Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

Production of Low Fat Yogurt Fortified with Mushroom Stalk Powder as Source of Antioxidant Dietary Fibers

Salah A.Heiba, Mohammed E.Aly, Mohammed A. Abd El Baky and Elsayed H.Atwaa

Food Science department, Faculty of Agriculture, Zagazig University, Egypt

Abstract

The aim of this study was to investigate the effect of different levels of mushroom stalk powder (1.0%, 2.0%, and 3.0%) on the viability of probiotic starter culture , physicochemical, rheological and sensory properties of low fat probiotic yogurt (1% fat). Low fat yogurt samples were stored at 5 ± 1˚C, analyzed when fresh and after 5, 10 and 15 day. The results showed a gradual increase in the values of pH, dietary fiber, viscosity, phenolic content and radical scavenging activity of low-fat yogurt with increasing proportion of mushroom stalk powder added. On the other hand, the values of acidity and synersis decreased by increasing the proportion of mushroom stalk powder. The survival of Lactobacillus acidophilus, Streptococcus thermophilus and Bifidobacterium bifidum decreased during storage time in all yogurt treatments, although it stood at recommended levels for health effects (at least 106 cfu/mL in traditional yogurt). Low fat yogurt that containing of 2% of mushroom stalk powder were the highest of sensory properties than the other treatments. Thus, the study demonstrates that mushroom stalk powder can be used as a source of dietary fiber and phenolic compounds in low fat yogurt at a rate of 2% which enhanced its nutritional value, rheological and sensory properties.

Keywords: yogurt, mushroom stalk powder, physicochemical properties, phenolic content, radical scavenging activity

1. Introduction

One of the most significant fermented milk products is yoghurt, which is made by fermenting lactose with a starting culture that contains Lactobacillus bulgaricus and Streptococcus thermophilus, which interact with milk protein to enhance the product's body texture and sensory qualities.(Dabija et al., 2018 : Atwaa et al, 2022).

Low fat dairy products including yogurt have gained popularity because of consumer awareness about health concerns related to decreasing the risks connected with obesity and coronary heart diseases (Sandoval et al., 2004: Lorden et al.,2018). However, the partial or total removal of fat from yogurt decreases the overall quality perceived by the consumers (Folkenberg and Martens, 2003: Dias et al, 2020). It was reported that reduction of fat content in yogurt resulted in lower gel strength and firmness than full fat yogurt, as a consequence of lower number of fat globules embedded in the protein network (Duboc & Mollet, 2003). To improve textural and functional properties of low fat yogurt, the use of plant fibers has been widely investigated (Hasania., 2017: Dabija et al., 2018). Dairy products, including yogurt do not contain fiber and has limited antioxidant activity. Many attempts have been conducted to fortify yogurt with fiber and antioxidants from natural sources, which represented a good impact and a new approach for yogurt development (Bertolino et al., 2016: Tizghadam et al., 2021: Ribeiro et al, 2021: Atwaa et al., 2022).

The fortification of milk and milk products with DF has resulted from discussed reasons, enhancement of fiber content of the product, replacement of fat or for some technological benefits, probiotic or synbiotic effect, bulking agent along with artificial sweeteners or micronutrient premixes, (Arora et al., 2015: Ozturkoglu-Budak et al., 2019).

Because they are a rich source of dietary fibre and several other bioactive compounds like minerals,

*Corresponding author e-mail: salah.a.a.heiba@gmail.com; (Salah A.Heiba).
EJCHEM use only: Received date 24 August 2022; revised date 25 September 2022; accepted date 29 September 2022
DOI: 10.21608/EJCHEM.2022.158288.6847

vitamins, and polyphenols that exhibit good antioxidant, anti-inflammatory, immunomodulatory, anti-cancer, and cholesterol-lowering activities, the stalk and other parts of the mushroom are removed during harvesting for application as functional food ingredients in food products. (Pateiro et al., 2018: Madane et al, 2019). These dietary fibers, in combination with phenolic compounds, form antioxidant dietary fibers (ADFs) (Das et al., 2020) which can be used as dietary supplements to improve gastrointestinal health, or as technical ingredients to inhibit lipid oxidation in foods, thereby extending their shelf-life (Madane et al. , 2020).The present study was planned to evaluation the effect of adding mushroom stalk powder as a source of dietary fiber and bioactive compounds on physicochemical, rheological, and sensory properties of low fat yogurt.

