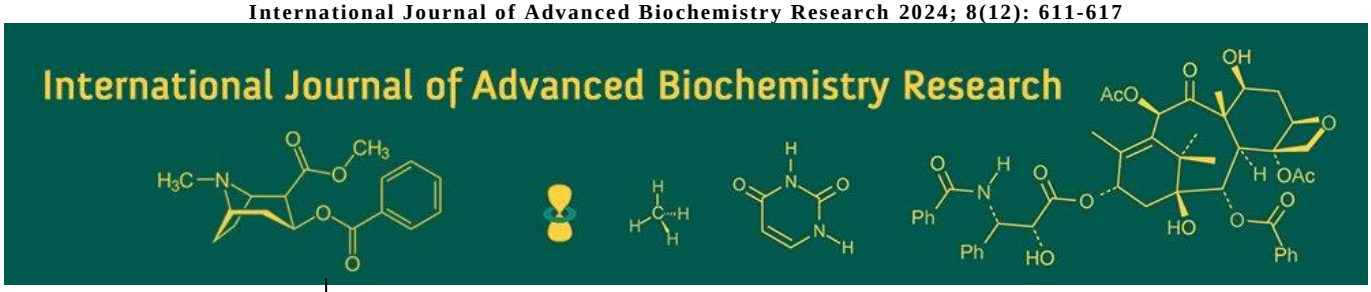

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(12): 611-617
www.biochemjournal.com
Received: 16-10-2024
Accepted: 19-11-2024

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Nutritional evaluation of mushroom powder fortified cookies during storage

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DOI: https://doi.org/10.33545/26174693.2024.v8.i12h.3224

Abstract
The present research was conducted to study the nutritional composition of mushroom powder fortified cookies as influenced by different proportions of mushroom powder. The mushroom fortified cookies were prepared by adding mushroom powder at 2.5, 5, 7.5 and 10%, respectively. The mushroom fortified cookies were stored in 100 microns Aluminum Laminated Pouches (ALP) at room temperature for 90 days. The stored cookies were analysed for physical properties, proximate composition, textural properties and sensory attributes, respectively. Enriched cookies possessed higher nutritional profile in comparison to control cookies. The moisture content ranges from 2.23-2.83%, protein 8.92-8.22, crude fibre 1.82-1.52, fat 25.09-24.81%, ash 1.56-1.35% and carbohydrate 60.69-60.44%, respectively. The sensory evaluation of cookies was carried out regularly at an interval of 30 days. Among the different treatments 5% mushroom powder along with 15% finger millet flour and 80% wheat flour recorded highest scores for organoleptic parameters like colour, appearance, flavour, texture and overall acceptability. Storage study of cookies revealed that the cookies prepared by incorporation of 5% mushroom powder were found to be acceptable up to storage period of 3 months.

Keywords: Mushroom powder, cookies, proximate analysis, textural properties, storage

Introduction
The evolution of humanity has been greatly influenced by bakery products, which provide a vital source of variety, convenience and a nutrient-dense food component to fulfil the demands of contemporary lives. The demand of healthy, natural, nutritious and tasty dehydrated food products is continuously increasing (Andhale *et al*., 2021) [4]. The increasing consumer demand of dehydrated products in national and international market indicates that there is great potential of processing and production of value added products such as cookies using mushrooms. Products from bakeries, especially cakes, cookies, breads, and biscuits, are appreciated by customers and play a significant role in providing bioactive substances for human diets (Alpaslan and Hayta, 2006) [3]. Most bakery products serve as a base for incorporating various nutritionally rich ingredients to enhance their diversity. Bakery products like cookies and biscuits are ready-to-eat, convenient and affordable foods that provide essential digestive and dietary benefits.

Mushrooms have been an essential part of the human diet because of their nutritional and medicinal properties (Devi *et al*., 2024; Kalac, 2012) [9, 12]. They are low in fat, free from cholesterol, rich in protein, and packed with antioxidant minerals like selenium, along with significant amounts of dietary fibre. As a result, they are regarded as next-generation health foods (Arora *et al*., 2018) [5]. Mushrooms possess great potential due to their high-quality proteins, B-complex vitamins, and essential minerals (Singh *et al*., 1995) [29]. Mushroom possess many nutraceutical properties such as prevention or treatment of parkinson, alzheimer, hypertension, and high risk of stroke, also mushrooms act as antibacterial, immune system enhancer and cholesterol lowering agents; additionally, they are important sources of bioactive compounds Valverde *et al*. (2015) [32]. Considering the significance of mushrooms in terms of its therapeutic, pharmacological, and nutritional importance, value addition of mushroom is essential to meet the needs of the world's expanding population. Thus, mushrooms can be dried and processed into powder form, which can be further used to fortify baked products such as cookies.

