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The Effect of Mushroom Stalk Powder on Proprieties of Low- Fat Probiotic Soft Cheese

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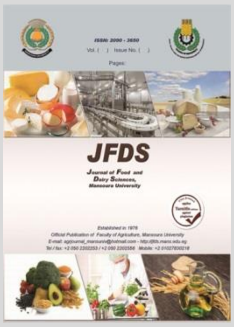

ABSTRACT

The effect of adding mushroom stalk powder as a source of antioxidants and fiber on the quality of low fat probiotic soft cheese was studied. Mushroom stalk powder was added to low fat milk (1 % fat) cheese at levels of 2 and 4 %. Results showed that addition of mushroom stalk powder to low fat probiotic soft cheese has a minimal impact on the fat content but had a positive impact on the total solids, protein, and fibre contents. Additionally, it boosted the amount of total volatile fatty acids and soluble nitrogenous compounds (flavour compounds) in the cheese treatments. Also, additions of mushroom stalk powder, improved rheological properties (curd tension). On the other hand, addition of mushroom stalk powder increased the phenolic content, antioxidant activity and organoleptic properties of low fat probiotic soft cheese. Overall, the low fat probiotic cheese with 1% fat containing 2 or 4 % mushroom stalk powder were similar in quality characteristics to the control of full fat cheese (4% fat). According to the results obtained in this work, we can recommend using mushroom stalk powder at level of 4 % for improving the proprieties of low- fat soft cheese and simulated products such as phenolic content, antioxidant activity, dietary fiber and organoleptic proprieties.

***Keywords*:** dairy products, probiotic bacteria, low-fat cheese, health factors

INTRODUCTION

In the world, there are more than 5000 different types of cheese, which can be categorised according to factors like flavour, colour, ripening, moisture, starter culture, manufacturing process, etc. By compressing milk numerous times, cheese is the earliest method of milk preservation (Varnam and Sutherland, 2009). The concentrated form of milk solids, primarily fat and milk protein is known as cheese. Cheese's structure (texture) is created by the protein and fat interconnecting (Omotosho *et al*., 2011). Despite the importance of fat in the production of cheese and the creation of its texture, excessive consumption of saturated fatty acids has been linked to a number of health issues in humans, including memory loss, arthritis, cardiovascular issues, high cholesterol, and obesity (Murtaza *et al*., 2022). Due to their changing lifestyles, consumers now have particular health concerns, such as eating less sugar, fat, and calories. Low-fat cheese is becoming more and more popular every day. On the basis of content, reduced and low fat cheeses are sought, but frequently fall short in terms of general quality (Murtaza, 2016). Several of the primary troubles with fat decline in cheese include the expansion of a firm texture that does not break down through eating, a weak gel network among fat and protein, a weak flavour and taste, and yield loss, all of which are unfavorable (Correll, 2011). Constituents referred to as "fat replacers" are those that are meant to be used in place of natural fats with the goal of lowering calorie content.

Numerous studies have been conducted on the use of plant fibres to enhance the textural and functional qualities of low-fat cheese (Aydinol & Ozcan., 2018: Murtaza *et al*, 2022). Yogurt and cheese are examples of dairy products that lack fiber and have little phenolic content. Numerous efforts have been made to support dairy products with fiber and natural antioxidants, which has had a positive effect and represented a novel method to the development of dairy products (Tizghadam *et al*, 2021: Ribeiro *et al*, 2021: Atwaa *et al*, 2022).

Dietary fibre (DF) is an indigestible component of food that aids the prevention of numerous diseases, many of which are primarily linked to modern lifestyles (Soliman, 2019). But milk is a strong source of nutrients that support life, has a rapid rate of digestion, and contains no DF at all. The enrichment of milk products with fiber has been the result of the aforementioned factors, including an increase in the product's fibre content, the substitute of fat or for several technological advantages, a probiotic or synbiotic effect, and the use of bulking agents in conjunction with artificial sweeteners or micronutrient premixes (Arora *et al*., 2015; Ozturkoglu-Budak *et al*., 2019).

According to Pateiro *et al.* (2018) and Madane *et al.* (2019), the mushroom's stalk and other parts are a rich source of dietary fibre as well as a number of other bioactive substances like polyphenols, vitamins, and minerals that have positive antioxidant, anti-cancer, immunomodulatory, anti-inflammatory, and cholesterol-lowering properties. These dietary fibres can be utilised as dietary complements to develop digestive health or as technical additives to stop

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lipid oxidation in foods, prolonging their shelf life. These dietary fibres are known as antioxidant dietary fibres (ADFs) (Das *et al*., 2020).

