2015), the energy value of different types of formulated mushroom biscuit samples was lower. Bello *et al*. (2017) found that the energy content of Mushroom flour biscuits (% dwb.) was 263.07 (KJ/100 g).

The success of the biscuits' organoleptic evaluations is dependent on a number of factors, including, but not limited to, their appearance, feel, taste, smell, and flavour. The sensory characteristics of the developed mushroom biscuits A, B, C, and D are summarized in Table 4. Sample D had the highest scores for appearance and colour (7.70.94), while Sample B had the highest scores for crispness and texture (8.40.51), flavour and aroma (7.90.87), and flavour (7.71.15). The overall acceptability of Sample C was the highest (8.00.81). On the other hand, Sample B received the lowest scores (6.60.51 for appearance and colour, and 7.30.67 for overall acceptability). The worst-tasting samples were samples C and D. The lowest scores for flavour and aroma were for sample C (7.30.82), and crispness and texture were for sample D (6.70.73). Since they are delicious and nutritious, mushroom biscuits are popular throughout the year. Sample C of the mushroom biscuits tested well on the hedonic scale, indicating its general acceptability. Farzana and Mohajan (2015) reported that the sensory attributes (taste, colour, texture, flavour, and overall acceptability) of soy-mushroom biscuits incorporating different levels of soy flour ranged from 7.2 to 8.2, 7.6 to 8.6, 6.9 to 7.6, 7.2 to 7.7, and 7.2 to 8.4. When it comes to a product's overall market success, nothing is more important than how well consumers receive it, and the product's sensory attributes largely determine this. Microbiological characteristics are indicators of the created products' safety, quality, and practicable timeline. The mushroom biscuits' microbiological characteristics reflect the product's safety, quality, and durability. Yeast and mould counts, as well as the total number of viable organisms, were calculated for each type of mushroom biscuit that had been created. The collected data is presented in Table 4. Neither yeast nor mould could be found in the samples examined for viability. Keeping a clean work environment during the production of mushroom biscuits improved the final product's safety, quality, and practicality.

4. Conclusion

This research shows that nutrient content varies among mushroom genera and within individual genera. Although these mushrooms vary in terms of their nutrient composition, their nutritional profile as a whole is fairly solid. They have the potential to significantly increase the consumption of micronutrients by the native population. Thus, mushrooms should be included in our diets more frequently to enhance the quality of our regular diets. This effort will unquestionably enhance our micronutrient situation, boosting people's health and security. This research confirmed previous findings that mushrooms are healthful foods. They contain a wide variety of essential minerals and macronutrients. The protein content is high, even surpassing that of many vegetables. Mushrooms are one of the few foods people of all ages can enjoy. The high potassium content of these foods makes them beneficial for managing hypertension. Proximate analysis of the biscuit composites showed that the sample had adequate levels of essential nutrients, including low moisture content, a respectable amount of other nutritional components, and a moderate energy value. Testing for mineral content revealed that the mushroom biscuits contained notably high potassium, calcium, sodium, and phosphorus concentrations.

Conflict of interest

The authors declared no conflict of interest.

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