Materials and methods

Fresh buffalo's milk (6.2% fat) was obtained from Dairy Technology Unit, Food Science Department, Faculty of Agriculture, Zigzag University, Egypt. Mushroom (Pleurotus ostreatus) was obtained from Agricultural Research Center, Giza, Egypt. The mushroom stalk were collected, washed, cut and dried in thermostatically controlled oven with air fan at 40-45°C for 48 hrs., then milled using a laboratory disc to pass through a 40 mesh/inch sieve, stored at 3-4°C until used for technological studies.

ABT-5 culture containing *Streptococcus thermophilus, Lactobacillus acidophilus* and *Bifidobacterium bifidum* were obtained from Chr-Hansen's Laboratories, Copenhagen, Denmark.

Manufacture of low fat yogurt

Full fat buffalo's milk containing 6.2 % fat was separated to skim-milk and cream. Cream used to standardize the percentage of milk fat. Low fat buffalo's milk (1% fat) was divided into 4 portions. The first portion was left without additive as a positive control (C), mushroom stalk powder was added to the other three portions at the rate of 1, 2 and 3% (T1, T2 and, T3). All milk bases were homogenized and heated to 90 ˚C for 15 min., then, cooled to 42 ± 1 ˚C, inoculated with 2% of ABT-5 culture, filled in plastic cups and incubated at 42 ˚C until obtaining uniform coagulation according to the methods described by Tamime and Robinson (1999),. The yogurt samples were kept at 5 ± 1˚C, analyzed when fresh and after 5, 10 and 15 day of storage.

Chemical, physicochemical, phytochemical analysis and sensory evaluation of yogurt treatments

For yogurt samples, the total protein, total solids, fat, ash, and titratable acidity were determined following (AOAC, 2007). Their pH values were monitored using a pH meter equipped with a glass electrode (HANNA, Instrument, Portugal). Syneresis and viscosity of yogurt was determined according to Aryana (2003) .Total phenolic content (TPC) (expressed as mg GAE (gallic acid equivalents)/100g) was assessed according to Kaur & Kapoor (2002) with minor modifications. Briefly, 100 µL of different concentrations of the test sample was mixed with 1 mL of diluted FC reagent (1:10). After 10 min, 1 mL of 7.5% (w/v) sodium carbonate solution was added to the mixture and incubated in the dark for 90 min. The absorbance was recorded at 725 nm. The TPC was calculated from the calibration curve of gallic acid Y = 0.2808 X + 0.0301; R2 = 0.9983. Antioxidant (AO) activity (%) of the prepared yogurts was assessed according to Brand Williams et al, (1995) and the absorbance was noted at 517 nm using a spectrophotometer (Thermo Scientific, Wilmington, NC, USA). The scavenging activity was calculated with the formula of DPPH radical scavenging % = 1- (Absorbance of sample - Absorbance of blank) / Absorbance of control × 100. The yogurt sample's sensory evaluation was studied in terms of color & appearance (9 points), flavor (9 points), body& texture (9 points), consistency (9 points) and overall acceptability following the method reported by Nelson and Trout (1981). Sensory evaluation was carried out by 20 trained panelists. The samples were packed and coded with a 3-digit code. The encoded samples were presented in a tray to the panelists. After each sample testing, the panelists were offered plain water to clean their palate before moving on to the next sample.

Microbiological analysis

In this step, *B. bifidum, L. acidophilus* and *S. thermophiles* were counted using the pour plate technique and serial dilutions in phosphate-buffer saline (1% PBS). Plate counts of *B. bifidum* were performed in Bifidobacterium agar under anaerobic incubation at 37 °C for 72 h. While, plate counts of *L.*

acidophilus was counted on MRS agar (pH 6.2) containing 1 mg/L sorbitol under anaerobic incubation at 37 °C for 72 h. Plate counts of *S. thermophilus* were performed in M17 agar (pH 7.2) under aerobic incubation at 37 °C for 48 h.

