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Enhancing the microbial and sensory qualities of soft cheese using black seed oil

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ABSTRACT

This study explored enhancing soft cheese quality by incorporating varying concentrations of Black Seed Oil (Habat Al-barakah) at 0.5%, 1%, and 1.5% (v/w). Fresh cow milk from Menoufia University, Egypt, was used to produce soft cheese supplemented with Black Seed Oil (0.5, 1.0, and 1.5% w/w) alongside a control. The cheese was manufactured following pasteurization (80°C/30 min) and stored at 4°C for 28 days. Physicochemical properties were analyzed using AOAC methods, while sensory evaluation and microbiological analysis including total bacterial count, coliforms, *S. aureus*, and yeasts/molds were conducted using standard plating techniques. There were significant ($P \leq 0.05$) variations in chemical composition between the control and treated cheese samples, particularly notable in the sample with 1.5% oil. Adding black seed oil increased cheese acidity from 0.25% in control to 0.33% in the 1.5% oil-treated cheese at a fresh time, and a consistent increase was observed in all samples during refrigerated storage. Microbiological investigations revealed that soft cheese treatments enriched with black seed oil exhibited the lowest total bacterial count, yeast, and mold. Coliform groups and Staphylococci were undetected in all soft cheese treatments and controls. Panelists positively acknowledged the taste of soft cheese with a higher concentration of black cumin oil (1.5%), with no complaints about appearance and flavor. Interestingly, the panelists favored the texture of soft cheese with a higher percentage of oil, ultimately leading to the highest overall acceptability for the 1.5% oil-treated cheese.

Introduction

Food industries and research institutions have great challenges in producing safe food with high nutritional value and of high keeping quality to achieve the increasing demand of consumers for food free from chemical and synthetic preservatives, which are often considered harmful and carcinogenic substances (Sendanayake *et al*., 2017; Ibrahim and Mousa 2021). Therefore, several approaches have been used to improve the properties of food using various natural antimicrobial agents, such as Lysozyme, bacteriocins, chitosan, lactoferrin, and casein; various plant extracts, spices, and essential oils from medicinal plants are regarded as the greatest examples of natural antibacterial agents used to improve food quality and safety (Iwalokun *et al*., 2004; Hassanien *et al*., 2014).

Essential oils (EOs) of medical plants have become one of the rising natural additives as they have GRAS stats and They have GRAS statistics and widespread approval (Burt, 2004). Black Seed Oil (Habat Al-barkah) oil is a natural antibacterial and antifungal agent that can inhibit the growth of most pathogenic and spoilage microorganisms found in food matrices due to its high concentration of phenolic compounds, flavonoids, phytosterols, fatty acids, vitamins, minerals, and some volatile compounds (Çakır and Çakmakçı, 2018; Georgescu *et al*., 2019; Puvača *et al*., 2020).

The oil extract of Black Seed demonstrated *in vitro* and *in vivo* antimicrobial properties against a wide range of pathogenic and spoilage bacteria (Mashhadian and Rakhshandeh, 2005), hence it has been employed in various food applications as an antibacterial and antifungal agent, as well as for its health advantages (Tarakci *et al*., 2005; Cakir *et al*., 2016; Georgescu *et al*., 2018).

White soft cheeses are the most popular dairy products in the world, and due to their high nutritional content, they are also the most popular variety sold and consumed in Egypt. They are regarded as the finest source of protein and certain minerals, particularly calcium and phosphorus, which are essential for human health and nutrition. However, the high moisture and low salt concentrations make this type of cheese prone to quick degradation by spoilage bacteria, which may reduce its shelf life and pose human health hazards. (Puvača *et al*., 2020, Mahgoub *et al*., 2013; Khider *et al*., 2022). Therefore, this work aimed to investigate the impact of Black seed oil on the quality and safety of examined soft cheese by assessing their organoleptic, chemical indices (acidity%), and microbiological status during refrigerating storage.

Materials and methods

Fresh cow milk was acquired without any interaction with the herd from the herd of the animal production Department, Faculty of Agriculture, Menoufia University in Egypt. Black seed oil (Habat Al-barkah oil) was sourced from Alrehab Herbs Company in Fayoum, Egypt. Before usage, a standard rennet solution was prepared using powder rennet (CHY-MAX, 2280 IMCU/ml) from Ch-Hansen's Laboratories (Denmark) and sterilized distilled water. EL-Nasr Company in Cairo, Egypt, supplied commercial pure fine-grade salt and calcium chloride (food quality grade). The chemicals utilized in this investigation were analytical grade and came from El-Nasser, Merck, and Sigma Companies.

