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Influence of Supplementing Parsley and Cilantro Extracts on Sensory Parameters of Soft Cheese with Highlighting on Their Antibacterial Impact

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Abstract

The study was achieved to show the influence of supplementing different concentrations of parsley and cilantro extracts on sensory and microbiological parameters of soft cheese during 2 weeks of storage. The antibacterial activity of crude extracts and the Minimum Inhibitory Concentration (MIC) of both plants were determined. Also, a study of food poisoning bacteria survival in artificially contaminated soft cheese. The *Escherichia coli* (*E. coli*), *Salmonella* Typhimurium (*S.* Typhimurium), and *Staphylococcus aureus* (*S. aureus*) were sensitive to oil extract (0.5%) of both plants, while *E. coli* and *S.* Typhimurium were sensitive to methanol extract (5.0%) of cilantro based on MIC. The oil extract (0.5%) of parsley had a significant ($p<0.05$) improving effect on the sensory parameters of samples throughout storage. In *E. coli* and *S.* Typhimurium inoculated samples, there was a significant difference ($p<0.05$) between samples with the oil extract (0.25% and 0.5%) of parsley and samples without extracts for pH value at end of the storage period. Based on the survival results, *S.* Typhimurium could not be isolated from all cheese samples with oil extract (0.5%) of cilantro on days 12 and 14 of storage, while *E. coli* count was reduced to 2.85 and 2.36 log CFU/g in cheeses with oil extract (0.25%) of parsley and cilantro, respectively. The *S. aureus* could not be isolated from all cheese samples with oil extract (0.5%) of parsley and cilantro from day eight till the end of the storage period. Results of the study recommended the use of these plants oil extracts to improve soft cheese safety and quality. This trial of the survival of food poisoning bacteria in the soft cheese supplemented by oil and methanol extracts of parsley and cilantro is one of the fewest studies, particularly in the Middle East.

KEYWORDS
Soft cheese, Parsley, Cilantro, Sensory parameters, pH, Survival

INTRODUCTION

One of the most popular dairy products sold, consumed, and loved globally in Egypt is white soft cheese (Mahgoub *et al*., 2013). Herbs have been used since the beginning of time not only as culinary flavorings but also for their medicinal benefits and preservative effects, which come from their antimicrobial constituents (Bandyopadhyay *et al*., 2007).

In the dairy business, it is essential that processed and prepared foods are of high quality and safe. The prevalence of pathogens, which are drug-resistant and the toxicity of currently used antibacterial chemicals have raised awareness of the antimicrobial activity of natural products. Public health has been concerned about dairy-borne illnesses brought on by eating dairy products, which have been tainted with harmful bacteria. Severe food-borne illnesses are caused by *Salmonella*, *Staphylococcus*, and *E. coli*. The use of natural plants as antimicrobial compounds appears to be a significant method to control the presence of pathogenic bacteria and to lengthen the shelf life of processed dairy products to improve food safety and decrease economic losses brought on by food-borne pathogens (Alboofetileh *et al*., 2014). Preservatives are created to extend food storing shelf life and stop bacteria from causing food to spoil. Although these synthetic preservatives work well, they can be harmful to human health, so more consumers are choosing food goods without preservatives or only containing natural ingredients (Kim *et al*., 2005).

Bacteria, among other microorganisms, are the primary cause of many human diseases. This is why the study of antimicrobial agents spans a wide area of the medical disciplines. The importance of finding novel antimicrobial compounds is also increased by the rise in antibiotic resistance. For many years, people have used plants as a natural supply of medicine. Because of their therapeutic potential and decreased side effects, the hunt for naturally occurring antioxidants and antimicrobial compounds is becoming more important today (Jin *et al*., 2009; Naveen *et al*., 2011; Makkia *et al*., 2022).

Cilantro seeds rank highly on the list of healing spices due to their reputation for promoting health. It has historically been known as; an analgesic, diuretic, anti-inflammatory, cholesterol-lowering, and antidiabetic drug. The oil tastes sweet, warm, and fragrant and has a distinctive linalool odor. Cilantro oil can be used as a flavor enhancer in culinary science. The utilization of cilantro oil in food has been approved by The Food and Drug Administration (Rezaei *et al*., 2016). The action of cilantro oil against many foodborne bacteria *in vitro* such as *S. aureus*, *E. coli*, and *L.*

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monocytogenes is a critical factor that influences its use. Essential oils and their constituents' organoleptic effects in dairy items continue to prevent their widespread use in dairy products. Additionally, the numerous biological benefits of cilantro oil may help customers improve their health, increasing the food item's value. Overall, the study on the use of cilantro oil as a food preservative is still in its infancy and has produced a wide range of success rates (Kačániová, 2023).

Because most herbs have antioxidant action and necessary components in the production of nutraceuticals and food products, researchers have become increasingly interested in medicinal plants in recent years. From various sections of cilantro, fatty acids, flavonoids, sterols, and oils have been discovered. All plant parts are extensively used and have significant antimicrobial, antioxidant, antimutagenic, antidiabetic, hypolipidemic, diuretic, anticonvulsant, antiulcer, hepatoprotective, and anxiolytic activity (Singh *et al*., 2002; Verma *et al*., 2011). Additionally, it functions defensively in the detoxification of heavy metals and lead toxicity (Nadeem *et al*., 2013; Zare-Shehneh *et al*., 2014).