Statistical analysis

The obtained results were evaluated statistically using analysis of variance as reported by McClave & Benson (1991). In addition the other reported values were expressed as mean ±SD and ±SE, two – tailed Student's t test was used to compare between different groups. . P value less than 0.05 was considered statistically significant. SPSS (Chicago, IL, USA) software window Version 16 was used.

Results and discussion

Chemical composition and antioxidant properties of mushroom stalk powder

Table (1) provides information on the mushroom stalk powder's chemical composition and anti-oxidant qualities. The contents of the mushroom stalk powder in terms of moisture, protein, fat, ash, and crude fibre were 9.32, 16.30, 0.94, 2.36, and 20.35 g/100g, respectively. These results are in agreement with the data obtained by Abu El-Maaty, et al., (2016) and Banerjee et al ., (2020).

Total phenolic content (TPC) of mushroom stalk powder was 420.14 mg/100g, while the radical scavenging activity % (RSA %) was 82.20%. These results agree with that previously reported by Abu El-Maaty, et al., 2016 and Banerjee et al ., (2020).

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

Components %	Concentrate
Chemical composition (g/100g)	
Moisture	9.32 ±0.74
Crude protein	16.30 ±1.14
Crude Fat	0.94± 0.16
Ash	2.36 ±0.56
Crude Fiber	20.85 ±1.30
Antioxidant properties	
Total phenolic compounds (mg/100g)	420.14±2.30
Radical scavenging activity (RSA) %	82.20 ±1.20

Chemical composition of low fat yogurt containing mushroom stalk powder

Table (2) showed that low fat yogurt treatments exhibited the least (TS) content. The TS content of low fat yogurt containing mushroom stalk powder increased gradually by increasing the percentage added. The TS content of all yogurt treatments slightly increased with storage period progressed. Fortified low fat yogurt treatments showed non-significant increase in total protein compared with low fat yogurt (C). The total protein of all yogurt treatments slightly increased with storage period progressed. Fortification of low fat milk with mushroom stalk powder did not affect the fat content of the resultant low fat yogurt. Dietary fiber content increased significant ($p \leq 0.05$) in low fat yogurt treatments in parallel with increasing the level of fortification with mushroom stalk powder. These results are in agreement with those reported by Salama et al, (2009) found that addition of mushroom to buffalo milk could be achieved successfully in yogurt making and increased the TS and dietary fiber content of resultant yogurt. Also, Pappa et al., (2018), found that addition of β-Glucans, isolated from mushroom enhanced physicochemical characteristics of low-fat yogurt.

Acidity and pH of low fat yogurt containing mushroom stalk powder

The pH values of control low fat yogurt and low fat yogurt containing 1, 2 and 3 % mushroom stalk powder treatments during storage periods are shown in Table (3). It can be noted that the pH values in control low fat yogurt reduced significantly (p<0.05) compared to low fat yogurt fortified with 1,2 and 3 % mushroom stalk powder after 15 day of storage periods and this may be due to the effect of mushroom stalk powder on the growth of slightly increased than barley or lupine flour treated yogurts, and there were significant differences (p <0.05) among treatments during storage periods.

The titratable acidity at zero time for control low fat yogurt and low fat yogurt containing 1,2 and 3 % mushroom stalk powder were 0.88, 0.86, 0.84 and 0.82 without any significant differences (p<0.05), and reached 1.42, 1.36, 1.28 and 1.14, respectively (Table 3). It was significant (p<0.05) for control low fat yogurt compared to low fat yogurt containing with 1,2 and 3 % mushroom stalk powder. The TA increasing as storage period progressed; this may be due to the activity of yogurt starter culture which converted lactose into lactic acid (Kumari et al., 2015) . The decreased of TA of mushroom stalk powder compared to control low fat yogurt may be due to mushroom stalk powder activity which reduced the growth of yogurt bacteria. These results agree with those reported by Hasani et al., (2016) who reported that titratable acidity of barley bran treated yogurt affected by barley bran addition which affected on pH increasing. Also, Jovanovi´c et al., (2020) found that use apple pomace in yogurt milk microorganisms and subsequently on pH values. The pH values of all yogurt treatments decreased during 15 day of storage. pH reduction during storage could be because of storage duration, starter culture variety, lactic acid conversion into lactose, and temperature of fermentation (Singh et al., 2011).These results have been confirmed by Al-hamdani et al, (2015) and Hasani et al., (2017), who reported that the pH value of plain yogurt
Also, Pappa et al., (2018), found that use β-Glucans, isolated from mushroom in yogurt milk increased pH values compared to the control sample.
decreased TA compared to the control sample.