Manufacture of soft cheese

Milk was separated into four equal groups, three supplemented with 0.5, 1.00, and 1.5% (w/w) Black seed oils, while the fourth served as a control group. To make soft cheese, all milk was pasteurized at 80°C for 30 minutes and chilled to 40°C before adding calcium chloride and sodium chloride at concentrations of 0.02% and 2% (w/w), respectively, before renneting. The whey was drained under light pressure through a cheesecloth before being spread into a cylindrical mold with perforations. The cheese was pressed overnight at 20◦C to remove extra whey. Cheese samples were maintained in sterile containers at 4°C for 21 days before being analyzed for physicochemical and sensory properties at 0, 7, 14, 21, and 28 days.

Chemical analysis of soft cheese samples

The physicochemical parameters of the produced cheese samples were studied by measuring their titratable acidity, moisture, fat, and protein concentrations, as reported in AOAC (2005). Curd tension was measured using the method employed by Shahein *et al*. (2014).

Sensory evaluation

The sensory evaluation protocol for the cheese samples was reviewed by the Menoufia University Ethics Committee (MUFHE/F). It was determined that ethical approval was not required, as per their guidelines. Sensory evaluation was conducted at the Department of Food Hygiene and Control, Menoufia University, Egypt. All steps followed the ethical standards set forth by the committee, and informed consent was obtained from all participants involved in the sensory evaluation. The study's purpose and procedures were transparently and comprehensively explained to the fifteen panelists (8 men and 7 women, aged 22 and 57), including any potential risks and benefits. Participants were informed of their right to withdraw from the study at any time without any consequence. The sensory evaluation was determined according to Shafei *et al*., (2008). The samples were evaluated for flavor (50 points), body and texture (40 points), appearance (10 points), and overall acceptability (100 points).

Microbiological examination

Eleven grams of cheese samples were homogenized with 2% sodium citrate and mixed with 99 mL of 0.1% buffered peptone water (Biolife Italiana, Italy). Ten-fold serial dilutions were produced, plated on Plate count agar and McConkey agar plates (Merck, Germany), and aerobically incubated at 37°C for 24-48 hours for Total Bacterial Count (TBC) and Total Coliforms, respectively, as reported by Wehr and Frank, (2004). *S. aureus* was counted on Baird Parker agar (Biolife, 401116) supplemented with egg yolk and incubated at 37°C for 48 hours, whilst yeasts and molds were cultivated on Sabaroud Dextrose Agar (Lab M) with 0.1 g/l chloramphenicol and aerobically incubated at 25°C for 5-7 days (Wehr and Frank, 2004). The colonies were counted, and the results were presented as $\log_{10}$ cfu/g.

Statistical Analysis

The data were statistically analyzed using ANOVA analysis using the general linear model (GLM) process of the statistical analysis system software (SAS version 9.1, SAS Institute, Inc., (SAS, 2003). The Duncan test measured differences between effects (P≤ 0.05).

Results

The effect of black seed oil on the chemical composition of soft cheese is presented in Table 1. Adding BSO to soft cheese resulted in slightly higher moisture content than the control cheese. Furthermore, there were significant differences in moisture contents observed among all cheese treatments. Overall, the findings indicate a gradual decrease in moisture content for all cheese treatments during storage.

The titratable acidity of BSO-treated cheese was greater than that of control samples, and the acidity of all cheese samples increased with storage. Significant variations (P≤0.05) in acidity levels between control and treated cheese. After 21 days of storage, the acidity values for control, T1, T2, and T3 were 0.35, 0.38, 0.40, and 0.45%, respectively.

The data in Table 2 showed chemical analysis, for fat and total protein (TP%). The fat percentage on a fresh day of storage with 1.5% BSO (T3) was 16.63%, whereas the control one had the lowest fat percentage of 15.88%.