Originally from Europe, Italy, Egypt, and Algeria, parsley is a species of Petroselinum that is extensively cultivated as an herb and a vegetable. Family Apiaceae plants are also referred to as nutraceutical plants and are frequently used as flavoring ingredients. Numerous species in this genus appear to be reliable sources of phytochemicals with strong antimicrobial and anti-inflammatory properties. Parsley oil extract demonstrated varying levels of antimicrobial action against various microorganisms. Therefore, using parsley oil as; an antimicrobial dietary additive or alternative medicinal treatment for microbes may be resistant to conventional medicine. This suggests a significant aid in preventing the proliferation of bacteria (Brkovic *et al*., 2006; Karimi *et al*., 2014).

Few investigations have evaluated the antibacterial impact of these plant extracts (Teixeira *et al*., 2013; Linde *et al*., 2016). Therefore, this study purposed to investigate the feasibility of incorporating parsley and cilantro extracts in soft cheese on its sensory parameters with the determination of pH value and evaluate the degree of antibacterial effect of parsley and cilantro oil extracts (0.25% and 0.5%), and cilantro methanol extract (5.0%) against *Escherichia coli* (*E. coli*), *Salmonella* Typhimurium (*S.* Typhimurium), and *Staphylococcus aureus* (*S. aureus*) based on MIC results during the 14-days storage of soft cheese in a refrigerator (5°C).

MATERIALS AND METHODS

Plant samples preparation

The various components of parsley (*Petroselinum crispum*) and cilantro (*Coriander sativum*) including seeds, leaves, and stems, were obtained from the Faculty of Pharmacy, Cairo University, Cairo, Egypt's research station for medicinal, aromatic, and dangerous plants. The plant's leaves and stems were cleaned with distilled water, dried for at least seven days in the dark, and then all of the plant's components were ground into fine dried powder using a blade mixer made by SPEX-SamplePrep-GenoGrinder® (Metuchen, USA). The powdered plant material was then kept at room temperature in the laboratory until the extraction process.

Extraction of essential oil from seeds

Separate seeds of parsley (*Petroselinum crispum*) and cilantro (*Coriander sativum*) were added to a hydro-distillation device. A Clevenger contraption for at least three hours was used for this purpose. After being cleaned, put into hydro-distillation tubes and dried over anhydrous sodium sulfate (Science Company, USA). The essential oils were kept in the refrigerator for further examination. Five ml of essential oil was generated from 250 g of seeds (Emam *et al*., 2021).

Freshly watery extract preparation of dried plants

According to the method applied by Ibrahim *et al*. (2023), the aqueous extracts from the dried plants were prepared. The exact amount of 100 g of dried powdered plants was steeped in 1000 ml of distilled water at 70 °C for 1 hour in a water bath (Memmert, Germany), and the mixture was then strained through cheesecloth. The filtrate was concentrated to a final volume of 50 ml in a rotary evaporator (Heidolph 2000, Germany); the running temperature was 60 °C at lower pressure (750 mmHg). The resultant water extracts were put into 100 ml glass bottles, autoclaved for 15 minutes at 121°C (Krishna Autoclave), and then stored in a refrigerator at 4 °C until usage.

Non-aqueous solvent extract preparation of dried plants

Methanol (El-Gomhoryia Company) 80.0% was employed as the solvent to extract the 250 g of each dried powdered plant. The solvent was then percolated 5-7 times until it was used up, which took at least 24 hours. These extracts were then filtered using Whatman no. 1 filter paper and condensed using a rotary evaporator (Heidolph 2000, Germany) at lowered pressure (750 mmHg) at a temperature of no greater than 40 °C, following the method described by Azouz *et al*. (2021). The semisolid extract was collected and then dried in an incubator (VEVOR lab incubator) for 24 hours at 37 °C, then weighed. The extracted components were stored at 5 °C until required.

Soft cheese processing

Buffalo's milk was obtained from the Department of Agriculture farm at Cairo University in Egypt. From the Proquiga Company in Spain, microbial rennet (Reniplus®, 2000 IMCU/g) was purchased. Edible salt (NaCl) produced by the Egyptian Company for Salts was utilized. The Merck Company provided the calcium chloride anhydrous for purchase. Salt, calcium chloride, and rennet were introduced in proportions of 3.0%, 0.2%, and 0.1%, respectively. After thorough stirring, the concoction was left to rest for about four hours. After the whey was drained, the cheese was curd and put into plastic receptacles for storage. For 14 days, the containers were kept in the refrigerator (5±1°C) with their lids securely shut.

Determination of the antibacterial activity of crude extracts and minimum inhibitory concentration (MIC) of plant extracts

The antibacterial efficacy of watery, methanol and oil crude preparations of both plants was assessed using the disc diffusion test. Also, MIC of methanol extract of cilantro (2.5%, 5%, and 10%) and oil extracts of parsley and cilantro (0.25%, 0.5%, and 1%) were evaluated against the selected strains; *Escherichia coli* ATCC 25922, *Salmonella* Typhimurium ATCC 14028TM, *Staphylococcus aureus* ATCC43300, *Listeria monocytogenes* ATCC 19115, and *Bacillus cereus* ATCC 33018 (Burt, 2004). The microorganisms were obtained from Cairo University's Faculty of Veterinary Medicine's Microbiology Department. The National Committee for Clinical Laboratory Standards guide, and a slipping caliper were used to

measure the sizes of the inhibition zones three times (CLSI, 2018).