Partially replacing wheat flour with mushroom powder in food products is reported to enhance their dietary fibre content (Nordiana *et al*., 2019) [19]. The present research was undertaken to study the effect of incorporation of mushroom powder on physical, proximate, textural and sensory attributes of cookies during storage.

Materials and method

Procurement and pre-processing: Fresh button mushrooms were procured from local market. Other ingredients required for preparation of cookies such as wheat flour, finger millet flour, sodium bicarbonate, ammonium bicarbonate, vanaspati ghee, etc. were also procured from local market. Fresh mushrooms subjected to cleaning and slicing. Mushroom slices were dried under the tray dryer with pre-treatment of 500 ppm potassium metabisulphite (KMS) at 50 °C drying temperature. The dried mushroom slices were converted into powder using pulverizer and used for fortification in cookies.

Formulation of cookies: The button mushroom cookies were formulated using various ingredients such as wheat flour, finger millet flour and mushroom powder as the main ingredients. Others like sugar (50 g), vanaspati ghee (50 g), sodium bicarbonate (0.5 g), ammonium bicarbonate (0.5 g). The cookies were standardized using different proportions of wheat flour, finger millet flour and mushroom powder as 80:20:0, 80:17.5:2.5, 80:15:5, 80:12.5:7.5 and 80:10:10 designated as T_0, T_1, T_2, T_3 and T_4, respectively. Preliminary trials and sensory evaluation was carried out before the cookies were formulated.

Treatment details: The mushroom powder cookies were prepared by using different proportions of mushroom powder (MP), wheat flour (WF) and finger millet flour (FMF) shown below:

Table 1: Treatment details for preparation of mushroom powder cookies

Treatments	Treatment combinations		
	Wheat flour, (%)	Finger millet flour, (%)	Mushroom powder, (%)
T_0 (control)	80	20	0
T_1	80	17.5	2.5
T_2	80	15	5
T_3	80	12.5	7.5
T_4	80	10	10

Chemical characteristics of raw material

The chemical characteristics such as moisture content, protein, fat, crude fibre, ash and carbohydrate content of fresh button mushroom and mushroom powder were determined as per the standard procedures as described in A.A.C.C. (2000) [1].

Physical characteristics of mushroom fortified cookies

The physical characteristics such as weight, diameter, and thickness of cookies were calculated as per A.A.C.C. (2000) [1] methods. Weight in terms of grams (g) was measured using electronic weighing balance. Diameter and thickness of cookies in terms of millimetre (mm) were measured with the help of vernier calliper having least count 0.01. The spread ratio was calculated as weight/thickness.

Proximate composition of mushroom fortified cookies

The moisture content, protein, fat, crude fibre, ash and carbohydrate content of mushroom fortified cookies were determined as per the standard procedures as described in A.A.C.C. (2000) [1]. The moisture content of cookies determined by placing 20 g sample in a moisture box and dried for 5 hours at 105 °C and cooled in desiccators for 30 minutes. The sample was weighed after cooling. The method was repeated until the constant weight was obtained. The protein content of cookies was estimated by determining total nitrogen content using standard Micro-Kjeldhal method. Fat content of the cookies was estimated by the soxhlet method. The crude fiber content in the products was estimated by A.A.A.C. (2000) [1] standard procedure. Total ash content was determined by placing the sample in a muffle furnace at 550 ℃ for 4 h and the residue left in the crucible was weighed after cooling. The carbohydrate content in the cookies were obtained by subtracting from 100, the sum of values of moisture, protein and fat content per 100 g of the sample (Raghuramulu, *et al*., 1993) [22].

Textural properties of mushroom fortified cookies

Textural properties of cookies such as cutting force, crushing force and penetration force was measured by using Instron Universal Testing machine (Make: Shimadzu; Japan Model: AX-G). Machine was fitted with the 1 KN load cell. Different probe assemblies were used for different tests. Machine was connected to computer via software. This software converts the received signals, collects the data and converts it in graphical representation (Texture profile) and prepares the report of individual test. Each cookie was placed on the loading cell and compressed as per the standard procedures given by Singh *et al*., (1993) [28].