The fat content of all treated cheese samples rapidly grew and reached maximum levels at the end of the storage period: 17.89, 18.02, and 18.76% for T1, T2, and T3, respectively. There was a favorable link established between oil content and fat percentages of the cheeses tested

The sensory evaluation of soft cheese prepared with different concentrations of black seed oil during refrigerated storage was presented in Table 3. Data showed that BSO improved the flavor, body and texture, and appearance of soft cheese compared to the control. Samples supplemented with 1.5% BSO had the highest score of flavors from production till the end of storage. The flavor scores of cheeses supplemented with 0.5 and 1% BSO at 28 days of storage were 38.0±0.5 and 44.0±0.18, respectively. However, texture gradually improved until 14 days of storage, after which it declined. After 21 days of storage, the body and texture of control, 0.5, 1, and 3% BSO-supplemented cheeses were 36.0±0.41, 37.0±0.7, 37.0±0.81, and 38.0±0.18, respectively.

There were noticeable differences between the control and cheese samples with different concentrations of BSO in appearance value. Appearance results of the control, 0.5, 1, and 3% BSO supplemented cheese after 21 days of storage were 8,9,9,9, respectively. In all cheese treatments, the sensory evaluation scores gradually decreased during the storage period. Also, it was clear that adding 1.5% BSO produced soft cheese with higher sensory acceptability than the control, both fresh and stored in the refrigerator for 28 days.

Table 4 demonstrates the variations in Total Bacteria count (TBC) of several soft cheese treatments after refrigerator storage. The findings revealed that TBC in all soft cheese samples significantly decreased after storage. A substantial reduction (P≤0.05) was found between soft cheese samples, especially after 14 days of storage. At 14 days of storage, the control cheese had a greater TBC 6.26 $\log_{10}$ cfu/g, but soft cheese with a higher BSO content (1.5%) had a lower TBC 5.87 $\log_{10}$ cfu/g.

The findings of this investigation revealed that coliform could not be

Table 1. Effect of Black Seed Oil on Titratable Acidity and moisture% of Soft Cheese during refrigerated storage.

Parameter Storage/Days	T.A%				Moisture %			
	C	T1	T2	T3	C	T1	T2	T3
Zero	0.25±0.02^{c}	0.27±0.03^{B}	0.28±0.02^{B}	0.33±0.01^{A}	67.70±0.05^{A}	68.64±0.05^{C}	68.51±0.08^{A}	69.48±0.03 ^{D}
7	0.27±0.03^{A}	0.30±0.02^{B}	0.31±0.04^{C}	0.35±0.03^{C}	65.44±0.06^{B}	67.41±0.03^{B}	68.33±0.02^{C}	68.54±0.02^{B}
14	0.32±0.01^{C}	0.35±0.02^{AB}	0.37±0.02^{A}	0.39±0.02^{A}	64.17±0.04^{A}	64.05±0.02^{B}	66.64±0.04^{C}	67.54±0.05^{D}
21	0.35±0.02^{A}	0.38±0.01^{B}	0.40±0.03^{AB}	0.45±0.03^{C}	62.94±0.02^{C}	63.71±0.02^{B}	65.84±0.03^{B}	66.78±0.02^{A}
28	S	0.41±0.01^{C}	0.46±0.01^{B}	0.58±0.05^{A}	S	60.43±0.02^{C}	62.58±0.02^{C}	64.71±0.02^{C}

Data are presented as Mean ± SE.
C: Control, T1: Cheese with 0.5 BSO, T2: Cheese with 1.0, T3 Cheese with 1.5 BSO, S: spoiled sample.
ABC Values in the same raw having different superscripts differ significantly (P < 0.05).

Table 2. Effect of Black Seed Oil on Fat & protein% and curd tension of soft cheese during refrigerated storage.

Parameter	Storage period	C	T1	T2	T3
Fat	Fresh	15.88±0.03^{A}	16.23±0.02^{B}	16.41±0.02^{C}	16.63±0.12^{C}
	7	15.32±0.03^{A}	16.41±0.03^{B}	16.67±0.05^{B}	17.49±0.02^{B}
	14	14.29±0.05^{B}	17.23±0.1^{AB}	17.27±0.01^{AB}	18.21±0.41^{AB}
	21	14.08±0.05^{B}	17.57±0.14^{A}	17.62±0.01^{AB}	18.53±0.2^{A}
	28	S	17.89±0.2^{A}	18.02±0.03^{A}	18.76±0.43^{A}
Total Protein (TP)	Fresh	10.64±0.13^{B}	10.71±0.23^{B}	10.84±0.32^{B}	10.92±0.11^{C}
	7	10.75±0.05^{B}	10.78±0.43^{B}	10.95±0.12^{B}	11.02±0.41^{B}
	14	10.89±0.05^{AB}	10.96±0.02^{AB}	11.13±0.04^{AB}	11.34±0.23^{AB}
	21	10.92±0.02^{A}	11.12±0.12^{A}	11.32±0.05^{A}	11.56±0.05^{A}
	S	10.98±0.02^{A}	11.18±0.05^{A}	11.45±0.43^{A}	11.63±0.23^{A}
Curd tension mg/ 100mg	Fresh	34.22±0.34^{B}	34.12±0.05^{C}	33.89±0.13^{C}	33.41±0.05^{SB}
	7	34.56±0.43^{AB}	34.43±0.14^{B}	33.23±0.24^{B}	33.18±0.32^{B}
	14	34.88±0.28^{AB}	34.58±0.12^{AB}	33.42±0.18^{AB}	33.32±0.05^{B}
	21	35.23±0.12^{A}	34.73±0.05^{AB}	33.58±0.02^{AB}	33.46±0.18^{AB}
	28	S	34.89±0.05^{A}	33.78±0.01^{A}	33.63±0.02^{A}