Soft cheese samples sensory evaluation according to Clark et al. (2009)

Each cheese sample was given a number and evaluated by three skilled panelists for taste (40), body and texture (40), color (10), salt (5), and style (5) when it was fresh and after 3, 6, 9, 12, and 14 days. All of the testers stated that they regularly rinse their mouths out with distilled water. The results of this assessment were finally recorded in a specific scorecard. This evaluation was done twice. Firstly, for detection of the degree of consumer acceptability for these newly incorporated plants to cheese at higher concentrations, 1.0% for oil extract and 10.0% for methanol extract, and second after MIC results at lower concentrations, 0.5% for oil extract and 5.0% for methanol extract.

Determination of pH value for different formulated soft cheese samples

Using the waterproof pH instrument AD11 (Adwa®, Szeged, Hungary), the pH values of cheese samples were measured three times in accordance with AOAC, (2000).

Trial for E. coli, S. Typhimurium*, and S. aureus survival in the examined soft cheese samples (Turgut and Diler, 2020)*

E. coli, *S.* Typhimurium, and *S. aureus* were selected for further action based on the MIC findings and kept at 5 °C until use. For each culture, five milliliters of brain heart broth (CM1135, Oxoid) were used at 37 °C for 24 hours. The strain was turned by centrifugation (Thermo-Fisher, USA) at 3500 RPM/10 min. Using 0.1% peptone water, the particle was washed three times (M028, Himedia). The same diluent and final quantity of *E. coli*, *S.* Typhimurium, and *S. aureus* cells at 10 log CFU/ml was used to re-suspend the cells. Decimal serial dilutions were achieved for the soft cheese inoculation.

According to the instructions provided by Turgut and Diler (2020), soft cheese was made from pasteurized milk which then cooled to 50 °C for addition of different ingredients. Milk (verified free from these bacteria by PCR) was divided into four portions (milk with oil extracts of parsley and cilantro 0.25% and 0.5%, milk with methanol extract of cilantro 5%, and milk without extract) for *E. coli* and *S.* Typhimurium trial, respectively, while milk divided into three portions (milk with oil extracts of parsley and cilantro 0.5% and milk without extract) for *S. aureus* trial. Inoculation of milk with approximately 8.93, 9.17, and 9.07 logs CFU/ml of *E. coli*, *S.* Typhimurium, and *S. aureus*, respectively, for each concentration of parsley and cilantro.

For a 14-day period of storage in the refrigerator, *E. coli*, *S.* Typhimurium, and *S. aureus* survival in the part of cheese samples were tested. Trials were carried out three times, and averages were recorded. Based on the MIC findings, carefully selected plant extract percentages were used.

Bacterial enumeration in the inoculated soft cheese samples

To create the soft cheese homogenate, eleven grams of cheese sample were aseptically mixed with 99 milliliters of diluent 2.0% sodium citrate (Sigma-Aldrich). To achieve a 1/10 dilution, the first dilution was mixed with Stomacher Seward 400 (Worthing UK) for 10 seconds. Then, 0.1 ml of the decimal serial dilutions (ISO, 2020) were distributed on agar plates by mixing 1 ml of the first dilution with nine ml of diluents. Three examinations were conducted, and estimates of the numbers of *E. coli*, *S.* Typhimurium, and *S. aureus* (CFU/g) were made in accordance with APHA (2015).

Statistical analysis of data

Using post hoc, Tukey HSD through SPSS version 25, the one-way ANOVA was used to calculate the p-value ($P \leq 0.05$) for significant differences between the mean values of the measured parameters in soft cheese samples for various concentrations and kinds of plant extracts.

RESULTS

The crude oil extract of parsley shows antibacterial activity against *E. coli*, *S.* Typhimurium, *S. aureus*, *L. monocytogenes*, and *B. cereus*, while the crude oil extract of cilantro shows antibacterial activity against *E. coli*, *S.* Typhimurium, *S. aureus*, and *L. monocytogenes*. The crude methanol extract of cilantro shows antibacterial activity against *E. coli* and *S.* Typhimurium only, while the crude methanol extract of parsley shows no antibacterial activity for all investigated bacteria. The water extract for both crude extracts showed no antibacterial activity for the five investigated bacteria (Fig. 1).

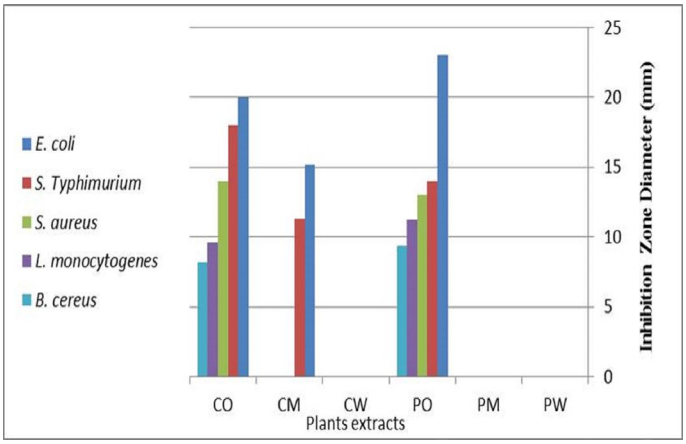

Fig. 1. Antibacterial activity of crude extracts against the selected bacterial strains.
Values an average of triplicates, PW: Parsley water extract; PM: Parsley methanol extract, PO: Parsley oil extract; CW: Cilantro water extract; CM: Cilantro methanol extract; CO: Cilantro oil extract, PW, PM, and CW with no inhibition zone

In Table 1, the Minimum Inhibitory Concentration (MIC) of both plants was determined. The *E. coli*, *S.* Typhimurium, and *S. aureus* were sensitive to oil extracts (0.5%) of both plants, while *E. coli* and *S.* Typhimurium were sensitive to methanol extract (5.0%) of cilantro.