Storage of mushroom fortified cookies

Mushroom fortified cookies were stored in 100 microns Aluminum Laminated Pouches (ALP) at room temperature for 90 days. Stored cookies were evaluated for sensory, textural as well as proximate composition at an interval of 30 days.

Sensory evaluation

Sensory evaluation of mushroom powder cookies were carried on 9-point hedonic scale. The cookies were evaluated for sensory attributes by a panel of 10 semi-trained judges, for different parameter like colour, appearance, texture, flavour and overall acceptability. Their judgments were recorded and mean values of 10 semi-trained judges were considered for evaluating the quality of cookies.

Statistical analysis

The obtained data were analyzed statistically to determine the statistical significance of applied treatments, according to the procedure given by Rangaswamy (2010) [23]. Completely Randomized Design (CRD) and Factorial Completely Randomized Design (FCRD) were used to test the significance of results. The analysis of variance revealed at $p<0.05$ significance level, S.E. and C.D. at 5% level.

Results and Discussion

Chemical characteristics of raw material

The findings obtained for chemical characteristics of fresh button mushroom and mushroom powder are presented here:

Table 2: Chemical characteristics of raw material

Chemical constituent (%)	Fresh button mushroom	Mushroom powder
Moisture content	90.18	4.77
Protein	3.16	29.88
Fat	0.38	1.74
Crude fibre	1.26	8.60
Ash	1.32	4.49
Carbohydrate	2.93	51.97

Each value is the average of three replications

For fresh button mushroom, the results are in line with the findings reported by Nadir *et al*., (2020) [18]. Harshavardhini and Sharma (2021) [10] reported that fresh button mushroom had 91.7% moisture, 2.1% crude protein, 0.33% fat, 1.3% of crude fibre, 0.76% ash and 3.78% carbohydrates, respectively. The chemical characteristics of mushroom powder are in comparable with the findings reported by Kumar and Barmanray (2007) [15] also Majeed *et al*. (2017) [17].

Physical characteristics of mushroom fortified cookies

The physical characteristics of cookies prepared from mushroom powder and the results pertaining to the same are given in Table 3. From table, it was observed that weight of cookies decreases from T_0 to T_4. The control treatment had highest weight of cookies as 12.83g followed by T_1, T_2, T_3 and T_4 as 12.39, 12.01, 11.79 and 11.57g, respectively. The diameter of cookies increases as powder concentration increases from T_0 to T_4. Treatment T_0 had lowest diameter as 43.86 mm whereas T_4 had highest as 45.97 mm. The thickness of cookies decreases with increasing powder concentration. Control treatment T_0 had highest thickness 16.45 mm and treatment T_4 had the lowest as 14.29 mm, respectively. The spread ratio of cookies increases from 2.67 to 3.21 with increasing powder concentration from 0 to 10%, respectively. Similar result was reported by Kumar and Barmanray (2007) [15] for button mushroom powder fortified biscuits and Kulthe *et al*. (2017) [14] for pearl millet fortified cookies, Shams *et al*. (2023) [26], Owheruo *et al*. (2023) [21].

Table 3: Physical characteristics of mushroom fortified cookies

Treatment	Weight (g)	Diameter (mm)	Thickness (mm)	Spread Ratio (D/T)
T_0	12.83	43.86	16.45	2.67
T_1	12.39	44.41	15.91	2.79
T_2	12.01	44.88	15.34	2.92
T_3	11.79	45.45	14.83	3.06
T_4	11.57	45.97	14.29	3.21
S. E	0.16	0.24	0.19	0.03
C.D @5%	0.48	0.74	0.58	0.10
CV (%)	2.67	1.11	2.55	1.83

Proximate composition of mushroom fortified cookies during storage

Moisture is a crucial factor to consider when assessing the quality and acceptability of products (Devi *et al*., 2024) [9]. Table 4 shows the data regarding changes in moisture content of mushroom fortified cookies during storage. During storage, moisture content of mushroom cookies shows gradual increase, the moisture content of treatment T_0 increased from 2.09 to 2.51% followed by treatment T_1 as 2.17% to 2.72%, treatment T_2 as 2.23 to 2.83%, treatment T_3 as 2.29 to 2.93% and treatment T_4 as 2.32 to 3.21%, respectively. Overall, treatment T_0 had lowest moisture content and treatment T_4 has highest moisture content throughout the storage period. The increased in moisture content with increasing powder concentration is observed may be attributed to the addition of mushrooms, as well as their naturally high water content and ability to retain water (Nordiana *et al*., 2019) [19]. Cookies moisture content increased while being stored, possibly because of the environment or the materials used in the packaging (Sharoon *et al.* 2014; Sujitha and Thirumani, 2014) [27, 30].

