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PRODUCTION OF FUNCTIONAL LABNEH SUPPLEMENTED WITH MUSHROOM (*AGARICUS BISPORUS)* POWDER

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ABSTRACT: The purpose of this study was to manufacture functional Labneh supplemented with mushroom *(Agaricus bisporus)* powder as a source of antioxidant compounds to increase its health benefits. Labneh was made by adding mushroom powder at zero, 0.5, 1, 1.5, 2, 2.5 and 3%. Labneh treatments were stored at 6±1ºC for 28 days and analysed on days fresh, 7, 14, 21 and 28 of the storage period to evaluate its chemical, microbiological and sensory properties. The obtained results revealed that supplementing labneh treatments with mushroom powder caused a significant increase of total bacteria counts, streptococci, lactobacilli, titratable acidity, total solids, total protein, ash, carbohydrates, total phenolic contents and antioxidant activity, while decreased significantly pH values and preventing the growth of molds and yeasts. Addition of mushroom powder up to 1.5% did not significantly affect the organoleptic properties of labneh, while increasing the rate of supplementation above 1.5% caused a significant decrease of organoleptic scores. During storage period, there were no significant differences in total solids, fat, total protein, and ash of all labneh treatments, while pH, carbohydrates, total phenolic contents, and antioxidant activity decreased, and titratable acidity increased. Streptococci and lactobacilli counts of labneh treatments increased up to the seventh day of storage period, while total bacterial counts increased up to the fourteenth day of storage, then all counts declined as the storage period proceeded. According to the panelists, treatment T3 supplemented with 1.5% mushroom powder was the most acceptable**.**

Key words: Functional foods; Concentrated yoghurt; edible mushroom *(Agaricus bisporus)* powder; Antioxidant compounds; Sensory acceptance.

INTRODUCTION

Functional foods have physiological effects on human health and can help reduce chronic disease risk (Chen *et al*., 2012). Consequently, functional foods have been developed as a type of food that has a positive impact on the health of the host (Rogelj 2000). Functional food ingredients are beneficial ingredients that occur naturally in foods or are added to foods as functional ingredients, including carotenoids, dietary fibers, fatty acids, flavonoids, isothiocyanates, phenolic acids, prebiotics, and probiotics, vitamins and minerals (Guiné *et al*., 2011). Hence, adding spices and herbs to dairy products can help to provide functional dairy products with medicinal and nutritional value (El-Sayed and Youssef 2019).

Labneh is interesting dairy product in the Middle East, which called as cheese spread. It is a semi-solid fermented dairy product made by straining yoghurt until it reaches a total solids content of 23 - 25 %, a fat content of 8 -11 %, with typical acidity and the pH values are 1.4 to 2.5% and 3.86 to 4.17, respectively. Labneh has a creamy or white color, smooth texture, good spreadability, low syneresis, and a clean taste (Hilali *et al*., 2011, Aloğlu and Oner 2013). Fresh Labneh was stored in the refrigerator and consumed within two weeks (Keceli *et al*., 1999). Labneh is higher in protein and lower in sugar and carbohydrates than yogurt because the filtered whey is removed by straining. Many lifestyle diseases are caused by an imbalanced diet. Therefore, functional foods that can regulate body functions and prevent civilized lifestyle

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diseases have attracted much attention in recent years (Basiony *et al.*, 2017). *Agaricus bisporus* is the most popular and most commonly eaten species of edible mushroom in the world. It is popular not only for its taste, but also due to its abundant nutrients compounds, and vitamins. *A. bisporus* is also a rich source of selenium, zinc and other elements such as copper, magnesium, iron, potassium, calcium, sodium, phosphorus, manganese (Elmastas *et al*., 2007, Foulongne-Orio *et al*., 2013 and Muszyńska *et al*., 2015).

Mushrooms contain diverse medicinal properties including antioxidant, antihypertensive, and anticancer compounds. As a powerful antioxidant, mushrooms are very effective at scavenging free radicals due to their high polyphenol content (Ghasemi *et al*., 2022). Natural polyphenolic compounds may reduce the risk of Parkinson's, Alzheimer's and cardiovascular diseases. (Muszyńska *et al*., 2017).

Therefore, the aim of this study was to improve the chemical, microbiological and sensory properties of functional labneh manufactured using mushroom (Agaricus bisporus) powder.