Probiotic-containing goods' significance for preserving health and wellbeing is increasingly influencing consumer decision-making, driving the rise and growth in the shop for such products. The bulk of probiotic foods currently available on the shop, such fermented milks and cheese, are fresh foods that must be taken shortly after production. A significant amount of study has been conducted recently on the possible health benefits of dairy products containing probiotic organisms such lactobacillus and Bifidobacterium spp. (Daliri *et al*., 2021; Atwaa *et al*., 2020a). The current study was designed to evaluation the impact of addition mushroom stalk powder as a source of bioactive compounds on chemical, phytochemical, microbiological, rheological, and organoleptic properties of low fat probiotic cheese.

MATERIALS AND METHODS

Materials

The Dairy Technology Unit, Food Science Department, Faculty of Agriculture, Zigzag University, Egypt, provided the fresh buffalo milk (6.2% fat). *Pleurotus ostreatus* (mushrooms) which containing (10.12, 16.80, 0.86, 2.14, and 21.30 g/100g of moisture, protein, fat, ash, and crude fibre, respectively) was purchased from the Agricultural Research Centre in Giza, Egypt. The mushroom stalk was procured, cleaned, sliced, and dried for 48 hours in a thermostatically planned oven with an air blower at 40–45°C. It was then milled by a laboratory disc to pass through a 40 mesh/inch sieve and kept at 3–4°C until it was used for technological investigations. Chr-Hansen's Laboratories in Copenhagen, Denmark, provided an ABT-5 culture including *Streptococcus thermophilus*, *Lactobacillus acidophilus*, and *Bifidobacterium bifidum* and the powder animal rennet. Pure calcium chloride was bought from El-Gomhoria Co. in Cairo, Egypt. When manufacturing soft cheese, clean, food-grade cooking salt (NaCl) was utilised.

Methods

Manufacture of low fat probiotic cheese (LFPC):

Fresh bulk buffaloe's milk (6.2% fat) was separated to skim-milk and cream. Cream used to standardize the percentage of milk fat. Soft cheese was created using standardised milk that had 4% fat as the control (C1). Three pieces of the 1% fat buffalo milk batch were made. As a positive control, the first portion was left unadjusted (C1). The other two sections (T1 and T2) received additions of mushroom stalk powder (MSP) at rates of 2 and 4% (T1 and T2). All treatments were pasteurised at 63°C for 30 minutes, cooled, adjusted to 37°C, and added calcium chloride and sodium chloride at the ratios of 0.02% and 4% (W/V), respectively. Finally, 2% of active probiotic cultures (ABT5) were added before renneting.. By using the traditional way of creating Domiati cheese, probiotic soft cheese treatments were created from all milk treatments (Tamime *et al*, 2006). With previously boiled whey, cheese treatments were packaged in plastic containers and kept at 4-5 °C for 4 weeks and sampled for analysis at fresh, 1, 2, 3 and 4 weeks of storage. This experimental was triplicated.

Chemical Analysis:

The probiotic cheeses were chemically examined for: fat, total solids, titratable acidity, total and soluble nitrogen percentages and fiber content were estimated as stated by AOAC (2016). Total volatile fatty acids (T.V.F.A.) were assessed as stated by Kosikowski (1978).

Rheological Measurements:

The Chandrosekhara *et al*., (1975) method was used to assess the curd tension of low fat probiotic soft cheese. The results were given as weight in grammes, which necessitated cutting off the crud with a knife.

Determination of Phenolic Content (TPC):

Using the Folin-Ciocalteu reagent, the amount of phenolic compounds was calculated and stated as milligrammes of Gallic acid equivalents (GAE) per 100 gm according to Kabir *et al*, (2021) for cheese samples Atiqur *et al*, (2023) for mushroom stalk powder.