The protein content of cookies increases with increase in powder concentration and decreases with storage period. The treatment T_0 had lowest protein content and treatment T_4 had highest throughout the storage period. The increase in protein content with increase in powder concentration was due to higher protein content of mushroom powder (Salehi, 2019; Biao *et al*., 2020; Owheruo *et al*., 2023) [25, 7, 21]. During storage, the protein content of treatment T_0 decreases from 8.66 to 7.85%, treatment T_1 from 8.79 to 8.09%, treatment T_2 from 8.92 to 8.22%, treatment T_3 from 9.05 to 8.51% and treatment T_4 from 9.20 to 8.65%, respectively. The decrease in protein content of mushroom fortified cookies during storage is due to proteolytic effect (Kumar and Barmanray, 2007) [15].

The crude fibre content of cookies increases with powder concentration and decreases with storage period. Throughout the storage period, treatment T_4 consistently shows the highest crude fibre content, while treatment T_0 shows the lowest, with all the other treatments exhibiting a gradual decrease in crude fibre content over time. Increase in fibre content with increase in powder concentration was due to higher fibre content of mushroom powder (Agu *et al*., 2020; Bello *et al*., 2017) [2, 6]. During storage, crude fibre content of treatment T_0 decreases from 1.69 to 1.32%, treatment T_1 from 1.74 to 1.41%, treatment T_2 from 1.82 to 1.52%, treatment T_3 from 1.89 to 1.64% and treatment T_4 from 1.95 to 1.75%, respectively. The decrease in fibre content of cookies during storage may be attributed to several factors, including oxidation, moisture absorption, and enzymatic activity.

The fat content of cookies decreases with increase in powder concentration and storage as well. The treatment T_0 had highest fat content and treatment T_4 had lowest throughout the storage. The decrease in fat content of cookies with addition of mushroom powder was obviously due to replacement of wheat flour containing higher fat with low fat mushroom powder (Owheruo *et al*., 2023) [21]. Similar findings were reported by Bello *et al*. (2017) [6] as well as Salehi (2019) [25]. During storage, the fat content of treatment T_0 decreases from 25.53 to 25.01%, treatment T_1 from 25.30 to 24.90%, treatment T_2 from 25.09 to 24.81%, treatment T_3 from 24.94 to 24.70% and treatment T_4 from 24.79 to 24.62%, respectively. The decrease in fat content of cookies during storage is primarily due to oxidation of the fats, a process called lipid oxidation. Storage conditions, such as exposure to light, air, and high temperatures, accelerate this oxidation process. Due to moisture absorption from surrounding breakdown of fat molecules takes place (Andhale *et al*., 2021) [4].

The ash content of cookies increases with powder concentration and decreases with storage period. Throughout the storage period, treatment T_4 consistently shows the highest ash content, while treatment T_0 shows the lowest. During storage, ash content of treatment T_0 decreases from 1.46 to 1.10%, treatment T_1 from 1.50 to 1.22%, treatment T_2 from 1.56 to 1.35%, treatment T_3 from 1.63 to 1.47% and treatment T_4 from 1.71 to 1.60%, respectively. Ibrahium and Hegazy, (2014) [11] as well as Agu *et al*., (2020) [2] reported that ash content increases with increasing concentration of mushroom powder.

The carbohydrate content of cookies decreases with increase in powder concentration and storage. The treatment T_0 had highest carbohydrate content and treatment T_4 had lowest throughout the storage. During storage, the carbohydrate content of treatment T_0 decreases from 61.58 to 60.61%, treatment T_1 from 60.83 to 60.53%, treatment T_2 from 60.69 to 60.44%, treatment T_3 from 60.54 to 59.31% and treatment T_4 from 60.43 to 59.27%, respectively. Storage conditions such as high humidity may promote moisture absorption, altering the structure of carbohydrates and potentially leading to microbial growth, which can further reduce the carbohydrate content. The carbohydrate content decreases with increase in powder concentration (Agu *et al*., 2020; Andhale *et al*., 2021) [2, 4].