MATERIALS AND METHODS

Materials

Fresh bulk Buffalo milk with 6.2% fat, 16.56% T.S, 4.58% protein, 0.92% ash, 0.18% acidity and pH 6.63 was obtained from the herd of the Faculty of Agriculture, Menoufia University, Shibin El.Kom, Egypt. Yoghurt starter culture consisting of *Streptococcus thermophilus* (EMCC 1043) and *Lactobacillus delbrueckii* subsp. *bulgaricus* (EMCC 1102) was obtained from Cairo Mircen, Ain Shams University, Egypt. *Streptococcus thermophiles and Lactobacillus delbrueckii* subsp. *bulgaricus* were activated individually by three successive transfers in sterile 10% reconstituted non-fat dry milk. White *Agaricus bisporus* was obtained from Shaza Mushroom Farm (Dr. Bahram Mahmoud), Tanta, Egypt. Salt was obtained from the local market, Shibin El-Kom, Menoufia, Egypt.

Preparation of mushroom powder

The fresh fruiting body of *Agaricus bisporus* was washed with water, cut into thin slices (about 3mm thick) with a knife, steam for 3 minutes (to prevent oxidative enzymes), soak in 0.5% citric acid solution for 30 minutes. Treated mushroom slices were put into an oven to dry them at 55°C±2°C until constant weight (24 hours) (Maray *et al.*, 2018). The dehydrated slices were electrically ground and passed through an 80-mesh sieve to obtain shiitake mushroom powder. The obtained powder was kept into a sterile bag and stored in refrigerator (6°C±1°C) until used. The chemical composition of mushroom powder is presented in Table (1).

Table (1). Total chemical composition of mushroom powder.

Components	Percentage (%)
Total solids	93.47
Protein	18.29
Total fat	3.78
Total carbohydrates	63.47
Total dietary fiber	13.64
Total ash	7.93
Antioxidant activity	79.4
Total phenolic compounds (mg gallic acid/100g)	620

Methods

Manufacture of labneh

Labneh was made according to the traditional method of Tamime and Robinson (1999). Fresh buffalo´s milk was standardized to 5.5 % fat, heated at 90 ºC for 15 min, then cooled to 42 ºC, and inoculated with 3% of the yoghurt starter (*Streptococcus thermophiles* and *Lactobacillus delbrueckii* subsp. *bulgaricus),* incubated at 42 ºC until complete coagulation. Fermented milk was cooled to 6 ºC ±1 overnight. The obtained coagulant is mixed evenly and packed into a cheese cloth bag, suspended in a refrigerator at 6°C ± 1 for 12 hours to drain the whey, and then fully mixed with 0.5% sodium chloride. The labneh was divided into seven batches, and dried mushroom was added to these batches (C, T1, T2, T3, T4, T5 and T6) at the rate of zero, 0.5, 1, 1.5, 2, 2.5 and 3 % respectively. Fresh labneh treatments were well mixed and packed into 100 gm plastic cups and stored at 6ºC ±1 for 28 days. Samples were taken from each labneh treatment weekly for evaluation of chemical, microbiological and sensory properties.

Chemical analysis

The fat content of mushroom powder samples was determined using Soxhlet extraction according to official method A.O.A.C. (2010). Dietary fiber content of mushroom powder samples was determined by acid-base digestion according to official method A.O.A.C. (2010). Refer to Ling (2008) for the determination of pH value, acidity and fat content in milk and labneh. Total solids, ash content and total protein content were determined as described in A.O.A.C. (2010). Carbohydrates (%) were calculated as follows: Carbohydrates (%) = Total solids (%) - [Fat (%) + Protein (%) + Ash (%)]. Total phenolic content was determined using Folin–Ciocalteu micro-method according to Allam *et al.* (2015). According to Tepe *et al.,* (2005) antioxidant activity was determined by 2, 2-diphenyl-1-picrylhydrazine (DPPH) radical scavenging activity. Tests were performed in triplicate.

Microbiological analysis

The total number of bacteria was determined using nutrient agar and incubated at 37ºC for 48 hours according to Difco, (1971). Streptococci was enumerated on M17 agar medium. The plates were incubated at 37ºC for 48 hrs according to Terzaghi and Sandine, (1975). Lactobacilli was enumerated on MRS medium. Plates were incubated at 37ºC for 48 hours according to Deman *et al.* (1960). Yeast and mold were enumerated on acidified potato dextrose agar medium. Plates were incubated at 25ºC for 5 days according to (APHA, 2005).