With respect to whey syneresis fortification of low fat yogurt with MSP significantly reduced whey syneresis and increased viscosity compared with control low fat yogurt and these parameters in parallel with increasing the level of fortification Table (3). The whey syneresis and viscosity of all yogurt treatments increased as storage period progressed. These results might be due to increasing the water holding capacity brought by MSP and the dietary fibers may offer physiological effects on viscosity, solubility, oil-binding capacity, hydration property in dairy products (Behnia et al., 2013: Jambi, 2018).Similar results were reported by El Attar et al., (2021), who found that addition of Oyster mushroom to yogurt reduced its whey syneresis and increased viscosity than control yogurt. Also, Pappa et al., (2018), found that addition of β-Glucans, isolated from mushroom to yogurt reduced the whey syneresis and increased the viscosity.

Table 2

Chemical composition of low fat yogurt containing mushroom stalk powder during storage at refrigerator temperature for 15 day

Components %	Storage period (Day)	Treatments			
		C	T_1	T_2	T_3
TS	Fresh	9.66±0.33^{bc}	9.84±0.35^{b}	10.02±0.32^{ab}	10.22±0.35^{a}
	5	9.94±0.32^{bc}	10.12±0.34^{b}	10.48±0.40^{ab}	10.74±0.33^{a}
	10	10.32±0.34^{cd}	10.58±0.35^{c}	10.94±0.32^{b}	11.28±0.35^{a}
	15	10.86±0.36^{cd}	11.08±0.40^{c}	11.52±0.35^{b}	11.94±0.40^{a}
Fat	Fresh	1.06±0.16^{a}	1.08±0.22^{a}	1.20±0.14^{a}	1.36±0.18^{a}

	5	1.14±0.14[a]	1.20±0.12[a]	1.34±0.16[a]	1.42±0.22[a]
	10	1.22±0.16[a]	1.32±0.18[a]	1.44±0.14[a]	1.64±0.16[a]
	15	1.44±0.14[a]	1.48±0.12[a]	1.62±0.22[a]	1.90±0.14[a]
Protein	Fresh	3.74±0.28[a]	4.02±0.32[a]	4.18±0.40[a]	4.26±0.45[a]
	5	3.92±0.45[a]	4.16±0.30[a]	4.32±0.28[a]	4. 50±0.26[a]
	10	4. 14±0.35[a]	4.40±0.40[a]	4.50±0.45[a]	4.78±0.30[a]
	15	4.26±0.40[a]	4.62±0.28[a]	4. 88±0.35[a]	5.04±0.26[a]
Fiber	Fresh	0.00	0.22±0.01[c]	0.56±0.03[b]	0.84±0.02[a]
	5	0.00	0.38±0.04[c]	0.84±0.02[b]	1.48±0.05[a]
	10	0.00	0.74±0.02[c]	1 .12±0.01[b]	2.06±0.03[a]
	15	0.00	0.96±0.01[c]	1.34±0.04[b]	2.24±0.02[a]

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).
C: control Low fat yogurt (1% fat) T1: Low fat yogurt treated with 1% mushroom stalk powder
T2: Low fat yogurt treated with 2% mushroom stalk powder T3: Low fat yogurt treated with 3% mushroom stalk powder

Table 3
Acidity, pH and Rheological properties of low fat yogurt containing mushroom stalk powder during storage at refrigerator temperature for 15 day