Table 4: Effect of storage on proximate composition of mushroom fortified cookies

Storage	Interaction	Moisture content (%)	Protein (%)	Crude Fibre (%)	Fat (%)	Ash (%)	CHO (%)
0 Days	$S0T_0$	2.09	8.66	1.69	25.53	1.46	61.58
	$S0T_1$	2.17	8.79	1.74	25.30	1.50	60.83
	$S0T_2$	2.23	8.92	1.82	25.09	1.56	60.69
	$S0T_3$	2.29	9.05	1.89	24.94	1.63	60.54
	$S0T_4$	2.32	9.20	1.95	24.79	1.71	60.43
30 Days	$S1T_0$	2.13	8.43	1.64	25.34	1.33	60.89
	$S1T_1$	2.31	8.52	1.66	25.26	1.46	60.80
	$S1T_2$	2.40	8.69	1.72	25.03	1.53	60.63
	$S1T_3$	2.49	8.81	1.79	24.87	1.60	60.50
	$S1T_4$	2.56	8.88	1.88	24.72	1.67	59.39
60 Days	$S2T_0$	2.50	8.08	1.50	25.19	1.16	60.74
	$S2T_1$	2.66	8.34	1.56	25.11	1.34	60.70
	$S2T_2$	2.79	8.58	1.60	24.96	1.43	60.57
	$S2T_3$	2.91	8.70	1.75	24.79	1.50	60.41
	$S2T_4$	3.02	8.83	1.78	24.59	1.63	59.31
90 Days	$S3T_0$	2.51	7.85	1.32	25.01	1.10	60.61
	$S3T_1$	2.72	8.09	1.41	24.90	1.22	60.53
	$S3T_2$	2.83	8.22	1.52	24.81	1.35	60.44
	$S3T_3$	2.93	8.51	1.64	24.70	1.47	59.31
	$S3T_4$	3.21	8.65	1.75	24.62	1.60	59.27
	SE(m) ±	0.05	0.16	0.03	0.16	0.03	0.37
	CD 5%	0.14	NS	0.07	NS	0.07	NS
	CV (%)	3.54	3.21	2.76	1.10	3.16	1.04

S_0-0th Days; S_1- 30th Days; S_3-60 Days; S_4-90 Days; T_0- Control cookies; T_1, T_2, T_3, T_4 - cookies with 2.5%, 5%, 7.5% and 10% mushroom powder

Effect of storage on textural properties of mushroom fortified cookies

The textural properties of cookies such as cutting force, crushing force and penetration force and results pertaining to the same are given in table 5. From table, it was observed that cutting force of cookies decreases with storage period and powder concentration. The treatment T_0 had highest cutting force and treatment T_4 had lowest throughout the storage period. During storage, the cutting force of treatment T_0 decreases from 60.27 to 54.63%, treatment T_1 from 57.39 to 52.76%, treatment T_2 from 54.21 to 50.13%, treatment T_3 from 51.81 to 47.54% and treatment T_4 from 50.76 to 46.60%, respectively. The decrease in cutting force of mushroom powder cookies during storage is often attributed to moisture migration and changes in the cookie structure. Over time, cookies tend to absorb moisture from the environment or redistribute internal moisture, leading to softening. These structural changes result in a reduced cutting force as the cookies become less rigid and easier to break or cut over time (Chauhan *et al*., 2016) [8].

The crushing force of cookies decreases with powder concentration and storage period. The treatment T_0 had highest crushing force and treatment T_4 had lowest crushing force throughout the storage period. During storage, the crushing force of treatment T_0 decreases from 49.08 to 48.05%, treatment T_1 from 48.33 to 47.82%, treatment T_2 from 47.95 to 47.55%, treatment T_3 from 47.48 to 46.96% and treatment T_4 from 46.88 to 46.43%, respectively. The decrease in the crushing force of mushroom powder cookies is mainly due to the disruption of the gluten network. Increased moisture retention and reduced cohesiveness contribute to lower crushing force Kaur *et al*. (2017) [13].

The penetration force of cookies decreases with powder concentration and storage. The treatment T_0 consistently showed the highest penetration force throughout the storage period while T_4 showed lowest penetration force. During storage, the crushing force of treatment T_0 decreases from 28.41 to 23.61%, treatment T_1 from 26.27 to 22.53%, treatment T_2 from 24.57 to 20.66%, treatment T_3 from 22.89 to 19.07% and treatment T_4 from 21.51 to 18.52%, respectively. Mushroom powder contains dietary fibres that disrupt the gluten network in the dough, leading to a softer, less cohesive texture. This weakens the overall structure. Consequently, these factors reduce the hardness, resulting in a lower penetration force during texture analysis. The results of this study are in line with the findings reported by Shams

et al., (2023) [26] that the cookies fracturability and hardness reduced as the amount of mushroom powder increased. The decrease in the penetration force of cookies during storage is primarily due to moisture absorption from the surrounding environment. The rise in moisture has an impact on the textural properties of the cookies (Romani *et al.*, 2016) [24].