Sensory evaluation

The organoleptic properties of labneh treatments were assessed by ten panelists from the staff members and graduate students at the Department of Dairy Science and Technology and Department of Food Science and Technology, Faculty of Agriculture, Menoufia University. Scored values for flavor (60 points), body and texture (30 points) and appearance (10 points) as described by Salem *et al.* (2007).

Statistical analysis

Data were analyzed using a completely randomized block design and a 2 × 3 factorial design. The Newman-Keuls test was used for multiple comparisons using the Costat procedure (Steel and Torrie, 1980). Significant differences were identified at ($p \leq 0.05$).

RESULTS AND DISCUSSION

Chemical composition

Changes in acidity, pH value and total solids are presented in Table (2).

The obtained results showed that the titratable acidity of labneh treatments were significantly increased ($p \leq 0.05$) by adding mushroom powder (Tupamahu and Budiarso 2017). This increase was proportional to the added rate of mushroom powder. These results

may be due to the stimulating effect of mushroom powder on bacterial growth and subsequent acidity development (Synytsya *et al*., 2009 and Nowak *et al.,* 2018). On the other hand, titratable acidity increased significantly ($p \leq 0.05$) in all labneh treatments as the storage period progressed (Ragab, 2000 and Basiony *et al*. 2017). While pH followed an opposite trend to acidity, the pH of labneh treatments gradually decreased during storage period. Similar results were reported by Ersöz *et al.* (2011) and Zaky *et al.* (2013). On the other hand pH values of labneh treatments decreased significantly ($p \leq 0.05$) by adding mushroom powder. These results are in accordance with those reported by Tupamahu and Budiarso (2017) and Ali (2020). These results may be due to the fact that mushrooms are a source of carbohydrates, which are nutrients for the growth of lactic acid bacteria. Therefore, adding mushrooms stimulates the growth of lactic acid bacteria and increases acidity, which lowers the pH in the labneh. These results are consistent with those reported by Synytsya *et al*. (2009); Tupamahu and Budiarso (2017) and Nowak *et al.* (2018).

By supplementing labneh with mushroom powder, the total solids content of labneh was significantly increased (Table 2). This may be due to the high percentage of total solids in mushroom powder. Therefore, the curd retained all the amount added from mushroom powder (El-Sayed *et al.*, 2017 and Aly *et al.*, 2020). On the other hand, there was no significant difference ($p > 0.05$) in total solids content among all labneh treatments during storage period. Similar trends were reported by Habib *et al*. (2017) ; Nasser *et al*. (2017) and Balabanova *et al*. (2020).

Supplementation of labneh with mushroom powder caused a slight significant difference ($P \leq 0.05$) in protein content of the resultant treatments (Table 3). Supplementation of labneh with mushroom powder increased the protein content, which might be due to the higher protein content of mushroom (Table 1) Abou Raya *et al.,* (2014); Amabye and Bezabh (2015) and Gonzále *et al.,* (2020). Protein content also did not significantly ($p \leq 0.05$) changed across all treatments throughout the storage period. These results are consistent with those of Habib *et al*. (2017) and Aly *et al.* (2020).

The fat content of labneh treatments was not significantly affected ($p \leq 0.05$) by supplementing labneh with mushroom powder (Table 3), this may be due to the low fat content of mushroom powder (Feeney *et al*., 2014). Also, fat content of labneh treatments didn´t change significantly ($p > 0.05$) during the storage period. These results are consistent with those of Tamime and Robinson (2007); Desouky *et al*. (2013); Habib *et al*. (2017) and Balabanova *et al.* (2020).

The ash content was slightly increased ($p \leq 0.05$) by supplementing the labneh treatments with mushroom powder (Table 3). This possibly because mushroom is a rich source of minerals such as potassium, phosphorus, calcium, magnesium, zinc, iron, copper and selenium (Mattila *et al.,* 2001; Vetter 2003; Muszyńska *et al.*, 2015 and Rzymski *et al.*, 2016). On the other hand, ash contents did not changed significantly ($p \leq 0.05$) during refrigerated storage period. These results are in accordance with those reported by Tamime and Robinson (2007); Habib *et al.* (2017) and Balabanova *et al.* (2020).

