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Properties of Novel Ultra-Filtrated Soft Cheese Supplemented with Sumac Extract

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Abstract

Sumac is a common spice and its ethanol extract is characterized as effect a natural preserving for food stuffs in addition to its health benefits. The objective of this study was to determine the result of ethanolic *sumac* extract on the selected pathogenic bacteria besides studying the addition of different amounts of (0.2, 0.4, 0.6, 0.8 and 1 %) the *sumac* extract on the chemical, microbial, and sensorial properties of UF-cheese. The results reflected that the *Sumac* extract had a strong effect on inhibiting pathogenic bacteria that cause spoilage, and the most affected pathogenic bacteria was *B. cereus*. The presence of the extract also enhances the growing of the starter culture and probiotic bacteria. The incorporation of the extract to the UF-cheese improved the physicochemical and textural properties, and improves the storage quality. The produced UF-cheese with 0.4% *sumac* extract was highly accepted by the panelists.

Keywords: Sumac extract; UF-Cheese; natural preservative; pathogenic bacteria; UF-cheese properties.

Introduction

Spices are a gift to nature for its ability to protect against many diseases. They contain many functional compounds that have many biological functions [1]. There are many ways to take advantage of effective compounds found in spices by delivering them through food. Dairy products are one of the most important carriers of these important active and vital substances as well as bacteria [2-4]. The adding of spices also extracts for milk and dairy products allows for beneficial interactions between the milk ingredients and active compounds of spices and herbs [5,6], which have a beneficial effect [7]. The *Sumac* (*Rhuscoriaria* L.) is considered a spice with multiple effects such as antibacterial, antioxidant, colorants in food, etc.. It can be used in the food manufacturing as a natural in addition effective preservative for its antibacterial, antifungal, and antioxidant properties [8-10]. The hydro-alcoholic *sumac* extract has the potential to delay undesirable chemical and microbiological changes and improve the favorite sensory characteristic of beef meat [11]. Regarding to Ahmadi et al., [12], the water extract of *sumac* has an antimicrobial effect on *Bacillus cereus* in the soup and is a natural preservative when used in food processing. *Sumac* ethanolic extract was tested in different concentrations on the growth of 12 *foodborne* and *pathogenic* strains, it was found effective against all tested strains [13]. The water extract of *sumac* affected five common types of oral bacteria and could prevent the formation of a bacterial biofilm on the orthodontic wires [14]. Recently, under the crisis that the world is going through, the COVID-19 epidemic has spread and the number of infections has increased, which can lead to death and an increase in the number of deaths as a result of the infection. It has been found that several plants are characterized by the high content of poly-phenols and antioxidants

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and have a positive effect as an antidote to this virus, including the *sumac* [15, 16].

White soft cheese is the most widespread cheese and is obtainable in the markets and available to the consumer and receives great attention in the Arab countries, especially Egypt [17]. Due to the spread of white cheese consumption, it is a good deliver for probiotic microorganisms [18-20] and many important compounds such as spices extracts.

According to the above, this study aimed to prepare the ethanolic extract of the *sumac*, to study its antibacterial effect against selected foodborne and pathogenic strains, to add it in different concentrations to manufacture UF-white soft cheese, and to investigate the chemical, bacteriological, in addition sensorial properties of the cheese with *sumac* extract or cheese containing *sumac* extract.

Materials and methods

Materials

Sumac was purchased from a local market, fresh skimmed UF-retentate was obtained from Animal Production Research Institute, Agriculture Research Center, Dokki, Egypt. Hannilas rennet powder was procured from Chr-Hansen, Lab, Denmark (CHY-Max powderextra), salt (commercial fine grade) was bought from El-Nasr saline's company, and calcium chloride was got from Sigma Company, USA.

Pathogenic bacteria strains (indicators)

B. cereus ATCC 33018, *S. aureus* ATCC 20231, *L. monocytogenes* V7, *E. coli* 0157: H7 ATCC 6933, *S. typhimurium* ATCC 14028, and *P. aeruginosa* ATCC 9027 were brought from the cultures in National Research Centre. These tests done under bio-safety cabinet class 2

Starter and probiotic strains

Lactococcus lactis sp. *lactis* and *Lactococcus lactis* sp. *cremors* were brought from Microbiology Dairy Lab., and *Bifidobacterium bifidium* was purchased from the Faculty of Agriculture, Ain Shams University.

Methods

Preparation of *Sumac* Extracts

Sumac ethanolic extract was prepared according to the method presented by Nasar-Abbas & Halkman [13]. 10 g ground *sumac* was soaked in 90 mL ethanol (96.5%) for 24 h at room temperature with rousing by magnetic stirrer (J.P. SELECTA, s.a, Ctra. NII Km: 585.1. Abrera (BARCELONA) SPAIN). The extract (10%, weight/volume (w/v)) was filtered through a Whatman 4 filter paper (Whatman® International Ltd, Maidstone, England) and then evaporated using a rotary evaporator (B-169 vacuum-system, BUCHI, Switzerland). The extract was kept at -18°C until used.