Radical Scavenging Activity (RSA %):

According to Meira *et al*. (2012), the DPPH (2, 2-diphenyl-1-picrylhydrazyl) assay was used to determine the antioxidant activity of cheese samples and mushroom stalks. The next formula was used to define the scavenging activity:

AOA(%) = 1- Abs sample _ Abs blank / Abs control ×100 (1)

Microbiological Analysis:

By the pour plate method and repeated dilutions of phosphate-buffer saline (1% PBS), *B. bifidum, L. acidophilus* and *S. thermophiles* were enumerated in this stage. Bifidobacterium agar was used for plate counts of *B. bifidum*, which were incubated anaerobically at 37 °C for 72 hours. While *L. acidophilus* plate counts were measured on MRS agar (pH 6.2) with 1 mg/L sorbitol during anaerobic incubation at 37 °C for 72 hours. *S. thermophilus* plate counts were carried out on M17 agar (pH 7.2) with aerobic incubation at 37 °C for 48 hours.

Sensory Evaluation:

According to Papas *et al*., (1996), low-fat probiotic cheeses were investigated after being stored in the refrigerator for 0, 1, 2, 3, and 4 weeks. The score panel comprising staff members from the Food Science Department, Faculty of Agriculture, Zagazig University, conducted the evaluation.

Statistical Analysis:

According to McClave & Benson (1991), the statistical analysis of variance was used to examine the outcomes. Two-tailed Student's t test was performed to compare the several groups after the other reported values were expressed as mean, SD, and SE. A P value of 0.05 or less was regarded as statistically significant. Version 16 of the SPSS (Chicago, IL, USA) software window was employed.

RESULTS AND DISCUSSION

Chemical and phytochemical composition of mushroom stalk powder.

The chemical and phytochemical composition of MSP is given in Table (1). MSP included 10.12, 16.80, 0.86, 2.14, and 21.30 g/100g of moisture, protein, fat, ash, and crude fibre, respectively. MSP had a total phenolic content

(TPC) of 380.60 mg per 100 g, and its RSA (%) was 87.50 %. These findings are consistent with the information acquired by Banerjee *et al*., (2020) and Abu El-Maaty *et al*., (2016).

Table 1. Chemical and phytochemical composition of mushroom stalk powder (g/100 g Dry Matter)

Items	Result
Chemical composition (g/100g)	
Moisture	10.12 ±0.84
Protein	16.80 ±1.22
Fat	0.86± 0.12
Ash	2.14 ±0.76
Fiber	21.30 ±1.40
Phytochemicals	
TPC (mg/100g)	380.60±2.50
RSA %	87.50 ±1.70

Chemical composition of low- fat probiotic cheese (LFC) supported with MSP:

Gross chemical composition of probiotic cheese made from low fat milk (LFM) as affected by adding MSP are presented in Table (2). Concerning the moisture contents of probiotic cheese, it could be observed that, probiotic cheese made from 4% milk fat (C) had higher moisture content compared with LFC made from LFM 1% fat (C1). Enrichment of LFM with MSP produced a significant ($P \leq 0.05$) reduction in its moisture contents. The moisture content of all cheese decreased as storage period progressed. The decrease in moisture content of cheeses along the storage period may be due to the curd concentration and whey expulsion resulting from acid development during the storage period (Atwaa *et al*., 2020b).

With respect to fat contents of LFC, it could be seen that, the adding of MSP did non- affected the fat content of LFC (Table 2) which might be due to the lower fat content of MSP. The fat content of all cheese increased as storage period progressed. This might be due to the decrease in moisture content and consequently the increase in total solids of the cheeses (Shehata *et al*, 2022).

The same Table (2) showed that, the enrichment of LFM with MSP produced a significant ($P \leq 0.05$) increase in TN of LFC in equal with raising the level of enrichment. However, TN of all cheeses reduced considerably ($P \leq 0.05$) during storage period, which might be due to the degradation of proteins into water SN. Also, the fortification of LFM with MSP caused a significant ($P \leq 0.05$) increase in fiber content of LFC in parallel with increasing the level of fortification. However, fiber content of all cheeses raised considerably ($P \leq 0.05$) throughout storage period. These outcomes matched those that were reported by El-Baz, (2013), Yahyavi and Kalajahi, (2014) and Basiony *et al*, (2018).