By increasing the rate at which the labneh treatments were supplemented with mushroom powder, the carbohydrate content of treatments was significantly increased (Table 4). This increase might be due to the fact that carbohydrates are the most abundant nutrients in mushroom. As shown in Table (1) mushroom powder contains about 63.47% of carbohydrates. These results are in agreement with those obtained by Rafiq and Ghosh (2017); Khider *et al.* (2017) and Shalaby *et al.* (2018). Carbohydrates content of labneh treatments decreased significantly ($p \leq 0.05$) as storage period proceeded. This reduction may be due to some carbohydrates being fermented by the microbiota in the labneh (Fathi *et al*., 2005).

Table (2). Changes in titratable acidity, pH value and total solids in functional labneh as affected by adding mushroom during storage (6°C ±1).

Treatments	Storage period (days)					Means**
	Fresh	7	14	21	28	
Titratable acidity (%)						
C*	1.26	1.32	1.43	1.45	1.49	1.39^{F}
T_1	1.26	1.30	1.41	1.45	1.51	1.38^{EF}
T_2	1.30	1.36	1.43	1.48	1.55	1.42^{E}
T_3	1.34	1.40	1.44	1.51	1.53	1.44^{D}
T_4	1.39	1.42	1.46	1.53	1.56	1.47^{C}
T_5	1.42	1.46	1.48	1.57	1.64	1.51^{B}
T_6	1.48	1.53	1.55	1.62	1.68	1.57^{A}
Means**	1.56^{a}	1.51^{b}	1.45^{c}	1.39^{d}	1.35^{e}	
pH value						
C*	4.56	4.46	4.38	4.38	4.33	4.42^{A}
T_1	4.49	4.43	4.32	4.33	4.21	4.35^{AB}
T_2	4.42	4.38	4.30	4.29	4.20	4.31^{B}
T_3	4.42	4.38	4.32	4.30	4.20	4.32^{C}
T_4	4.38	4.36	4.30	4.25	4.18	4.29^{D}
T_5	4.38	4.32	4.30	4.22	4.18	4.28^{E}
T_6	4.38	4.34	4.32	4.26	4.22	4.30^{F}
Means**	4.43^{a}	4.38^{b}	4.32^{c}	4.29^{c}	4.21^{d}	
Total solids(%)						
C*	25.78	25.90	26.13	26.26	26.48	26.11^{G}
T_1	26.25	26.33	26.41	26.49	26.56	26.40^{F}
T_2	26.70	26.78	26.83	26.94	26.98	26.84^{E}
T_3	27.24	27.28	27.34	27.39	27.43	27.33^{D}
T_4	27.66	27.78	27.93	27.98	28.06	27.88^{C}
T_5	28.09	28.17	28.33	28.42	28.51	28.30^{B}
T_6	28.63	28.72	28.86	28.91	28.98	28.82^{A}
Means**	27.19^{a}	27.28^{a}	27.40^{a}	27.48^{a}	27.57^{a}	

*C: control labneh without mushroom powder.

T1 ,T2 ,T3 ,T4 ,T5 and T6 labneh treatments made by adding , 0.5, 1, 1.5, 2, 2.5 and 3 % mushroom powder respectively.

- Means with different small superscripts in the same row means that treatments are different during storage period, while means with different capital superscripts in the same columns means that treatments are significantly different at significant level 0.05%.

Table (3). Changes in protein, Fat and ash in functional labneh as affected by adding mushroom during storage (6°C ±1).