For the sensory trial results, the oil (1%) and methanol (10%) extracts of both plants had a significant ($p < 0.05$) lowering effect compared with control samples throughout the storage periods except samples with oil extract of parsley after 6 days of storage (Table 2). For the sensory grading of samples, that obtaining after MIC results, the overall acceptability of cheese samples with oil extract (0.5%) of parsley was significantly ($p < 0.05$) improved in comparison with control cheese samples after the storage for 3, 6, 9, 12, and 14 days (Table 3).

In *E. coli* and *S.* Typhimurium inoculated samples, the oil extract of parsley had a significant effect ($p<0.05$) in comparison with samples without any extracts for pH value at end of storage period, while in *S. aureus* inoculated samples, the oil extract of cilantro had a significant effect ($p<0.05$) in comparison with sam-

ples without extracts at end of the storage period (Table 4).

Based on the survival results, *S.* Typhimurium could not be isolated in samples with oil extract (0.5%) of cilantro on days 12 and 14 of storage, while *E. coli* count Lowered from 5.44 to 2.36 log CFU/ g in samples with oil extract (0.25%) of cilantro throughout the storage period (Figs. 2 and 3). The *S. aureus* could not be isolated from all cheese samples with oil extract (0.5%) of parsley and cilantro from day eight till the end of the storage period, while the count in control samples ranged from 4.71 to 2.86 log CFU/ g in the same period of storage (Fig. 4).

DISCUSSION

In Fig. 1, water extracts of the two plants had no antibacterial effect on all examined strains without any zone of inhibition. For methanol extract, parsley extract had no effect on all bacterial strains, while cilantro extract had an inhibitory effect on *E. coli* and *S.* Typhimurium. All examined strains were highly affected by oil extracts of both plants with a zone of inhibition (8.2- 23 mm). For that, MIC was done for two oil extracts against all strains and cilantro methanol extract against *E. coli* and *S.* Typhimurium. The resistance of investigated Gram-negative bacteria to these extracts may be attributed to membrane enzymes and structure, which stop extract molecules from penetrating. Some studies suggest that the structure of the membrane, which stops other molecules from penetrating, may be the cause of the growth of these bacteria. Additionally, this framework contains enzymes (Gao *et al*., 1999).

In Table 1, the Minimum Inhibitory Concentration (MIC) of both plants was determined. The *E. coli*, *S.* Typhimurium, and *S.*

Table 1. Minimum inhibitory concentration (MIC) of tested plants extracts against the selected bacterial strains.

Tested strains	Inhibition Zone Diameter (mm)								
	PO concentration (%)			CM concentration (%)			CO concentration (%)		
	0.25	0.5	1	2.5	5	10	0.25	0.5	1
E. coli	17.3	18.7	22	8.2	10.9	24	15.3	18	20.7
S. Typhimurium	6.7	17	18	5.3	9.6	17	7	17	17.3
S. aureus	-	10.3	16	-	-	-	-	9.7	12.3
L. monocytogenes	-	4.3	5	-	-	-	-	-	3.7
B. cereus	-	-	-	-	-	-	-	-	-

-: No inhibition zone; Values an average of triplicates; PW: Parsley water extract; PM: Parsley methanol extract; PO:Parsley oil extract; CW: Cilantro water extract; CM: Cilantro methanol extract; CO: Cilantro oil extract

Table 2. Trial results for grading of the examined cheese samples based on sensory parameters at different storage periods.

Storage day	Sample	Flavor (40)	Texture (40)	Color (10)	Salt (5)	Style (5)	Total acceptability (100)
Zero-day (Production day)	PO	32	37	8	5	5	87[a]
	CO	33	36	8	5	5	87[a]
	CM	30	33	5	5	5	78[b]
	Control	37	39	9	5	5	95[c]
After 3 days	PO	35	39	8	5	5	92[a]
	CO	34.3	37	8	4	5	88.3[b]
	CM	31	35.3	5	5	4	80.3[c]
	Control	37.3	39	9	5	5	95.3[d]
After 6 days	PO	35	38	8	4	5	90[a]
	CO	35	37.3	7	4	4	87.3[b]
	CM	32.3	34.3	5	4	4	79.6[c]
	Control	35.7	38	9	4	5	91.7[a]
After 9 days	PO	30	36.7	6	4	5	81.7[a]
	CO	31	35.3	6	4	4	80.3[b]
	CM	29.3	31	4.3	4	4	72.6[c]
	Control	34	37.3	8	4	5	88.3[d]
After 12 days	PO	30	36	6	3.7	4	79.7[a]
	CO	30	34.3	6	3.3	4	77.6[b]
	CM	24.3	26.7	2.3	3.7	3	60[c]
	Control	34	37	7.3	4	4	86.3[d]
After 14 days	PO	25.3	34	5	3.7	3	71[a]
	CO	27	32	5.7	3	3	70.7[a]
	CM	22.7	24.7	1.7	2.3	2.7	54.1[b]
	Control	33	35	6	3.7	3.7	81.4[c]