Item	Storage period (Day)	Treatments			
		C	T_1	T_2	T_3
	Fresh	0.88±0.02[a]	0.86±0.04[a]	0.84±0.01[a]	0.82±0.03[a]
	5	1.06±0.05[a]	0.94±0.02[b]	0.90±0.04[c]	0.88±0.02[c]
Acidity %	10	1.24±0.04[a]	1.12±0.03[b]	1.04±0.05[c]	0.96±0.05[d]
	15	1.42±0.02[a]	1.36±0.06[b]	1.28±0.06[c]	1.14±0.04[d]
pH	Fresh	4.50±0.03[c]	4.55±0.04[b]	4.62±0.02[ab]	4.64±0.02[a]
	5	4.42±0.05[c]	4.46±0.05[b]	4.50±0.04[ab]	4.52±0.06[a]
	10	4.30±0.06[d]	4. 40±0.01[c]	4.46±0.01[b]	4.50±0.04[a]
	15	4.10±0.04[c]	4.36±0.02[b]	4.40±0.03[ab]	4.42±0.02[a]
Whey syneresis (ml/100gm)	Fresh	34.00±0.52[a]	32.00±0.50[b]	28.00±0.40[c]	25.00±0.50[d]
	5	37.00±0.54[a]	34.00±0.42[b]	32.00±0.44[c]	30.00±0.40[d]
	10	42.00±0.50[a]	38.00±0.44[b]	35.00±0.52[c]	33.00±0.50[d]
	15	45.00±0.60[a]	41.00±0.54[b]	39.00±0.56[c]	36.00±0.40[d]
Viscosity (C.	Fresh	40300±102[d]	4130±120[c]	4420±134[b]	4800±120[a]

P.S.)	5	4150±108^{d}	4190±120^{c}	4460±140^{b}	5000±130^{a}
	10	4260±124^{d}	4210±132^{c}	4520±122^{b}	5090±128^{a}
	15	4290±110^{d}	4290±130^{c}	4570±160^{b}	5120±140^{a}

* Values (means ±SD) with different superscript letters are statistically significantly different (P ≤ 0.05)

Total phenolic content and radical scavenging activity of low fat yogurt containing mushroom stalk powder

Data illustrated in Table (4): revealed that TPC and RSA% of low fat yogurt containing mushroom stalk powder were increased by mushroom stalk powder increasing in the yogurt product. The TPC and RSA% of all yogurt treatments decreased as storage period progressed. These results are in agreement with those reported by Atwaa et al., (2020) who found that fortification of low fat yogurt with mango pulp fiber waste increased the TPC and RSA% of yogurt treatments. Also, Mohamed et al, (2015) found that adding different levels of dried grape pomace as a source of antioxidants and fiber at level 1.0% to 5.0% increased the TPC and RSA% of yogurt treatments. The antioxidant activity of yogurt samples containing mushroom stalk powder is due to the presence of polyphenols in mushroom stalk (Banerjee et al ., 2020), where there is a positive relationship between the antioxidant activity of mushroom stalk and their content of total phenols and flavonoids (Mishra et al., 2015).

Table (4)
The effect of mushroom stalk powder on total phenolic content and radical scavenging activity of low fat yogurt during storage at refrigerator temperature for 15 day

Item	Storage period (Day)	Treatments C	T_1	T_2	T_3
Total phenolic content (mg /100 g)	Fresh	20.40±5.12^{d}	32.20±3.14^{c}	63.60±4.14^{b}	90.02±3.18^{a}
	5	15.20±4.18^{d}	25.40±3.62^{c}	50.82±4.20^{b}	74.30±5.02^{a}
	10	10.26±3.12^{d}	16.30±3.12^{c}	44.40±3.12^{b}	68.60±4.14^{a}
	15	8.20±3.52^{d}	11.50±4.18^{c}	32.90±4.20^{b}	56.40±3.63^{a}
Radical scavenging activity RSA %	Fresh	20.00±1.36^{d}	26.10±1.32^{c}	40.20±1.14^{b}	51.40±1.22^{a}
	5	12.70±1.44^{d}	21.50±1.32^{c}	35.40±1.32^{b}	40.20±1.12^{a}
	10	9.00±1.38^{d}	18.20±1.32^{c}	31.30±1.38^{b}	35.70±1.42^{a}
	15	7.20±1.32^{d}	11.60±1.36^{c}	22.10±1.54^{b}	30.60±1.60^{a}