Treatments	Storage period (days)					Means**
	Fresh	7	14	21	28	
Protein(%)						
C*	10.18	10.23	10.29	10.32	10.36	10.27^{D}
T_1	10.27	10.39	10.42	10.49	10.54	10.42^{D}
T_2	10.38	10.52	10.58	10.61	10.65	10.54^{CD}
T_3	10.49	10.56	10.63	10.66	10.71	10.61^{BC}
T_4	10.63	10.72	10.81	10.88	10.94	10.79^{AB}
T_5	10.72	10.76	10.84	10.88	10.96	10.83^{AB}
T_6	10.83	10.89	10.96	10.98	11.06	10.94^{A}
Means**	10.50^{a}	10.58^{a}	10.64^{a}	10.68^{a}	10.74^{a}	
Fat (%)						
C*	11.40	11.40	11.60	11.70	11.80	11.58^{A}
T_1	11.40	11.40	11.50	11.60	11.70	11.52^{A}
T_2	11.50	11.50	11.60	11.80	11.80	11.64^{A}
T_3	11.60	11.70	11.70	11.80	11.90	11.74^{A}
T_4	11.70	11.80	11.80	11.90	12.00	11.84^{A}
T_5	11.70	11.70	11.90	12.00	12.10	11.88^{A}
T_6	11.90	11.90	12.00	12.20	12.20	12.04^{A}
Means**	11.6^{a}	11.62^{a}	11.72^{a}	11.85^{a}	11.92^{a}	
Ash(%)						
C*	1.12	1.15	1.19	1.26	1.35	1.21^{C}
T_1	1.18	1.21	1.27	1.31	1.38	1.27^{C}
T_2	1.26	1.33	1.40	1.43	1.47	1.37^{BC}
T_3	1.32	1.37	1.43	1.48	1.56	1.43^{BC}
T_4	1.37	1.43	1.50	1.56	1.61	1.49^{AB}
T_5	1.43	1.48	1.56	1.63	1.68	1.55^{AB}
T_6	1.49	1.56	1.63	1.70	1.77	1.63^{A}
Means**	1.31^{a}	1.36^{a}	1.42^{a}	1.48^{a}	1.54^{a}	

• Refer to the footnotes under Table 2.

Supplementation of labneh with mushroom powder resulted in a significant increase ($p \leq 0.05$) of total phenolic compounds content and antioxidant activity (Table 4). These results might be due to the highest content of phenolic acids, ergothioneine, β-carotene and β-glucans also exhibit antioxidant properties, histidine derivative which is one of the strongest antioxidants, as well as vitamin C and E which act as antioxidant agents (Chen *et al*., 2012; Liu *et al.,* 2013; Ghahremani-Majd & Dashti, 2015 and Muszyńska *et al.,* 2017).

The total phenolic compound content and antioxidant activity of labneh treatment decreased significantly ($p \leq 0.05$) as storage period advanced. Similar results were reported by El-Sayed *et al.* (2017); Mohamed *et al.* (2018) and Heba *et al.* (2022). The decrease in total phenolic compounds throughout storage may be due to protein-polyphenol interactions (Viljanen *et al.*, 2004) and Tseng and Zhao (2013). In addition, the decrease in antioxidant activity throughout the storage period may be due to accelerated oxidation by oxygen, resulting in a decrease in antioxidant activity due to the removal of active oxygen species . (Sagdic *et al.*, 2011) and/or the interaction of phenolic compounds with protein, which masked the antioxidant activity Arts *et al*. (2002) reported that the masking depends on the type and amount of protein and bioactive compound.

Microbiological properties

From Table (5), it can be clearly seen that all labneh treatments with added mushroom showed a significant increase ($p \leq 0.05$) in total bacteria, Streptococcus and Lactobacillus counts (Mohamed *et al.*, 2018; Sakul *et al.*, 2020 and Heba *et al.*, 2022). The increase in total bacteria counts may be due to the stimulating effect of mushroom powder containing many ingredients that stimulate bacterial growth (Synytsya *et al.*, 2009 and Nowak *et al*., 2018) and/or the microbial community present in the mushroom powder itself (Elsanhoty and Ramadan, 2018). Meanwhile, the higher counts of Streptococcus and Lactobacillus may be due to that mushrooms containing carbohydrates and dietary fiber, which are considered prebiotics. In addition, mushrooms contain beta-glucan, which acts as a prebiotic and promotes the growth of lactic acid bacteria (Tupamahu & Budiarso, 2017). On the other hand, total bacteria counts gradually increased during the storage period reached the highest level at the 14^{th} day of storage period, and then decreased as storage period advanced (Table 5), which might be due to the effect of developed acidity. These results agree with those of Al-Otaibi and El- Demerdash (2008); Basiony *et al*. (2017); Zaky *et al.* (2013); Elsanhoty and Ramadan (2018) and Heba *et al.* (2022). Whereas the counts of Streptococci and Lactobacilli in the labneh treatments increased up to the seventh day of the storage period and then decreased as the storage period progressed. These results are in agreement with those of Badran (2004); Kebary *et al.* (2004); Kebary *et al.* (2009); Zaky *et al*. (2013) and Basiony *et al.* (2017).