Data are presented as Mean ± SE. C: Control, T1: Cheese with 0.5 BSO, T2: Cheese with 1.0, T3 with 1.5 BSO, S: spoiled sample.

Table 3. Sensory characteristics (mean n = 3) of soft cheese supplemented with different concentrations of (BSO) during refrigerated storage.

Treatment	Storage	C	T1	T2	T3
Flavor (50)	Fresh	41±0.5^{C}	43±0.26^{B}	46±0.18^{A}	49 ±0.26^{A}
	7	40±0.8^{C}	42±0.12^{AB}	46±0.14^{B}	49±0.22^{A}
	14	37±0.5^{A}	42±0.23^{B}	45±0.22^{C}	48±0.18^{C}
	21	34±0.4^{C}	41±0.23^{B}	44±0.22^{A}	48±0.5^{C}
	28	S	38±0.5	44±0.18	47±0.14^{C}
Body &Texture (40)	Fresh	38±0.34^{A}	38±0.43^{A}	38±0.33^{A}	39±0.46^{A}
	7	38±0.58^{B}	38±0.22^{B}	38±0.66^{A}	39±0.58^{A}
	14	37±0.34^{C}	38±0.09^{AB}	38±0.35^{AB}	38±0.4^{A}
	21	36±0.41^{C}	37±0.7^{C}	37±0.81^{B}	38±0.18^{A}
	28	S	37±0.18^{B}	37±0.25^{A}	37±0.05^{A}
Appearance (10)	Fresh	9±0.20^{B}	10±0.35^{A}	10±0.48^{A}	10±0.35^{A}
	7	9±0.15^{B}	9±0.18^{B}	9±0.32^{B}	9±0.19^{B}
	14	8±0.55^{C}	9±0.79^{B}	9±0.36^{B}	9±0.81^{B}
	21	8±0.28^{B}	9±0.63^{A}	9±0.41^{AB}	9±0.26^{AB}
	28	S	9±0.23^{B}	9±0.18^{A}	9±0.17^{A}
Overall score (100)	Fresh	88±0.38^{C}	91±0.87^{B}	94±0.82^{A}	98±0.88^{A}
	7	87±0.75^{B}	89±0.31^{B}	93±0.71^{AB}	97±0.41^{A}
	14	82±0.48^{A}	89±0.43^{A}	92±0.32^{A}	95±0.44^{A}
	21	78±0.41^{D}	88±0.18^{C}	90±0.38^{B}	95±0.73^{A}
	28	S	87±0.41^{B}	90±0.43^{A}	93±0.91^{A}

Data are presented as Mean ± SE.
C: Control, T1: Cheese with 0.5 BSO, T2: Cheese with 1.0, T3 with 1.5 BSO, S: spoiled sample. A, B, C, D Means ± SE in the same letters followed by different Raws are significantly different (P<0.05).

Table 4. Effect of Black Seed Oil on Total Bacterial counts (TBA) ($\log_{10}$ Mean±SE) and Coliforms counts in soft cheese during refrigerated storage.