Table 5: Effect of storage on textural properties of mushroom fortified cookies

Storage	Interaction	Cutting Force (N)	Crushing Force (N)	Penetration Force (N)
0 Days	$S0T_0$	60.27	49.08	28.41
	$S0T_1$	57.39	48.33	26.27
	$S0T_2$	54.21	47.95	24.57
	$S0T_3$	51.81	47.48	22.89
	$S0T_4$	50.76	46.88	21.51
30 Days	$S1T_0$	58.40	49.00	26.97
	$S1T_1$	55.67	48.28	25.73
	$S1T_2$	53.27	47.83	23.64
	$S1T_3$	49.21	47.34	22.41
	$S1T_4$	48.63	46.75	20.79
60 Days	$S2T_0$	56.21	48.85	25.67
	$S2T_1$	54.37	48.13	23.88
	$S2T_2$	51.90	47.65	22.66
	$S2T_3$	48.80	47.15	21.34
	$S2T_4$	47.22	46.55	19.67
90 Days	$S3T_0$	54.63	48.05	23.61
	$S3T_1$	52.76	47.82	22.53
	$S3T_2$	50.13	47.55	20.66
	$S3T_3$	47.54	46.96	19.07
	$S3T_4$	46.60	46.43	18.52
	SE(m) ±	0.59	0.30	0.35
	CD @ 5%	1.65	NS	0.98
	CV (%)	1.96	1.07	2.66

S_0-0th Days; S_1- 30th Days; S_3-60 Days; S_4-90 Days; T_0- Control cookies; T_1, T_2, T_3, T_4 - cookies with 2.5%, 5%, 7.5% and 10% mushroom powder

Effect of storage on sensory characteristics of mushroom fortified cookies

One of the most important indicators for evaluating the acceptability of food products is sensory evaluation (Lafta *et al*., 2019) [16]. The cookies made up with mushroom powder were tested for colour, appearance, texture, flavour and overall acceptability during storage period of three months. The corresponding results are given in Table 6. Table observation revealed that, sensory scores of cookies with various treatment combinations decreased across the storage period of 90 days. Increasing mushroom powder tends to enhance sensory scores. The treatment T_2 (5% mushroom powder) had the highest scores across most parameters. As storage duration increases, the scores for all treatments decrease, but treatment T_2 maintains relatively higher scores even after 90 days of storage. The effect of individual parameters as well as their interactive effect was significant at $p<0.05$. Sensory scores for colour, appearance, texture, flavour were decreased from 8.52 to 7.77, 8.57 to 8.04, 8.46 to 7.91, 8.34 to 7.84, respectively and the overall acceptability scores varied from 8.47 to 7.88 during storage period of three months.

Lipid oxidation is a common issue during storage, especially in baked goods. Fresh mushroom powder contains certain volatile compounds responsible for its unique flavour. These compounds can degrade over time, leading to a loss of flavour intensity. Mushroom powder contains pigments, which can undergo chemical changes during storage due to exposure to light, oxygen, or humidity. This could result in a less appealing appearance over time, contributing to lower colour and appearance scores Okafor *et al*. (2012) [20]. The combination of the factors such as moisture loss, oxidation, staling, degradation of flavours, and potential microbial or enzymatic changes causes a decline in the sensory quality of mushroom powder cookies over the three-month storage period.

Table 6: Effect of storage on sensory characteristics of mushroom fortified cookies

Storage	Interaction	Colour	Appearance	Texture	Flavour	Overall acceptability
0 Days	$S0T_0$	7.88	7.91	7.82	7.76	7.86
	$S0T_1$	8.14	8.14	8.08	8.00	8.13
	$S0T_2$	8.52	8.57	8.46	8.34	8.47
	$S0T_3$	8.32	8.35	8.21	8.15	8.28
	$S0T_4$	8.00	8.03	7.94	7.88	7.98
30 Days	$S1T_0$	7.85	7.79	7.66	7.60	7.61
	$S1T_1$	7.94	7.92	7.89	7.93	7.90
	$S1T_2$	8.22	8.37	8.23	8.22	8.17
	$S1T_3$	8.04	8.15	8.05	8.06	8.04
	$S1T_4$	7.87	7.91	7.77	7.77	7.75
60 Days	$S2T_0$	7.40	7.63	7.47	7.40	7.48
	$S2T_1$	7.64	7.89	7.81	7.74	7.75
	$S2T_2$	7.92	8.16	8.10	8.04	8.08
	$S2T_3$	7.80	8.03	7.95	7.88	7.84
	$S2T_4$	7.52	7.75	7.66	7.57	7.60
90 Days	$S3T_0$	7.37	7.37	7.30	7.25	7.29
	$S3T_1$	7.53	7.77	7.59	7.54	7.57
	$S3T_2$	7.77	8.04	7.91	7.84	7.88
	$S3T_3$	7.64	7.90	7.76	7.67	7.74
	$S3T_4$	7.44	7.59	7.48	7.42	7.44
	SE(m) ±	0.05	0.07	0.06	0.06	0.06
	CD @ 5%	0.15	0.20	0.18	0.15	0.17
	CV (%)	1.16	1.57	1.40	1.23	1.35