It is worthy noted that mold and yeast did not detected at the end of the storage period of labneh treatments (Table 6), which may be due to the good hygienic conditions followed during the manufacture of labneh (El-Sayed *et al.*, (2017); Habib *et al.* ,(2017) and Nasser *et al.*, (2017). On the other hand, molds and yeast did not detected in labneh treatments containing mushroom powder (Thabet *et al*., 2014), which is most likely related to the inhibitory components of the mushroom powder, such as the peptide eryngin and the polypeptide alveolin. Some researchers have shown that mushrooms have antifungal activity (Wang *et al*., 2004; Turkoglu *et al*., 2006; Solak *et al*., 2006 and Öztürk *et al.*, 2011).

Organoleptic properties

Table (7) shows the evaluation of organoleptic properties (flavor, body and texture, appearance) of the labneh treatments during storage. It can be clearly noticed that the addition of mushroom powder up to 1.5% in labneh has no significant effect ($P > 0.05$) on the organoleptic properties scores. The score then droped as the supplementation rate increased. This reduction is mainly due to the color changes of the resulting labneh treatments (Table 7). Mushrooms turn brown during processing, so labneh resulted in a color change that reduced their organoleptic scores (Fathi *et al.*, 2005). On the other hand the scores of organoleptic properties of all labneh treatments did not change significantly ($P>0.05$) during the first week of storage period after that the scores decreased slightly up to the end of storage period (Kebary *et al.*, 2004; Al-Hamdani *et al.*, 2015; Atwaa *et al.*, 2020; and Heba *et al.*, 2022).

Table (4). Changes in carbohydrates, total phenolic compounds and antioxidant activity in functional labneh as affected by adding mushroom during storage (6°C ±1).

Treatments	Storage period (days)					Means**
	Fresh	7	14	21	28	
Carbohydrates (%)						
C*	3.08	3.12	3.05	2.98	2.97	3.04^{G}
T_1	3.4	3.33	3.22	3.09	2.94	3.19^{F}
T_2	3.56	3.43	3.25	3.1	3.06	3.28^{E}
T_3	3.83	3.65	3.58	3.45	3.26	3.554^{D}
T_4	3.96	3.83	3.82	3.64	3.51	3.75^{C}
T_5	4.24	4.23	4.03	3.91	3.77	4.03^{B}
T_6	4.41	4.37	4.27	4.03	3.95	4.206^{A}
Means**	3.78^{a}	3.70^{b}	3.60^{c}	3.45^{d}	3.35^{e}	
Total phenolic compounds (mg gallic acid/100g labneh)						
C*	6.09	5.13	4.93	4.02	3.68	4.77^{G}
T_1	9.36	7.98	6.87	5.19	4.16	6.71^{F}
T_2	13.07	11.69	9.81	8.02	6.73	9.86^{E}
T_3	17.25	14.06	12.09	11.36	9.02	12.75^{D}
T_4	21.09	18.93	15.76	13.08	11.01	15.97^{C}
T_5	26.34	21.78	19.27	17.13	14.09	19.72^{B}
T_6	29.46	26.30	23.01	20.18	16.53	23.09^{A}
Means**	17.52^{a}	15.12^{b}	13.10^{c}	11.28^{d}	9.31^{e}	4.77^{G}
Antioxidant Activity(%)						
C*	18.36	14.18	10.30	9.01	7.03	11.77^{G}
T_1	30.51	25.32	21.69	15.31	10.64	20.69^{F}
T_2	37.86	28.16	24.36	19.73	15.01	25.02^{E}
T_3	48.03	39.15	30.83	26.11	19.92	32.80^{D}
T_4	53.51	44.56	38.13	30.85	26.31	38.67^{C}
T_5	56.08	48.03	43.32	36.25	31.56	43.04^{B}
T_6	61.31	53.99	51.52	41.66	36.15	48.92^{A}
Means**	43.66^{a}	36.19^{b}	31.45^{c}	25.56^{d}	20.94^{e}	

• Refer to the footnotes under Table 2.

Table (5). Changes in microbiological properties in functional labneh as affected by adding mushroom during storage period (6°C ±1).