Table 2. Chemical composition of low- fat cheese fortified with mushroom stalk powder

Item	Treatments	Storage period (weeks)				
		Fresh	1	2	3	4
Moisture %	C	61.12±0.83^{a}	60.29±0.72^{a}	58.41±0.74^{a}	57.39±0.94^{a}	55.27±0.84^{a}
	C1	59.05±0.94^{b}	57.47±0.80^{b}	55.71±0.66^{b}	55.51±0.88^{b}	54.41±0.80^{b}
	T1	58.03±0.82^{c}	56.29±0.74^{c}	55.29±0.58^{bc}	54.73±0.96^{c}	53.43±0.74^{c}
	T2	57.21±0.74^{d}	54.91±0.92^{d}	52.91±0.72^{c}	53.93±0.78^{d}	52.73±0.68^{d}
% Fat	C	17.51±0.84^{a}	18.77±0.94^{a}	19.87±0.78^{a}	20.95±0.24^{a}	21.85±0.74^{a}
	C1	4.55±0.92^{b}	5.73±0.77^{b}	6.41±0.82^{b}	6.69±0.78^{a}	6.85±0.94^{b}
	T1	4.59±0.96^{b}	5.75±0.86^{b}	6.45±0.84^{b}	6.75±0.94^{b}	6.91±0.88^{b}
	T2	4.61±0.94^{b}	5.79±0.88^{b}	6.51±0.77^{b}	7.05±0.80^{b}	6.97±0.90^{b}
T.N%	C	2.41±0.04^{d}	2.36±0.03^{d}	2.31±0.04^{d}	2.21±0.02^{d}	2.19±0.02^{d}
	C1	3.45±0.03^{c}	3.39±0.04^{c}	3.37±0.03^{c}	3.31±0.03^{c}	3.29±0.04^{c}
	T1	3.52±0.04^{b}	3.47±0.02^{b}	3.45±0.04^{b}	3.39±0.03^{b}	3.35±0.03^{b}
	T2	3.61±0.02^{a}	3.53±0.03^{a}	3.51±0.02^{a}	3.47±0.02^{a}	3.43±0.04^{a}
Fiber %	C	0.00±0.0^{c}	0.00±0.0^{c}	0.00±0.0^{c}	0.00±0.0^{c}	0.00±0.0^{c}
	C1	0.00±0.0^{c}	0.00±0.0^{c}	0.00±0.0^{c}	0.00±0.0^{c}	0.00±0.0^{c}
	T1	0.22±0.04^{b}	0.25±0.02^{b}	0.29±0.05^{b}	0.33±0.03^{b}	0.38±0.03^{b}
	T2	0.48±0.03^{a}	0.52±0.04^{a}	0.58±0.03^{a}	0.64±0.04^{a}	0.70±0.02^{a}

*** Values with distinct superscript letters (means and standard deviation) are statistically different ($P \leq 0.05$).**
- C and C1, = Control probiotic cheese from buffaloe's milk containing 4 and 1% fat resp.
- T1 and T2: probiotic cheese made from low fat buffaloe's milk fortified with stalk powder at the rate of 2 and 4 % resp.

Acidity, yield and curd tension of low fat probiotic cheese enriched with MSP

Table (3) exhibited that, fortification of LFM with MSP caused significant ($P \leq 0.05$) decrease in the acidity of LFC compared to control LFC (C1), and this may be due to the effect of MSP on the viability of microorganisms and then on pH values. The results of Katsiari and Voutsinas (1994), who studied low-fat feta cheese, further support the notion that during the ripening process, the acidity values of LFC were lower than those of full-fat cheese. The findings show that the acidity of every sample of cheese varied significantly as a result of the different dietary fibre amounts utilised to make LFC. We can infer that cheese samples with higher fibre concentrations were less acidity. Basiony *et al*, (2018) also noted that supplementation of kareish cheese with dietary fiber and probiotic bacteria caused a significant decreased in chees acidity. Acidity of all cheeses increased as storage period advanced. Comparable results were found from soft cheese by Yahyavi and Kalajahi, (2014) and Basiony *et al*, (2018).

Fortification of LFM with MSP extensively ($P \leq 0.05$) increased cheese yield, in parallel with rising the amount of fortification (Table 3). Throughout the storage time, the yield of all cheeses significantly ($P \leq 0.05$) decreased, which may have been caused by moisture loss. Comparable results were described for traditional soft cheese by Basiony *et al*, (2018) and Kondyli *et al*, (2022).

Adding of MSP to LFC significantly ($P \leq 0.05$) reduction the curd tension of cheese. The decline of cheese curd tension as a result of addition MSP might be due to their restriction with communication and synthesis of casein micelles. As the storage period progressed, the hardness of all cheese curds decreased significantly ($P \leq 0.05$) (Table 3). These outcomes concur with those that were reported by Shehata *et al*, (2022), El-Baz, (2013) and Basiony *et al*, (2018).