Values an average of triplicates, PO 1% = Parsley oil extract, CO 1% = Cilantro oil extract, CM 10% = Cilantro methanol extract, Control= without any extract.
SE± for zero, 3, 6, 9, 12, 14 days was 0.81, 0.46, 0.56, 0.41, 0.56 and 0.52, respectively.
For each storage period: different superscript letters in the same column only is significant ($p<0.05$).

aureus were sensitive to oil extracts (0.5%) of both plants, while *E. coli* and *S.* Typhimurium were sensitive to methanol extract (5.0%) of cilantro. The methanol extract of cilantro was effective only against *E. coli* and *S.* Typhimurium, for that, MIC was done against these microorganisms with selected concentrations (2.5%, 5%, and 10%). After examination, a concentration of 5% was effective and selected to be tested against these microorganisms in the cheese samples. *E. coli* was the most sensitive pathogen; a 0.25% concentration of the two oils was selected. *S.* Typhimurium was not sensitive to this concentration (0.25%), but it was very sensitive to the 0.5% concentration from both oils, so this concentration was selected against *S.* Typhimurium in the cheese samples. On the same side, *S. aureus* showed sensitivity to a concentration of 0.5% only, so this concentration was also selected in the cheese samples.

On the other side, *L. monocytogenes* and *B. cereus* showed insensitivity against the three tested concentrations for both oils extracts, although they had showed sensitivity against the crude oil extract. These bacteria are sensitive to oil extracts of plants but with a higher concentration. This is not accepted for application, as higher concentrations of oil extracts could alter the sensory parameters of cheese to an unacceptable level for the consumer.

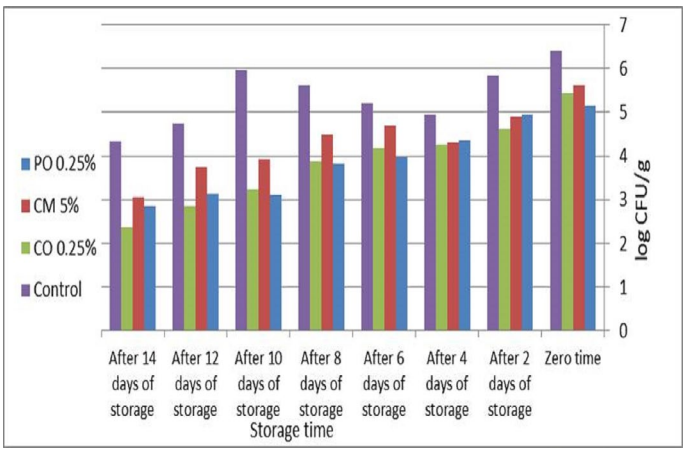

Fig. 2. Effect of parsley oil extract and cilantro methanol and oil extracts on the survival of *E. coli* in soft cheese samples during storage.
Values an average of triplicates, PO: Parsley oil extract; CM: Cilantro methanol extract; CO: Cilantro oil extract

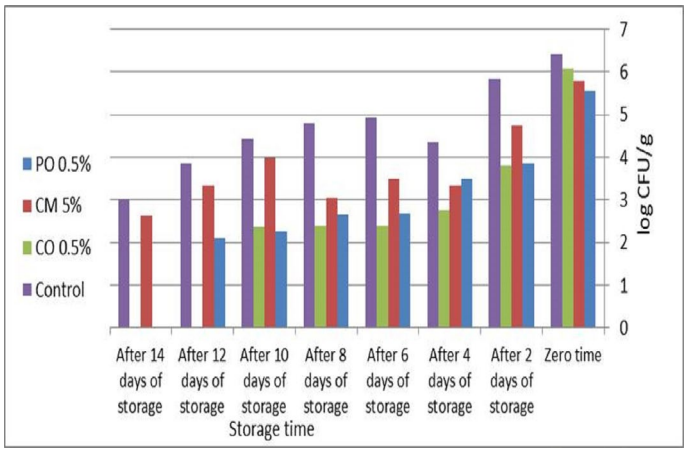

Fig. 3. Effect of parsley oil extract and cilantro methanol and oil extracts on the survival of *S.* Typhimurium in soft cheese samples during storage.
Values an average of triplicates, PO: Parsley oil extract; CM: Cilantro methanol extract; CO: Cilantro oil extract

Table 3. Sensory parameters evaluation of the examined cheese samples at different storage periods based on MIC results.

Storage day	Sample	Flavor (40)	Texture (40)	Color (10)	Salt (5)	Style (5)	Overall acceptability (100)
Zero-day (Production day)	PO	37	38.3	10	5	5	95.3[a]
	CO	36.7	39	8.7	5	5	94.4[a]
	CM	36	38.7	8.7	4.7	4.3	92.4[b]
	Control	37	39	9	5	5	95[a]
After 3 days*	PO	38.7	39	10	5	5	97.7
	CO	38.3	39	9	5	5	96.3
	CM	36.7	38.7	8.3	4.7	4.3	92.7
	Control	37.3	39	9	5	5	95.3
After 6 days	PO	38	38	9.3	5	5	95.3[a]
	CO	36.7	37.3	9	5	5	93[b]
	CM	35.7	36.7	8	4.7	4	89.1[c]
	Control	35.7	38.3	9	5	5	93[b]
After 9 days	PO	37	37.7	8	5	5	92.7[a]
	CO	35	36.3	8	5	4	88.3[b]
	CM	33.7	35	7	4.3	4	84[c]
	Control	35	36.3	8.7	5	5	90[b]
After 12 days	PO	35.7	37.3	8	4.7	4	89.7[a]
	CO	34.3	35.3	8	5	4	86.6[b]
	CM	33	35	7	4.3	4	83.3[c]
	Control	34	35	8	4.7	4	85.7[b]
After 14 days	PO	33	34.5	7.7	4.7	4	83.9[a]
	CO	33.3	32.7	7.3	4.7	4	82[a]
	CM	31.7	33.7	6.7	4	3	79.1[b]
	Control	32.3	32	7	4	3.7	79[b]