Treatments	Storage period (days)					Means**
	Fresh	7	14	21	28	
Total bacteria counts of (CFU×10^7\gm)						
C*	73	88	102	96	74	86.6^{G}
T_1	78	96	113	98	83	93.6^{F}
T_2	89	102	125	109	92	103.4^{E}
T_3	93	109	131	118	101	110.4^{D}
T_4	95	117	136	122	106	115.2^{C}
T_5	100	122	143	129	112	121.2^{B}
T_6	103	120	145	133	122	124.6^{A}
Means**	90.14^{e}	107.71^{c}	127.85^{a}	115^{b}	98.57^{d}	
Lactobacilli Counts (CFU×10^7\gm)						
C*	66	72	78	51	48	63^{G}
T_1	73	88	80	63	52	71.2^{F}
T_2	73	92	86	67	55	74.6^{E}
T_3	78	99	90	73	55	79^{D}
T_4	80	103	95	73	60	82.2^{C}
T_5	80	105	95	77	63	84^{B}
T_6	85	111	101	82	72	90.2^{A}
Means**	76.42^{c}	95.71^{a}	89.28^{b}	69.42^{d}	57.85^{e}	
Streptococci counts (CFU×10^7\gm)						
C*	53	68	62	51	42	55.2^{G}
T_1	58	73	68	56	46	60.2^{F}
T_2	60	78	70	61	50	63.8^{E}
T_3	63	86	76	61	53	67.8^{D}
T_4	69	93	88	77	60	77.4^{C}
T_5	73	101	93	78	62	81.4^{B}
T_6	73	113	98	83	65	86.4^{A}
Means**	64.14^{d}	87.42^{a}	79.28^{b}	66.71^{c}	54^{e}	

• Refer to the footnotes under Table 2.

Table (6). Effect of adding mushroom powder and storage period on counts of mould and yeast (CFU×10^2\gm) of functional labneh.

Treatments•	Storage period(days)				
	Fresh	7	14	21	28
	Mold and yeast counts (CFU×10^2\gm)				
C*	ND	ND	ND	8	11
T1	ND	ND	ND	ND	9
T2	ND	ND	ND	ND	ND
T3	ND	ND	ND	ND	ND
T4	ND	ND	ND	ND	ND
T5	ND	ND	ND	ND	ND
T6	ND	ND	ND	ND	ND

• Refer to the footnotes under Table 2.
ND: Not detected

Table (7). Effect of adding mushroom powder and storage period on the organoleptic properties of functional labneh.

Treatments*	Flavour (60)					Body and Texture (30)					Appearance (10)					Total Scores (100)				
	Storage period (days)																			
	Fresh	7	14	21	28	Fresh	7	14	21	28	Fresh	7	14	21	28	Fresh	7	14	21	28
C*	56^{Aa}	56^{Ab}	52^{Ac}	50^{Ad}	48^{Ae}	27^{Aa}	25^{Aa}	25^{Aa}	22^{Ab}	20^{Ae}	9^{Aa}	9^{Aa}	9^{Ab}	8^{Ac}	7^{Ad}	92^{Aa}	90^{Aab}	86^{Abc}	80^{Acd}	75^{Ad}
T_1	56^{Aa}	55^{Ab}	52^{Ac}	51^{Ad}	48^{Ac}	27^{Aa}	25^{Aa}	25^{Aa}	25^{Ab}	22^{Ac}	9^{Aa}	9^{Aa}	8^{Ab}	8^{Ac}	7^{Ad}	92^{Aa}	89^{Aab}	85^{Abc}	84^{Acd}	77^{Ad}
T_2	55^{ABa}	54^{ABb}	51^{ABc}	50^{ABd}	46^{ABe}	27^{ABa}	26^{ABa}	25^{ABa}	23^{ABb}	23^{ABc}	9^{ABa}	9^{ABa}	8^{ABb}	8^{ABc}	8^{ABd}	91^{Aa}	89^{Aab}	84^{Abc}	81^{Acd}	77^{Ad}
T_3	53^{Ba}	52^{Bb}	52^{Bc}	50^{Bd}	47^{Be}	27^{ABa}	26^{ABa}	24^{ABa}	23^{ABb}	22^{ABc}	9^{Ba}	8^{Ba}	8^{Bb}	7^{Bc}	7^{Bd}	89^{ABa}	86^{ABab}	84^{ABbc}	80^{ABcd}	76^{ABd}
T_4	52^{Ca}	50^{Cb}	47^{Cc}	45^{Cd}	45^{Ce}	25^{BCa}	25^{BCa}	24^{BCa}	23^{BCb}	22^{BCc}	8^{Ca}	7^{Ca}	6^{Cb}	6^{Cc}	6^{Cd}	85^{BCa}	80^{BCab}	77^{BCbc}	74^{BCcd}	71^{BCd}
T_5	48^{Da}	46^{Db}	46^{Dc}	43^{Dd}	43^{De}	25^{CDa}	25^{CDa}	23^{CDa}	23^{CDb}	22^{CDc}	6^{Da}	6^{Da}	6^{Db}	6^{Dc}	5^{Dd}	79^{Da}	77^{Dab}	72^{Dbc}	72^{Dcd}	70^{Dd}
T_6	46^{Ea}	45^{Eb}	45^{Ec}	43^{Ed}	43^{Ee}	23^{Da}	23^{Da}	22^{Da}	22^{Db}	20^{Dc}	6^{Ea}	6^{Ea}	6^{Eb}	5^{Ec}	5^{Ed}	75^{Ea}	74^{Eab}	79^{Ebc}	70^{Ecd}	68^{Ed}