Table 3. Acidity, yield and curd tension of low fat probiotic "cheese as affected by addition of mushroom stalk powder

Item	Treatments	Storage period (weeks)				
		Fresh	1	2	3	4
Acidity (%)	C	0.47±0.02^{d}	0.49±0.04^{d}	0.53±0.02^{d}	0.59±0.03^{d}	0.62±0.02^{d}
	C1	0.61±0.04^{a}	0.65±0.03^{a}	0.69±0.02^{a}	0.74±0.02^{a}	0.78±0.02^{a}
	T1	0.55±0.04^{b}	0.59±0.02^{b}	0.63±0.02^{b}	0.68±0.03^{b}	0.73±0.02^{b}
	T2	0.52±0.02^{c}	0.56±0.02^{c}	0.60±0.03^{c}	0.64±0.04^{c}	0.70±0.03^{c}
Yield %	C	32.13±0.84^{a}	30.21±0.70^{a}	28.31±0.66^{a}	27.13±0.70^{a}	26.65±0.64^{a}
	C1	27.91±0.90^{d}	25.81±0.75^{d}	24.85±0.54^{d}	23.21±0.52^{d}	22.81±0.80^{d}
	T1	29.57±0.94^{c}	27.85±0.80^{c}	26.67±0.70^{c}	25.53±0.55^{c}	24.17±0.66^{c}
	T2	30.41±0.92^{b}	28.61±0.64^{b}	27.51±0.62^{b}	26.29±0.64^{b}	25.32±0.74^{b}
Curd tension (gm/100gm)	C	23.6±0.66^{d}	23.8±0.74^{d}	25.4±0.77^{d}	26.1±0.62^{d}	25.5±0.70^{d}
	C1	36.7±0.74^{a}	37.1±0.65^{a}	37.5±0.68^{a}	38.1±0.74^{a}	39.3±0.64^{a}
	T1	31.1±0.72^{b}	31.3±0.76^{b}	31.9±0.70^{b}	32.3±0.77^{b}	32.4±0.74^{b}
	T2	30.1±0.88^{c}	30.3±0.72^{c}	30.4±0.84^{c}	31.2±0.70^{c}	31.3±0.80^{c}

*** Values with distinct superscript letters (means and standard deviation) are statistically different ($P \leq 0.05$).**

Ripening indices of low fat probiotic cheese enriched with MSP:

The determination of (SN/TN %) and total volatile fatty acids (T.V.F.A) were taken as indices for the degree of proteolysis and lypolysis in ripened cheese during storage. From results in Table (4), it could be observed that, the degree of proteolysis (SN/TN %) slightly increased significantly ($P \leq 0.05$) in low fat cheese. However, cheese treatments fortified with MSP gradually increased this parameter with storage period advanced. This is associated with the retention of more moisture and coagulant in the cheese curd, a condition which enhances cheese proteolysis and the formation of more nitrogenous compounds. These outcomes concur with those mentioned by Basiony *et al*, (2018) and Kondyli *et al*, (2022).

Slightly differences were noticed in T.V.F.A of low fat cheese than the full fat cheese which might be due to the differences in fat content of the resultant cheese. Fortification of low fat cheese milk with MSP significantly ($P \leq 0.05$) increased the T.V.F.A of low fat cheese treatments. This effect may be due to higher proteolysis in MSP treatments which help some lactic organisms to much lipolysis in cheese treatments. The same results clearly indicated All cheese treatments' T.V.F.A. content gradually rose during storage. It might be related to starter cultures' proteolytic and lypolytic activity during cheese production and storage (Kondyli *et al*, 2022). These outcomes concur with those mentioned by Shehata *et al*, (2022), El-Baz, (2013) and Basiony *et al*, (2018).

Table 4. Ripening indices of low fat probiotic cheese as affected by addition of mushroom stalk powder