S_0-0th Days; S_1- 30th Days; S_3-60 Days; S_4-90 Days; T_0- Control cookies; T_1, T_2, T_3, T_4- cookies with 2.5%, 5%, 7.5% and 10% mushroom powder

Conclusion

The results indicate that the cookies weight and thickness decrease with increasing mushroom powder concentration from 2.5 to 10%, while diameter and spread ratio increases. The proximate analysis of mushroom fortified cookies shows that moisture content increases with storage period and protein, fibre, fat, ash, and carbohydrate content decreases. Higher mushroom powder concentrations enhancing protein, fibre, and ash levels but reducing fat and carbohydrate levels throughout the storage period. The textural properties of cookies, including cutting, crushing, and penetration forces, decreases with increasing mushroom powder concentration and storage time due to disrupted gluten structure, moisture absorption, and changes in cookies cohesiveness and rigidity. Sensory evaluation scores for cookies with mushroom powder decreases over 90 days of storage, with 5% mushroom powder (T_2) consistently achieving the highest scores across parameters, indicating better acceptability even after prolonged storage. Thus, the results shows that the best quality cookies were prepared with 5% mushroom powder i.e. treatment T_2 (WF:FMF:MP-80:15:5) were found to be best in respect of physical properties, proximate analysis, textural and sensory parameters during storage period of 90 days.

References

1. A.A.C.C. Approved methods of the American Association of Cereal Chemists. 10th ed. St. Paul, MN, USA; 2000. p. 914-918.
2. Agu HO, Onuoha GO, Elijah OE, Jideani VA. Consumer acceptability of acha and malted Bambara groundnut (BGN) biscuits sweetened with date palm. Heliyon. 2020;6(11):05522. https://doi.org/10.1016/j.heliyon.2020.e05522.
3. Alpaslan M, Hayta H. The effect of soy and corn flours on the textural and sensory properties of bakery product. J Food Qual. 2006;5:617-627.
4. Andhale SS, Kotecha PM, Chavan UD, Katte AT. Studies on nutritional quality of mushroom powder cookies. The Pharma Innov J. 2021;10(12):1384-1388.
5. Arora B, Kamal S, Sharma VP. Nutritional and quality characteristics of instant noodles supplemented with oyster mushroom (*P. ostreatus*). J Food Process Preserv. 2018;42(2):13521.
6. Bello M, Oluwamukomi M, Enujiugha V. Nutrient composition and sensory properties of biscuit from mushroom-wheat composite flours. Arch Curr Res Int. 2017;9(3):1-11.
7. Biao Y, Chen X, Wang S, Chen G, Mcclements DJ, Zhao L. Impact of mushroom (*Pleurotus eryngii*) flour upon quality attributes of wheat dough and functional cookies-baked products. Food Sci Nutr. 2020;8(1):361-370.
8. Chauhan A, Saxena DC, Singh S. Physical, textural, and sensory characteristics of wheat and amaranth flour blend cookies. Cogent Food Agric. 2016;2(1):1125773.
9. Devi PV, Narzary P, Sharma D, Islam J, Sultana F. Effect of oyster mushroom on nutritional composition, shelf life and organoleptic characteristics of enriched cookies. Food Humanity. 2024;3:100357.
10. Harshavardhini B, Sharma PD. Drying characteristics of button mushroom. Int J Curr Microbiol App Sci. 2021;10(06):503-512.
11. Ibrahium M, Hegazy A. Effect of replacement of wheat flour with mushroom powder and sweet potato flour on nutritional composition and sensory characteristics of biscuits. Curr Sci Int. 2014;3(1):26-33.
12. Kalac P. Chemical composition and nutritional value of European species of wild growing mushrooms. In: Mushrooms: types, properties and nutrition. Nova Science Publishers; 2012. p. 130-151.
13. Kaur P, Sharma P, Kumar V, Panghal A, Kaur J, Gat Y. Effect of addition of flaxseed flour on nutritional, physicochemical, phytochemical and antioxidant