* Values (means ±SD) with different superscript letters are statistically significantly different (P ≤ 0.05)

Microbiological evaluation of low fat yogurt fortified with mushroom stalk powder

Table 5 shows Lactobacillus acidophilus, Streptococcus thermophilus and Bifidobacterium bifidum viable counts in control low fat yogurt and low fat yogurt containing 1, 2 and 3 % mushroom stalk powder during storage periods. At zero time, there was non-significant (p<0.05) content of Lactobacillus acidophilus, Streptococcus thermophilus and Bifidobacterium bifidum for all treatments and this content decreased slightly till the 10 day and reduced gradually after day 15. The counts of Lactobacillus acidophilus, Streptococcus thermophilus and Bifidobacterium bifidum have decreased during storage, and this decline is noticeable from day 10-15, probably due to increased yogurt acidity (Tavakoli et al, 2019) . The presence of mushroom stalk powder in yogurt led to lower

LAB content, and this may be attributed to mushroom stalk antimicrobial components such as sterol, sesquiteropenoids and its compound sterpurol, flammulinol-A, enokipodin (Wang et al., 2012:Wu et al., 2014) . The results of the present study agree with those reported by EL-Dardiry et al, (2015) who found that addition of mushroom to yogurt led to lower LAB content. Hasani et al., (2016) found that the presence of barley bran in yogurt led to lower LAB content. Also, Jovanovi´c et al., (2020) found that the presence of apple pomace flour in yogurt led to lower LAB content. Lactobacillus acidophilus, Streptococcus thermophilus and Bifidobacterium bifidum viability slightly decreased with mushroom stalk powder but its number was still within the recommended range for probiotic cultures (>log 7 CFU/mL) (Nagpal et al., 2012).

Table (5)

Microbiological evaluation of low fat yogurt containing mushroom stalk powder during storage at refrigerator temperature for 15 day

Item	Treatments	Storage period (days)			
		Fresh	5	10	15
Streptococcus thermophiles (log CFU/mL)	C	8.88±0.04^{a}	8.86±0.05^{a}	8.80±0.03^{a}	8.74±0.02^{a}
	T1	8.85±0.02^{ab}	8.83±0.03^{ab}	8.77±0.02^{ab}	8.71±0.04^{ab}
	T2	8.82±0.05^{b}	8.80±0.02^{b}	8.75±0.05^{bc}	8.67±0.02^{b}
	T3	8.78±0.02^{c}	8.75±0.04^{c}	8.68±0.02^{c}	8.62±0.05^{c}
Lactobacillus acidophilus (log CFU/mL)	C	8.14±0.02^{a}	8.10±0.04^{a}	80.2±0.03^{a}	7.95±0.04^{a}
	T1	8.10±0.04^{ab}	8.08±0.03^{a}	7.98±0.04^{a}	7.91±0.03^{b}
	T2	8.07±0.02^{bc}	8.04±0.02^{b}	7.94±0.02^{b}	7.87±0.02^{c}
	T3	8.04±0.03^{c}	8.02±0.03^{b}	7.92±0.04^{c}	7.82±0.03^{d}
Bifidobacterium. bifidum (log CFU/mL)	C	8.64±0.04^{a}	8.62±0.02^{a}	8.55±0.03^{a}	8.51±0.02^{a}
	T1	8.60±0.02^{b}	8.58±0.04^{ab}	8.50±0.02^{b}	8.46±0.04^{b}
	T2	8.57±0.02^{bc}	8.55±0.02^{bc}	8.48±0.04^{b}	8.42±1.03^{c}
	T3	8.53±0.03^{c}	8.50±0.03^{c}	8.42±0.02^{c}	8.37±0.04^{cd}

ND= not detected.