Values an average of triplicates, PO 0.5% = Parsley oil extract, CO 0.5% = Cilantro oil extract, CM 5% = Cilantro methanol extract, Control= without any extract.
SE± for zero, 3, 6, 9, 12, 14 days was 0.48, 0.43, 0.59, 0.65, 0.48 and 0.68, respectively.
For each storage period: different superscript letters in the same column only is significant ($p<0.05$), while *after 3 days, all is significant ($p<0.05$) except between PO and CO, CO and Control.

Based on the supportive sensory trial results of this study, even a 1% oil extract of cilantro had a lowering significant (P<0.05) effect on the sensory parameters of cheese samples throughout the storage period.

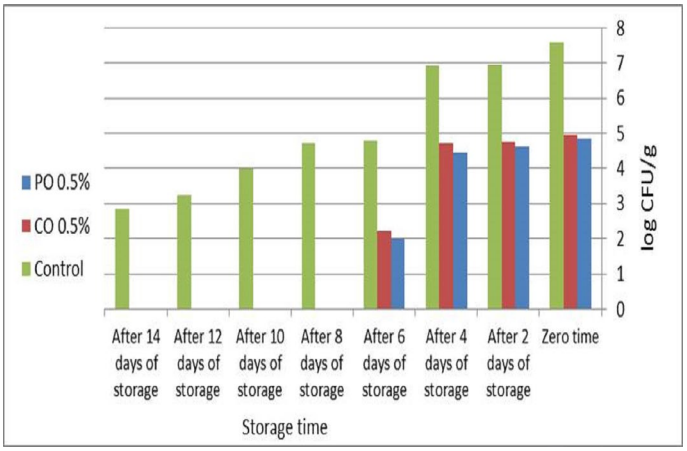

Fig. 4. Effect of parsley and cilantro oil extracts on the survival of *S. aureus* in soft cheese samples during storage.
Values an average of triplicates, PO: Parsley oil extract; CO: Cilantro oil extract

According to Linde *et al.* (2016), parsley oil extract had a mean MIC value of 0.52 mg/ml, which inhibited the development of all tested bacteria. *Salmonella enterica*, *S. aureus*, and *L. monocytogenes* were the most vulnerable bacteria, and *E. coli* was the most resistant. With approximate MIC values, the disc diffusion technique is straightforward and practical (Jorgensen and Ferraro, 2009; Balouiri *et al.*, 2016). According to Nawel *et al.* (2014), parsley oil extract had no activity against *E. coli* and only moderate antibacterial activity against *S. aureus* and *Bacillus cereus*.

On *S. aureus*, parsley had an inhibition zone that was greater than that of cilantro extracts. According to Manderfield *et al.* (1997), numerous flavonoids, including furocoumarins, have been isolated from parsley leaves and are recognized for their antibacterial properties against *Listeria*, Micrococcus species, and *E. coli*. The extracts' phenolic compound content is what gives them antimicrobial properties. Plant extracts can inhibit the development of certain bacterial strains by interfering with the double layers phospholipid of the cell membrane, which increases permeability, or by impairing a number of different enzymatic systems) Jeongmok *et al.*, 1995).

The first sensory trial was done only to the highest concentrations (1% for oil extract and 10% for methanol extract) to determine the degree of acceptability to the consumer, as a fortified cheese with different plant flavors. It was done during storage for 14 days to assess the extracts' effect on the cheese quality with time. There was a significant (p<0.05) difference between cheese samples with these extracts' concentration of both plants and control samples based on the sensory parameters, except samples with oil extract of parsley after six days of storage (Table 2). Oil extracts for both plants had a significant (p<0.05) lowering effect on cheese's overall acceptability throughout the storage periods except after six days from processing. After storage for six days, the flavor and texture of cheese samples with two plant oil extracts resembled the control samples. After storage for nine days, green discoloration increased in depth, loose consistency, and unacceptable taste for methanol extract of cilantro cheese samples. Cilantro methanol extract (10%) had a significant (p<0.05) lowering effect on cheese sensory parameters; the most obvious was the green discoloration of cheese which was not acceptable by the panelist; also, it was slightly grainy with the mouth feel of some particles from the extract. Its flavor was more obvious than the original cheese flavor.

At the same point, the oil extracts of both plants showed a clear bitter aftertaste. After storage for 12 days, the flavor, color, and texture of cheese with methanol extract of cilantro were unacceptable to the panelist. After storage for 14 days, the bitter flavor of samples with oil extract of parsley increased and became unacceptable. The same was for samples with oil extract of cilantro but with a lower effect, as agreed with Gulluce *et al.* (2003). As anticipated, overall acceptability ratings dropped as storage times increased. The sensory perception of food is a complex process that is affected by a variety of elements, including the flavor, texture, and appearance of the dairy product (Smit *et al.*, 2005).