properties of cookies. J Saudi Soc Agric Sci. 2017. https://doi.org/10.1016/j.jssas.2017.12.004.
14. Kulthe AA, Thorat SS, Lande SB. Evaluation of physical and textural properties of cookies prepared from pearl millet flour. Int J Curr Microbiol App Sci. 2017;6(4):692-701.
15. Kumar K, Barmanray A. Nutritional evaluation and storage studies of button mushroom powder fortified biscuits. J Mushroom Res. 2007;16(1):31-35.
16. Lafta SS, Khairy HL, Hakim IM. Effect of fortified low-fat soft cheese with Arabic gum on physicochemical and rheological properties. Plant Arch. 2019;19(2):616-621.
17. Majeed M, Khan MU, Owaid MN, Khan MR, Shariati MA, Igor P, *et al*. Development of oyster mushroom powder and its effects on physicochemical and rheological properties of bakery products. J Microbiol Biotechnol Food Sci. 2017;6(5):1221.
18. Nadir HA, Al-Zubaidy AMA, Al-Rawi AAF, Ibrahim KJ. Nutritional value of white button mushroom (*Agaricus bisporus*) which is most widely consumed in Kurdistan Region-Iraq. Ibn Al-Haitham J Pure Appl Sci. 2020;33(2):1-10.
19. Nordiana AB, Rosli WW, Nizam WWA. The effect of oyster mushroom (*Pleurotus sajor-caju*) flour incorporation on the physicochemical quality and sensorial acceptability of pasta. Int Food Res J. 2019;26(4):1249-1257.
20. Okafor JNC, Okafor GI, Ozumba AU, Elemo GN. Quality characteristics of bread made from wheat and Nigerian oyster mushroom (*Pleurotus plumonarius*) powder. Pak J Nutr. 2012;11(1):5-10.
21. Owheruo JO, Edo GI, Oluwajuyitan DT, Faturoti AO, Martins IE, Akpoghelie PO, *et al*. Quality evaluation of value-added nutritious biscuit with high antidiabetic properties from blends of wheat flour and oyster mushroom. Food Chem Adv. 2023;3:100375.
22. Raghuramulu N, Nair MK, Kalyanasundaram S. A Manual of Laboratory Technique. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India; 1993. p. 69-72.
23. Rangaswamy R. A Textbook of Agricultural Statistics. 2nd ed. New Age International Publishers, New Delhi; 2010. p. 234-458.
24. Romani S, Rocculi P, Tappi S, Rosa M. Moisture adsorption behaviour of biscuit during storage investigated by using a new dynamic dew point method. Food Chem. 2016;195:97-103.
25. Salehi F. Characterization of different mushrooms powder and its application in bakery products: A review. Int J Food Prop. 2019;22(1):1375-1385. DOI: 10.1080/10942912.2019.1650765.
26. Shams R, Singh J, Dash KK, Dar AH, Pandiselvam R. Utilization of button mushroom (*Agaricus bisporus*) powder to improve the physiochemical and functional properties of cookies. Sustain Food Technol. 2023;1(2):306-318.
27. Sharoon M, Zafar I, Atta M, Arif M, Rafiq G, Anjum R. Effect of linseed oil substitution on physico-chemical properties of cookies. J Agric Res. 2014;52(3):425-437.
28. Singh B, Bajaj M, Kaur A, Sharma S, Sindhu J. Studies on development of high protein biscuits from composite flours. Plant Foods Hum Nutr. 1993;43(2):181-189.
29. Singh S, Kumar CG, Singh S. Production, processing, and consumption pattern of mushrooms. Ind Food Packer. 1995;14:38-47.
30. Sujitha R, Thirumani D. Physicochemical and sensory characteristics of value-added breakfast biscuits. Int J Adv Res. 2014;2(3):556-563.
31. Togay SO, Guneser O, Yuceer YK. Evaluation of physicochemical, microbiological, sensory properties and aroma profiles of goat cheeses provided from Canakkale. Int J Dairy Technol. 2017;70(4):514-525.
32. Valverde ME, Hernandez-Perez T, Paredes-Lopez O. Edible mushrooms: Improving human health and promoting quality life. Int J Microbiol. 2015;376387.