Item	Treatments	Storage period (weeks)				
		Fresh	1	2	3	4
SN/TN%	C	9.70±0.44^{d}	13.80±0.84^{d}	18.45±0.77^{d}	22.05±0.70^{d}	26.52±0.94^{d}
	C1	12.85±0.52^{c}	17.78±0.92^{c}	20.40±0.64^{c}	24.50±0.62^{c}	27.20±0.86^{c}
	T1	14.87±0.38^{b}	19.60±0.74^{b}	22.24±0.82^{b}	26.15±0.84^{b}	29.02±0.72^{b}
	T2	17.20±0.42^{a}	22.70±0.55^{a}	26.05±0.54^{a}	29.70±0.78^{a}	31.54±0.84^{a}
T.V.F.A (0.1 N-NaOH/100 gm)	C	9.60±0.48^{a}	14.8±0.84^{a}	18.20±0.77^{a}	20.30±0.86^{a}	22.70±0.94^{a}
	C1	5.0±0.64^{d}	6.80±0.92^{d}	8.30±0.74^{d}	10.90±0.90^{d}	11.50±0.86^{d}
	T1	6.52±0.56^{c}	7.50±0.64^{c}	9.70±0.66^{c}	12.50±0.94^{c}	13.90±0.78^{c}
	T2	7.94±0.44^{b}	9.30±0.55^{b}	12.10±0.84^{b}	13.70±0.96^{b}	15.50±0.87^{b}

*** Values with distinct superscript letters (means and standard deviation) are statistically different ($P \leq 0.05$).**

TPC and RSA% of low fat cheese enriched with MSP.

Data demonstrated in Table (5): revealed that RSA% and TPC of LFC fortified with MSP were raised compared to control LFC. The RSA% and TPC of all treatments reduced as storage period advanced. These findings are consistent with those made by Lucera *et al.* (2018), who found that fortifying spreadable cheese with flours made from by-products as sources of fibre and antioxidant compounds increased the TPC and RSA% of cheese. Also, Weragama *et al*, (2021) and Atiqur *et al*, (2023) discovered that adding different levels of dried curry leaves powder or dehydrated oyster mushroom increased the RSA% and TPC of cheese. The antioxidant activity of cheese having MSP is due to the existence of polyphenols in mushroom stalk (Banerjee *et al* ., 2020).

Viable bacterial count of low- fat cheese enriched with MSP

Table 6 shows that *S. thermophilus, L. acidophilus* and *B. bifidum* viable counts in low fat cheese fortified with MSP through the storage periods. At fresh period, there was non-significant ($p<0.05$) viable count of S. *thermophilus*, *L. acidophilus* and *B. bifidum* for all treatments and this count reduced gradually during storage. The existence of MSP in cheese led to lesser LAB count, and this may be accredited to mushroom stalk antimicrobial constituents such as sesquiteropenoids and sterol, and its compound flammulinol-A,, sterpurol and enokipodin (Wang *et al*, 2012:Wu *et al*, 2014) . These outcomes concur with those mentioned by EL-Dardiry *et al*, (2015) who located that adding of mushroom to yogurt led to lesser LAB count. Also, Basiony *et al*, (2018) discovered that addition of 0.5 and 1% date seed powder or oat powder to kareish cheeses led to lesser LAB and *Bifidobacteria* contents.

Table 5. TPC and RSA% of low fat cheese fortified with MSP throughout storage at refrigerator temperature for 4 weeks

Item	Treatments	Storage period (weeks)				
		Fresh	1	2	3	4
TPC (mg /100 g)	C	36.40 ± 2.24^{b}	25.34 ± 2.70^{b}	18.82 ± 1.92^{b}	10.94 ± 1.55^{b}	7.60 ± 1.04^{d}
	C1	13.90 ± 1.42^{d}	7.80 ± 1.06^{d}	5.16 ± 0.82^{d}	5.16 ± 0.82^{d}	2.20 ± 0.28^{d}
	T1	27.30 ± 2.02^{c}	21.90 ± 1.12^{c}	18.60 ± 1.04^{c}	9.70 ± 0.98^{c}	6.50 ± 0.55^{b}
	T2	43.20 ± 3.24^{a}	36.40 ± 2.28^{a}	30.50 ± 2.72^{a}	22.80 ± 2.42^{a}	18.40 ± 1.43^{a}
RSA (%)	C	18.20 ± 1.12^{c}	12.50 ± 1.42^{c}	9.60 ± 1.36^{c}	6.70 ± 1.24^{c}	5.10 ± 0.87^{c}
	C1	10.80 ± 1.56^{d}	7.50 ± 1.74^{d}	5.90 ± 1.28^{d}	4.20 ± 1.30^{d}	3.30 ± 0.90^{d}
	T1	16.70 ± 1.52^{b}	10.20 ± 1.30^{b}	7.30 ± 1.55^{b}	5.50 ± 1.46^{b}	4.20 ± 1.02^{b}
	T2	33.60 ± 1.54^{a}	29.80 ± 1.12^{a}	22.70 ± 1.78^{a}	18.50 ± 1.55^{a}	14.30 ± 1.24^{a}