Storage/ days	Total Bacterial counts				Coliforms count			
	C	T1	T2	T3	C	T1	T2	T3
Zero	6.35 ± 0.01^{B}	6.35 ± 0.03^{B}	6.32 ± 0.02^{C}	6.37 ± 0.02^{A}	ND	ND	ND	ND
7	6.35 ± 0.14^{A}	6.30 ± 0.00^{B}	6.28 ± 0.05^{C}	6.25 ± 0.11^{C}	ND	ND	ND	ND
14	6.26 ± 0.10^{A}	5.94 ± 0.04^{AB}	5.91 ± 0.11^{B}	5.87 ± 0.03^{C}	ND	ND	ND	ND
21	6.15 ± 0.05^{A}	5.92 ± 0.11^{B}	5.87 ± 0.2^{BC}	5.84 ± 0.05^{C}	ND	ND	ND	ND
28	S	5.85 ± 0.05^{A}	5.83 ± 0.03^{A}	5.79 ± 0.01^{B}	S	ND	ND	ND

Data are presented as Mean ± SE.
C: Control, T1: Cheese with 0.5 BSO, T2: Cheese with 1.0, T3 with 1.5 BSO, S: spoiled sample. A, B, C Means ± SE in the same letters followed by different Raws are significantly different (P<0.05).

Table 5. Effect of Black Seed Oil on yeast & mold counts (log_{10} Mean ±SE) and Staphylococcus in soft cheese during refrigerated storage.

Storage/ Days	Yeast and molds				*Staphylococcus* sp.			
	C	T1	T2	T3	C	T1	T2	T3
Zero	ND	ND	ND	ND	ND	ND	ND	ND
7	ND	ND	ND	ND	ND	ND	ND	ND
14	1.15 ± 0.01 ^{A}	ND	ND	ND	ND	ND	ND	ND
21	1.35 ± 0.05 ^{B}	1.08 ± 0.01 ^{A}	ND	ND	ND	ND	ND	ND
28	S	1.21 ± 0.03^{C}	1.04 ± 0.01 ^{B}	0.58 ± 0.05 ^{A}	S	ND	ND	ND

Data are presented as Mean ± SE.
C: Control, T1: Cheese with 0.5 BSO, T2: Cheese with 1.0, T3 with 1.5 BSO, S: spoiled sample.
A, B, C Means ± SE in the same letters followed by different columns is significantly different (P<0.05).

discovered in any of the cheese samples tested, whether fresh or refrigerated, until the end of the shelf life. Table 5 shows that yeast began to appear in control cheese samples on the 14th day of refrigerated storage with mean values of 1.15 ± 0.01and increased slightly till the end of shelf life on the 21st day with a mean value of 1.35±0.05 Log_{10} cfu/g. But cheese samples with 1 and 1.5% BSO showed the absence of yeast and mold till the 28th day of storage began to grow with a mean value of 1.04±0.01 Log_{10} cfu /g and 0.58 ± 0.05, respectively.

Discussion

Adding BSO to soft cheese resulted in slightly higher moisture content than the control cheese among all cheese treatments. Overall, the findings indicate a gradual decrease in moisture content for all cheese treatments during storage. This decrease could be attributed to the curd shrinking due to acid development, which aids in expelling whey from the cheese curd. The highest moisture content, 69.48%, was obtained in soft cheese with a higher concentration (1.5%) of BSO at the fresh time, while the lowest moisture content, 60.43%, was obtained in soft cheese with a lower concentration (0.5 %) of BSO at the end of storage, 28 days. These results agreed with results detected by Hassanien *et al.* (2014) and Cakir *et al.* (2016), who found that with the addition of BSO to soft cheese and Erzincan Tulum cheese, respectively.

The growth of titratable acidity may be related to the fermentation of leftover lactose and the acidity impact of black seed oil because of its fatty acid content, which interferes with acidity outcomes (Çakır and Çakmakçı, 2018). The moisture content of the cheese during the storage period significantly impacted its acidity compared to the other cheese treatments. This correlation can be attributed to the fact that the formation of acidity results in the expulsion of whey from the curd (Effat *et al.*, 2001). Our data differ from those reported by Hassanien *et al.* (2014). These differences might be attributed to the differences in the method of cheese manufacture, type of milk, and concentration of oils.

The fat content of all treated cheese samples rapidly grew and reached maximum levels at the end of the storage period: 17.89, 18.02, and 18.76% for T1, T2, and T3, respectively. There was a favorable link established between oil content and fat percentages of the cheeses tested. This is most likely owing to lower (Hassanien *et al.*, 2014; Abdel-Latif *et al.*, 2021) solids-non-fat content from protein breakdown and partial loss in whey during storage. Because of the loss of water/total solids, the protein content of treated cheese samples increased after storage compared to the control. These findings were supported by Mahgoub *et al.* (2013) and Abd Elmontaleb *et al.* (2020).