* Refer to the footnotes under Table 2.

Conclusion

Mushrooms are considered a rich source of protein, carbohydrates, vitamins, minerals, and phenolic compounds with antioxidant activity. Hence, it is possible to make a good-quality labneh by adding up to 1.5% powder mushroom (*Agaricus bisporus*) without adversely affecting the quality of the labneh.

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إنتاج اللبنة الوظيفية المدعمة بمسحوق فطر عيش الغراب (*Agaricus bisporus*)

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الملخص العربى

كان الهدف الرئيسي من هذه الدراسة هو تصنيع لبنة وظيفية مدعمة بمسحوق فطر عيش الغراب القبعي (*Agaricus bisporus*) كمصدر للمركبات المضادة للأكسدة. تم تدعيم اللبنة بمسحوق الفطر بنسب صفر، ١,٠، ١,٥، ٢,٠، ٢,٥، ٣,٠٪، وتم تخزين معاملات اللبنة علي درجة حرارة ٦ ± ١ درجة مئوية لمدة ٢٨ يومًا ، وتم أخذ عينات منها أثناء فترات التخزين طازج و ٧ و ١٤ و ٢١ و ٢٨ يومًا لتقييم الصفات الكيميائية والميكروبيولوجية والحسية. أظهرت النتائج المتحصل عليها ان إضافة مسحوق الفطرالي اللبنة أدي في زيادة معنوية في العدد الكلي للبكتيريا وأعداد بكتيريا Streptococci, Lactobacilliونسبة الحموضة والجوامد الصلبة الكلية ومحتوى الكربوهيدرات والمركبات الفينولية الكُلية والنشاط المضاد للأكسدة ومنع نمو الفطريات والخمائر. بينما انخفضت قيم الأس الهيدروجيني معنويا مع وجود فروق معنوية طفيفة في نسبة البروتين الكُلي والرماد، ولم يكن له تأثير معنوي على نسبة الدهن. لم يُؤثر تدعيم اللبنة بمسحوق الفطر حتى نسبة إضافة ١,٥٪ معنويًا على درجات التحكيم الحسّي، ثم انخفضت هذه الدرجات مع زيادة مُعدل إضافة مسحوق الفطر أعلى من ذلك. من ناحيةٍ أخرى، لم تتغير درجات التحكيم الحسي لجميع مُعاملات اللبنة بشكلٍ ملحوظ خلال الأسبوع الأول من فترة التخزين بعد ذلك انخفضت الدرجات بشكلٍ طفيف حتى نهاية فترة التخزين. لم يتغير محتوى الجوامد الصلبة الكلية ، محتوى الدهون ، البروتين الكلي ، محتوى الرماد بين جميع معاملات اللبنة أثناء التخزين بشكل ملحوظ ، بينما قيم الأس الهيدروجيني، محتوى الكربوهيدرات ، والمركبات الفينولية الكُلية والنشاط المضاد للأكسدة انخفضت مع تقدم فترة التخزين، وزادت نسبة حموضة. كما زاد عدد بكتيريا Streptococci, Lactobacilli حتى اليوم السابع من التخزين، في حين زاد العدد الكُلي للبكتيريا في مُعاملات اللبنة حتى اليوم الرابع عشر من التخزين، ثم انخفضت الأعداد بعد ذلك خلال فترة التخزين. تم قبول مُعاملات اللبنة من قِبَل أعضاء لجنة التحكيم، وكانت المُعاملة الأكثر قبولاً T3 التي تمت بإضافة ١,٥٪ من مسحوق فطر عيش الغراب القبعي.