*** Values with distinct superscript letters (means and standard deviation) are statistically different (P ≤ 0.05).**

Table 6. Viable bacterial count *(log CFU/mL)* of low- fat cheese supplemented with MSP during storage period

Properties	Treatments	Storage period (weeks)				
		Fresh	1	2	3	4
Streptococcus thermophiles (log CFU/mL)	C	7.94 ± 0.02^{a}	7.52 ± 0.04^{a}	7.00 ± 0.02^{a}	6.70 ± 0.03^{a}	6.20 ± 0.08^{a}
	C1	7.86 ± 0.05^{b}	7.36 ± 0.03^{b}	6.70 ± 0.05^{b}	6.54 ± 0.03^{b}	6.14 ± 0.05^{b}
	T1	7.80 ± 0.04^{c}	7.28 ± 0.04^{c}	6.63 ± 0.02^{c}	6.48 ± 0.02^{c}	6.08 ± 0.06^{c}
	T2	7.72 ± 0.02^{d}	7.24 ± 0.05^{d}	6.55 ± 0.04^{d}	6.35 ± 0.03^{d}	6.00 ± 0.05^{d}
Lactobacillus acidophilus (log CFU/mL)	C	7.26 ± 0.03^{a}	6.92 ± 0.02^{a}	6.60 ± 0.04^{a}	6.15 ± 0.02^{a}	6.06 ± 0.04^{a}
	C1	7.18 ± 0.05^{b}	6.86 ± 0.06^{b}	6.52 ± 0.05^{b}	6.05 ± 0.05^{b}	6.00 ± 0.02^{b}
	T1	7.08 ± 0.06^{c}	6.75 ± 0.05^{c}	6.44 ± 0.06^{c}	5.97 ± 0.08^{c}	5.92 ± 0.05^{c}
	T2	7.00 ± 0.02^{d}	6.70 ± 0.08^{d}	6.37 ± 0.07^{d}	5.88 ± 0.06^{d}	$5.830.02^{d}$
Bifidobacterium. bifidum	C	7.70 ± 0.02^{a}	7.46 ± 0.03^{a}	7.12 ± 0.02^{a}	6.90 ± 0.04^{a}	6.50 ± 0.04^{a}
	C1	7.65 ± 0.05^{b}	7.36 ± 0.05^{b}	7.05 ± 0.06^{b}	6.81 ± 0.05^{b}	6.44 ± 0.03^{b}
	T1	7.60 ± 0.07^{c}	7.28 ± 0.06^{c}	6.96 ± 0.05^{c}	6.74 ± 0.04^{c}	6.37 ± 0.02^{c}
	T2	7.54 ± 0.04^{cd}	7.15 ± 0.08^{cd}	6.87 ± 0.06^{d}	6.66 ± 1.03^{d}	6.26 ± 0.05^{d}

*** Values with distinct superscript letters (means and standard deviation) are statistically different (P ≤ 0.05).**

Organoleptic properties low- fat cheese complemented with MSP:

Tables (7) showed that average score points given for appearance, body characteristics, flavour and total of low fat probiotic cheese made from LFM as affecting by adding MSP, the results showed that, the decrease of milk fat in LFC (C1) achieved the lowermost grades for organoleptic properties. Enrichment of LFM with MSP enhanced the organoleptic properties of LFC. LFC fortified with 4% MSP was like to the full fat cheese (C). The grades of probiotic cheese treatments reduced regularly up to the end of storage period. These findings are consistent with those made by Basiony *et al*, (2018) and Lucera *et al*. (2018).

Table 7. Organoleptic properties low- fat cheese supplemented with MSP throughout storage period