The taste of soft cheese is significantly influenced by the BSO, as it contains organic and volatile fatty acids that can potentially affect the flavor of the cheese when evaluated by panelists (Abdel-Razig *et al.*, 2014). Comparable findings were also reported concerning the aroma development in Damietta cheese by Ibrahim and Abdel-Hakiem (2015) and Iranian white cheese by Ehsani *et al.* (2016). Adding BSO to cheese samples resulted in considerably increased body and texture outcomes (P≤0.05). However, texture gradually improved until 14 days of storage, after which it declined. After 21 days of storage, the body and texture of control, 0.5, 1, and 3% BSO-supplemented cheeses were 36.0±0.41, 37.0±0.7, 37.0±0.81, and 38.0±0.18, respectively. These findings could be attributed to oil's softening effect on cheese texture, as well as the effect of storage on cheese texture development via proteolysis and hydrolysis of the cheese matrix during storage, depending on the rate of protein breakdown and the release of small peptides and free amino acids. These findings agree with those published by Foda *et al.* (2008) and Coşkun *et al.* (1996).

There were noticeable differences between the control and cheese samples with different concentrations of BSO in appearance value. Appearance results of the control, 0.5, 1, and 3% BSO supplemented cheese after 21 days of storage were 8,9,9,9, respectively. Nearly comparable results were observed by Halamova *et al.*, (2010) and Hamid *et al.* (2014); who reported by Halamova *et al.* (2010) and Hamid *et al.* (2014), who reported that adding 0.1% and 0.3% of NSO improved the appearance of the tested cheese. However, higher concentrations may cause undesirable color and flavor changes.

In all cheese treatments, the sensory evaluation scores gradually decreased during the storage period. Also, it was clear that adding 1.5% BSO produced soft cheese with higher sensory acceptability than the control, both fresh and stored in the refrigerator for 28 days. These results agree with those obtained by Foda *et al.* (2008) and El-Bialy (2016).

The larger decrease of TBC in soft cheese with BSO might be attributed to the antibacterial action of BCO, which contains phenolics and fatty acids. These findings were consistent with Badawi (2004), which used BSO at a concentration of 0.5% in soft cheese to reduce total bacterial counts, and Çakır and Çakmakçı (2018), which used Tulum cheese with black cumin.

Coliforms were absent in tested cheese samples, whether fresh or refrigerated, until the end of the shelf life. This could be due to the efficient heat treatment and good sanitation conditions applied during the manufacture and storage of cheese samples. These results agreed with those reported by El-Bialy (2016) and came per those documented by EOSQ (2005), which stated that coliform should not exceed 10 cfu/ g or 1Log_{10} cfu/g of soft cheese.

The yeast growth began to appear in control cheese samples on the 14th day of refrigerated storage and increased slightly till the end of shelf life on the 21st day. This agrees with the results reported by Mehanna *et al.* (2002), who found that the yeast and mold of soft cheese began to appear after seven days of storage. But cheese samples with 1 and 1.5% BSO showed the absence of yeast and mold till the 28th day of storage began to grow. This may be attributed to Black seed oils, characterized by high levels of phenolics, considered powerful active compounds expressing strong antimicrobial activities (Luther *et al.*, 2007). These findings were nearly similar to the result detected by Tarakci *et al.* (2005) in Tulum cheese, who found that black cumin decreased the number of yeast & molds in cheese, and these counts came under those reported by Badawi *et al.* (2004), who stated that yeast count should not exceed 400 cfu/g of cheese.

Conclusion

Incorporating Black Seed Oil (BSO) extract into soft cheese substantially impacted various quality aspects, encompassing chemical composition, sensory attributes, and microbial stability. The using of BSO led to a minor rise in moisture content, increased titratable acidity, and an overall favorable influence on the chemical composition of the soft cheese. The highest level of sensory acceptability present in soft cheese supplemented with 1.5% BSO, underscoring the positive influence of BSO on the overall quality of the product. The results imply that BSO holds promise as a natural preservative to improve the quality and prolong the shelf life of soft cheese, so the observed positive effects on flavor, texture, and microbial stability open avenues for developing healthier and more appealing soft cheese products with potential applications in the dairy industry. Further research and exploration into BSO's optimal concentrations and application methods in cheese manufacturing would contribute to advancing and practically implementing this innovative approach in the food industry.

Conflict of interest

The authors have no conflict of interest to declare.

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