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$)

Organoleptic properties of low fat yogurt containing mushroom stalk powder

Table (6) showed that, the reduction of fat content from yogurt milk gained the lowest scores for organoleptic properties. Fortification of low fat yogurt milk with MSP improved the organoleptic properties of low fat treatments and this improvement in parallel with increasing the level of supplementation. Low fat yogurt fortified with 2 % MSP had the highest organoleptic properties compared to other treatments. The Organoleptic properties of all yogurt treatments decreased as the storage period progressed. A similar observation was found by EL-Dardiry et al, (2015) who found that addition of mushroom powder to yogurt enhanced the sensory evaluation of resultant yogurt .Al-hamdani et al., (2015), found that supplementation yogurt with lupine flour enhanced the sensory evaluation of resultant yogurt .Also El Attar et al, (2021), found that addition of *Oyster mushroom* to yogurt enhanced the sensory evaluation of resultant yogurt.

Table (6)

Organoleptic properties of low fat yogurt as affected by adding mushroom stalk powder during storage at refrigerator temperature for 15 day

Properties	Storage period (Day)	Treatments			
		C	T_1	T_2	T_3
Appearance	Fresh	7.20±0.22^{c}	7.60±0.18^{b}	7.90±0.16^{a}	7.40±0.20^{bc}
	5	7.00±0.28^{c}	7.40±0.24^{bc}	7.60±0.20^{a}	7.10±0.22^{b}

	10	6.70±0.33^bc^	7.10±0.30^ab^	7.40±0.28^a^	6.90±0.24^b^
	15	6.50±0.35^bc^	6.90±0.32^b^	7.30±0.38^a^	6.60±0.33^bc^
Flavour	Fresh	7.00±0.20^d^	7 .20±0.18^c^	8.00±0.22^a^	7.70±0.20^b^
	5	7.30±0.35^c^	7.50±0.30^c^	8.40±0.33^a^	8.00±0.26^b^
	10	7.10±0.35^c^	7.30±0.32^c^	8.10±0.25^a^	7.80±0.30^b^
	15	6.80±0.32^c^	7.00±0.28^c^	7.80±0.23^a^	7.40±0.26^b^
Texture	Fresh	6 .00±0.34^d^	6.40±0.30^c^	7.90±0.24^b^	8.20±0.20^a^
	5	5.70±0.38^d^	6.00±0.34^c^	7.50±0.28^b^	7.80±0.23^a^
	10	5.50±0.43^d^	5.80±0.36^c^	7.20±0.33^b^	7.50±0.30^a^
	15	5.20±0.40^d^	5.50±0.37^c^	7.00±0.34^b^	7.10±0.33^a^
Consistency	Fresh	5.80±0.32^d^	6.20±0.28^c^	7.20±0.25^b^	7.50±0.22^a^
	5	5.50±0.35^d^	6.00±0.31^c^	7.00±0.28^b^	7.30±0.28^a^
	10	5.30±0.40^cd^	5.70±0.33^c^	6.70±0.32^b^	7.10±0.30^a^
	15	5.20±0.43^b^	5.50±0.35^b^	6.50±0.34^ab^	6.80±0.29^a^
Overall acceptability	Fresh	5.70±0.27^d^	6.50±0.24^c^	7.80±0.20^a^	7.50±0.22^b^
	5	5.40±0.30^d^	6.20±0.27^c^	7.60±0.23^a^	7.30±0.25^b^
	10	5.20±0.33^c^	6.00±0.30^b^	7.30±0.27^a^	7.10±0.29^ab^
	15	5.00±0.35^c^	5.80±0.32^b^	7.20±0.30^a^	7.00±0.33^ab^

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$)

Conclusion

The fortification of low fat yoghurt milk with mushroom stalk powder resulted in a fermented product with good physicochemical and sensory properties and a high nutritional value. Furthermore, this study concluded that mushroom stalk powder has a high content of bioactive compounds, such as phenolic compounds, flavonoids and dietary fiber. More importantly, the fortification of low fat yoghurt milk with mushroom stalk powder at a rate of 2 % to manufacture low fat yoghurt improved the chemical, nutritional, antioxidant, rheological, and sensory properties, and added the nutritive and healthy benefits of low fat yoghurt. Natural plant-based additives need further studies about their health and technological influence in dairy product manufacture.

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