Item	Treatments	Storage period (weeks)				
		Fresh	1	2	3	4
Flavour (50)	C	47 ± 2.12^{a}	49 ± 2.44^{a}	48 ± 1.94^{a}	47 ± 2.85^{a}	47 ± 2.12^{a}
	C1	33 ± 2.36^{c}	39 ± 2.57^{c}	38 ± 2.08^{c}	37 ± 2.74^{c}	38 ± 2.25^{c}
	T1	43 ± 2.22^{b}	44 ± 2.28^{b}	42 ± 2.11^{b}	40 ± 2.62^{b}	39 ± 2.20^{b}
	T2	44 ± 2.55^{b}	45 ± 2.36^{b}	43 ± 2.38^{b}	41 ± 2.50^{b}	41 ± 2.14^{b}
Body & Texture (40)	C	37 ± 1.23^{a}	37 ± 1.94^{a}	36 ± 1.80^{a}	35 ± 2.02^{a}	33 ± 2.20^{a}
	C1	32 ± 1.57^{c}	33 ± 1.86^{c}	32 ± 1.74^{c}	30 ± 2.18^{c}	29 ± 2.33^{c}
	T1	35 ± 1.28^{b}	35 ± 1.64^{b}	34 ± 1.20^{b}	33 ± 2.22^{b}	31 ± 2.54^{b}
	T2	36 ± 1.54^{bc}	36 ± 1.28^{bc}	35 ± 1.28^{bc}	34 ± 2.14^{b}	32 ± 2.16^{b}
Appearance (10)	C	9 ± 0.98^{a}	9 ± 0.82^{a}	8 ± 0.78^{a}	7 ± 0.84^{a}	7 ± 0.94^{a}
	C1	5 ± 0.94^{c}	6 ± 0.74^{c}	5 ± 0.86^{c}	5 ± 0.90^{d}	4 ± 0.85^{c}
	T1	8 ± 0.84^{b}	8 ± 0.86^{b}	7 ± 0.92^{b}	7 ± 0.92^{b}	6 ± 0.87^{b}
	T2	7 ± 0.88^{bc}	7 ± 0.94^{bc}	6 ± 0.94^{bv}	6 ± 0.88^{c}	5 ± 0.90^{bc}
Total (100)	C	93 ± 3.22^{a}	95 ± 3.92^{a}	92 ± 4.08^{a}	89 ± 3.78^{a}	87 ± 3.90^{a}
	C1	70 ± 4.06^{c}	78 ± 4.36^{c}	76 ± 3.84^{c}	72 ± 4.02^{c}	71 ± 4.20^{c}
	T1	86 ± 4.14^{b}	87 ± 3.84^{b}	83 ± 3.66^{b}	80 ± 3.74^{b}	76 ± 3.84^{b}
	T2	87 ± 3.64^{bc}	89 ± 3.18^{bc}	85 ± 4.12^{bc}	82 ± 4.16^{bc}	77 ± 3.28^{bc}

*** Values with distinct superscript letters (means and standard deviation) are statistically different (P ≤ 0.05).**

CONCLUSION

High levels of dietary fibre can be found in mushroom stalk powder. Therefore, to enhance the physicochemical, rheological, and sensory qualities of low-fat cheese, mushroom stalk powder could be added at a level of 4% as a source of dietary fibre and health benefits.

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تأثير مسحوق ساق المشروم علي خواص الجبن الطري منخفض الدهن

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الملخص

تمت دراسة تأثير إضافة مسحوق ساق المشروم كمصدر لمضادات الأكسدة والألياف على جودة الجبن الطري الحيوي قليل الدهن . تمت إضافة مسحوق ساق المشروم إلى لبن الجبن منخفض الدهن (١% دهن) بمستويات ٢ و٤%. أظهرت النتائج أن إضافة مسحوق ساق المشروم للجبن الطري الحيوي منخفض الدهن لم يؤثر معنويا على محتوي الدهن ولكنه أدي الي زيادة محتوي الجبن من المواد الصلبة الكلية والبروتين والالياف كما أدي الي زيادة محتوي المركبات النتروجينية القابلة للذوبان والأحماض الدهنية الكلية المتطايرة (مركبات النكهة) للجبن الناتج . كما أن إضافة مسحوق سيقان المشروم أدي إلى تحسين الخصائص الريولوجية (قوة الخثرة). من ناحية أخرى، أدت إضافة مسحوق ساق المشروم إلى زيادة المحتوى الفينولي والنشاط المضاد للأكسدة والخواص الحسية للجبن الطري الحيوي منخفض الدهن. بشكل عام، كان الجبن قليل الدهن المحتوي على ١% دهن والمدعم ب٢و ٤% مسحوق ساق المشروم متشابهًا في خصائص الجودة مع الجبن كامل الدهن (٤% دهن). ووفقًا للنتائج التي تم الحصول عليها في هذا العمل، يمكننا أن نوصي باستخدام مسحوق ساق المشروم بنسبة تصل الي ٤% لتحسين المحتوى الفينولي، والنشاط المضاد للأكسدة، والألياف الغذائية وخصائص القوام في الجبن الطري الحيوي منخفض الدهن والمنتجات المشابهة.