In Table 3, the sensory examination was done for 2nd time after obtaining the results of MIC to evaluate the degree of consumer acceptability of these extract's concentration. The oil extract of parsley is a significantly (p< 0.05) better effect than the oil extract

Table 4. pH values for all inoculated soft cheese samples at different storage periods.

	Inoculated cheese samples										
Storage day	1	2	3	4	5	6	7	8	9	10	11
Zero time	6.5	6.5	6.52	6.6	6.45	6.43	6.44	6.5	6.63	6.59	6.61
After 2 days	6.51	6.5	6.54	6.61	6.46	6.43	6.44	6.52	6.64	6.6	6.63
After 4 days	6.52	6.52	6.55	6.61	6.48	6.46	6.47	6.52	6.66	6.61	6.64
After 6 days	6.43	6.49	6.45	6.56	6.43	6.45	6.5	6.5	6.7	6.65	6.64
After 8 days	6.41	6.45	6.42	6.54	6.4	6.42	6.5	6.49	6.68	6.66	6.66
After 10 days	6.5	6.54	6.47	6.55	6.46	6.47	6.5	6.52	6.68	6.68	6.69
After 12 days	6.45	6.52	6.43	6.5	6.4	6.42	6.49	6.5	6.65	6.62	6.64
After 14 days	6.41	6.48	6.4	6.47	6.39	6.37	6.44	6.47	6.58	6.56	6.6

1: Cheese sample with 0.25% PO inoculated with *E. coli*.
2: Cheese sample with 0.25% CO inoculated with *E. coli*.
3: Cheese sample with 5 % CM inoculated with *E. coli*.
4: Control Cheese sample inoculated with *E. coli* without any extract.
5: Cheese sample with 0.5% PO inoculated with *S.* Typhimurium.
6: Cheese sample with 0.5% CO inoculated with *S.* Typhimurium.
7: Cheese sample with 5 % CM inoculated with *S.* Typhimurium.
8: Control Cheese sample inoculated with *S.* Typhimurium without any extract.
9: Cheese sample with 0.5% PO inoculated with *S. aureus*.
10: Cheese sample with 0.5% CO inoculated with *S. aureus*.
11: Control Cheese sample inoculated with *S. aureus* without any extract.
SE± for zero day was 0.014, SE± for 3, 6, 9, 12, 14 days was 0.008 for each. At zero day of storage; there was non-significant difference (P>0.05) only between 1,2- 1,3- 1,5-,1,8-2,3-2.5-2,8-3,8-4,9-4,10-4,11-5,6-5,7-,5,8-6,7-9,10-9,11-10,11. At 2 days; there was non-significant difference (P>0.05) only between 1,2- 1,8- 2,8- 3,8- 4,10-4,11-5,7-6,7- 9,11. At 4 days; there was non-significant difference (P>0.05) only between 1,2- 1,8- 2,8- 4,10-5,6-5,7- 6,7-9,11. At 6 days; there was non-significant difference (P>0.05) only between 1,3- 1,5- 1,6-2,7-2,8- 3,5-3,6- 5,6- 7,8-10,11. At 8days; there was non-significant difference (P>0.05) only between 1,3- 1,5-1,6- 3,5- 3,6- 5,6- 7,8- 9,10- 9,11- 10,11. At 10 days; there was non-significant difference (P>0.05) only between1,7-1,8-2,4-2,8-3,5- 3,6- 5,6- 7,8- 9,1- 9,11- 10,11. At 12 days; there was non-significant difference (P>0.05) only between 1,3- 2,4-2,8- 3,6- 4,7- 4,8- 5,6- 7,8- 9,11-10,11. At 14 days; there was non-significant difference (P>0.05) only between 1,3-1,5- 2,4-2,8- 3,5- 4,8- 5,6- 9,10- 9,11.

of cilantro during the storage of cheese samples. After storage, the samples with two oil extracts (0.5%) were better than control samples without the appearance of any deterioration signs and were more acceptable with good appearance, this agrees with Lawless (1995).

According to Mishra and Dubey (1994), the parsley and cilantro oil's aromatic effect caused the samples that were treated with oil extracts to significantly increase in terms of flavor, texture, and aroma. Therefore, the use of herbal preparations to enhance sensory qualities, prevent lipid oxidation, and lengthen the shelf life of soft cheeses has received a lot of attention in recent years (Lagouri and Nisteropoulou, 2009). The taste ratings are thought to be connected to the cheese's shelf life. The sensory ratings for the cheese's appearance, texture, flavor, and general acceptability were all significantly affected by the addition of cilantro extract (Turgut and Diler, 2020).

In *E. coli* and *S.* Typhimurium inoculated cheese samples, the oil extracts of parsley and cilantro had a significant ($p<0.05$) effect in comparison to samples without extracts for pH value at zero, 2, 4, 6, and 8 days of storage, while in *S. aureus* inoculated samples, the oil extract of cilantro had a significant ($p<0.05$) effect in comparison to samples without extracts at 2, 4, and 14 days of storage (Table 4). The acidity of cheese during storage affected the investigated bacteria so the bacterial counts in control samples were also decreased (Possas *et al*., 2021). The rise in pH of the control cheese samples may be the result of microbial growth, which may lead to protein hydrolysis and the release of nitrogenous compounds that elevate the pH of the cheese. Although the pH value of samples containing plant extracts was lower than the control, this could be explained by the plants' antibacterial properties (Chen *et al*., 2017).

Based on the *E. coli* and *S.* Typhimurium survival trial (Figs. 2 and 3), the oil extract of parsley, methanol extract of cilantro, and oil extract of cilantro could be able to reduce the *E. coli* (log CFU/ml) to 2.85, 3.07, and 2.36, also for *S.* Typhimurium (log CFU/ml), not detected, 2.63, and not detected in the examined samples at the end of storage, respectively. The oil extracts (0.5%) of parsley and cilantro could be able to reduce the *S. aureus* (log CFU/ml) to 2.0 and 2.23 after 6 days of storage, respectively (Fig. 4). These findings suggest that the used plant extracts have an antibacterial impact. Producing these innovative, fortified soft cheese varieties that are acceptable to consumers at reasonable costs is also a plus. Gram-negative bacteria tend to be more resistant to plant oil extracts than Gram-positive bacteria, as our study has shown. These differences have been connected to the complexity of the plant oil-interfering cell walls of gram-negative bacteria. The cell walls of gram-positive bacteria are made in such a manner that hydrophobic molecules can enter and interact with the cell wall and cytosol (Nazzaro *et al*., 2013). In addition, there may be differences in how biologically active essential oils occur (Linde *et al*., 2016).

This research indicates that cilantro oil extract has antibacterial qualities that are effective against *S. aureus*. This microorganism is frequently present in raw milk and grows during the fermentation process. It flourishes in animal mucous membranes and the skin. *S. aureus* is a major cause of foodborne outbreaks connected to cheeses and other enterotoxin-contaminated foods (Greig *et al*., 2007; Gazzola and Cocconceli, 2008).

The presence of certain bacteriostatic substances called phenols and flavonoids, which have an antibacterial effect on the majority of microorganisms, in parsley oils may be the cause of the observed drop in microbial counts. Ashour *et al*. (2014); Farah *et al*. (2015) and Alsaiqali *et al*. (2016) discovered that parsley extract significantly decreased the number of bacteria like *E. coli* and *S. aureus*. *E. coli* could be more resistant than *Salmonella* to parsley extract based on a study (Mohammad, 2014). A further finding by Alsaiqali *et al*. (2016) was that parsley extract had a potent antimicrobial effect against *S. aureus* and *E. coli* during the storage period, but that this effect waned over time. As a result, using parsley oil as a natural remedy to treat this bacterial infection is a choice (Franciscato *et al*., 2022). The study recommended using parsley oils to enhance the safe and natural antimicrobial defenses of soft cheese.

According to a study by Brantner and Grein (1994), parsley extracts can cause bacterial cells to break. The study by Peter *et al*. (2006) implied that these compounds might dissolve the cell wall of bacteria. This suggested that some components of the extract had prevented or delayed bacterial growth. Some plants have compounds that hinder bacterial growth and movement rather than breaking (Moazedi *et al*., 2007). Another research revealed that some plant extracts can prevent bacteria from growing while also slowing growth by extending the life cycle of the bacteria (Mangesh *et al*., 2009).

Based on Yakout *et al*. (2013) and Ali and Malik (2020), cilantro contains a significant number of valuable flavonoids and polyphenols (free radicals suppressors), which are the cause of cilantro's extensive antimicrobial activity against pathogenic and spoilage strains. Cilantro oils have been found to have both bacteriostatic and antibacterial effects (El-Sayed *et al*., 2022). Since the destructive effects of aldehydes and alcohols on the microbial biofilm are linked with the antibacterial activity of cilantro oil extract, it can be used in combination with other medications or as an alternative to antibiotics (Alves *et al*., 2016). Damage to bacterial cells is caused by alcohol-extracted cilantro, iron-chelating action, and the hydrophobic nature of phenolic compounds (Wong and Kitts, 2006).

Accordingly, decreasing microbial presence during the processing of soft cheese is essential for prolonging its shelf life and improving safety. This also shows that adding these extracts to the soft cheese during processing has a synergistic antimicrobial effect. Future research on the safety of soft cheese can use the study's survivor trail as a significant source of updated information. The use of cilantro and parsley oil extracts can improve the soft cheese's sensory and microbial qualities. The cheese will benefit from the addition of parsley and cilantro oil additives to its marketing. One could argue that its use in the dairy sector could be advantageous and would be simple to introduce into the Egyptian market. As a result, this study will help to raise the standards used to evaluate and regulate soft cheese on the market. To create a high-safe soft cheese, excellent production practices, and HACCP plan verification in the soft cheese plant are crucial (Adam *et al*., 2021; Ibrahim *et al*., 2022).

CONCLUSION

In this study, *S.* Typhimurium and *S. aureus* could not be isolated from all cheese samples with oil extracts (0.5%) of parsley and cilantro, while *E. coli* count was reduced by (2.29- 3.08 logs) in oil extract (0.25%) of both plants at the end of the storage period. This suggests that these extracts are improving the cheese's wholesomeness. The oil extract (0.5%) of parsley can be utilized to produce soft cheese with excellent sensory parameters. Also, oil extracts of both plants conserved the soft cheese pH values during storage and preserved its quality till the end of the storage period. The additions of these environmentally friendly, secure, and economically advantageous oil plant extracts during the production of soft cheese should be started by soft cheese makers who are familiar with this information.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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