Activation of the bacterial strains

All microbial strains were activated according to Hekmat & McMahon [21]; El-Shenawy et al., [19].

Antibacterial activity

One ml culture of the pathogenic bacteria (10^5cells/ml) was inoculated into 20 ml of Mueller-Hinton agar (Becton Dickinson, USA) and 50µL of different concentrations of *sumac* extract delivered in each well. Afterward, the inhibition zones were measured [22].

Manufacture of white soft cheese

UF soft cheese manufacture was carried out according to Abdel-Salam [23]. UF Soft cheese was prepared using fresh skimmed retentate, heat-treated at 72°C/15 min, and then chilled to 37°C. The *L. lactis*, *L. cremoris*, and *B. Bifidum* (1:1:1 volume: volume: volume (v:v:v)) were added at the rate of 1% (volume/volume (v/v)) served as mixed starter culture into the retentate. Control without *sumac* extract and different concentrations of *sumac* extract (0 (control)), 0.2, 0.4, 0.6, 0.8, and 1% by volume) emulsified in 10 ml corn oil, 0.1 g monoglyceride, homogenized and emulsified, then mixed with retentate, using the electric blender (Molinex blender). Calcium chloride, sodium chloride, and rennet were added at the ratios of 0.02, 3, and 0.05% (w/v), respectively. All cheese treatments were packaged in plastic cups (50 mL) and kept to coagulate at 37°C. Soft cheese samples were stored in a refrigerator (SJ-PV58G, SHARP Refrigerator Inverter Digital, Japan) at 7±2°C for 30 days and analysed when fresh and after 7, 15, 21, and 30 days for chemically, rheological properties and sensory

evaluation. The best antibacterial effects of the dissimilar concentrations of *sumac* extract (0, 0.2, 0.4, 0.6, 0.8, and 1%) were selected as 1% of *sumac* extract that contaminated by different pathogenic bacteria and divided as follow:

(1) Starter cultures (*L. lactis* and *L. cremoris*) (control).

(2) Starter cultures + *Staphylococcus aureus* + *sumac* extract 1% (T1).

(3) Starter cultures + *Staphylococcus aureus* + *sumac* extract 1% + Probiotic bacteria (T2).

(4) Starter cultures + *Bacillus cereus* + *sumac* extract 1% (T3).

(5) Starter cultures + *Bacillus cereus* + *sumac* extract 1% + Probiotic bacteria (T4).

(6) Starter cultures + *Salmonella typhimurium* + *sumac* extract 1% (T5).

(7) Starter cultures + *Salmonella typhimurium* + *sumac* extract 1% + Probiotic bacteria (T6).

After the contamination, the soft probiotic cheese samples were stored in a refrigerator at 7±2°C/30 days, then analysed when fresh (0^{th} day) and after 7^{th}, 15^{th}, 21^{st}, and 30^{th} days of storage for microbiological evaluation for the survival of *Staphylococcus aureus, Bacillus cereus,* and *Salmonella typhimurium.*

Chemical Analysis

Titratable acidity, moisture, total solids, protein, soluble nitrogen (SN), and ash contents of UF-soft cheese samples were determined according to AOAC [24]. pH values were measured using a digital laboratory Jenway 3510 pH meter (UK. Bibby Scientific LTD. Stone, Stafford shire, ST 15 OSA).

Texture profile analysis (TPA)

TPA was tested on the all UF-soft cheese was assessed via a texture analyser (mecmesin limited, Slinfold, West Sussex, UK). UF-Soft cheeses were 20 mm in height and 30 mm in diameter. The several textural parameters were estimated according to the method of IDF [25] and Saad et al., [26].

Microbiological analysis

Twenty-five grams of UF cheese samples were added to 225 ml of sterile solution (2% w/v) of sodium citrate and homogenized for 1 minute.

The microbiological tests were done according to FDA [27] for *L. lactis* and *L. cremoris* were carried out using the M17 agar medium (Oxoid). Plates were incubated at 35ºC/24-48 h, colonies were counted and calculated per gm of the sample. Yeasts and molds were carried out using the potato dextrose agar medium (Oxoid). Plates were incubated at 22-25ºC/3-5 days. *Enterobacteriaceae* in samples was carried out by spreading 0.l ml of each sufficient (expected) dilution onto the surface agar medium (violet red bile glucose agar) (Oxoid). *S. aureus* in samples was carried out by spreading 0.l ml of each of sufficient (expected) dilution onto the surface agar medium. Baird Parker media (Oxoid) supplemented with egg yolk and potassium tellurite solution. Plates were incubated at 37ºC/48 hrs. *B. cereus* was determined by the surface plating technique onto the *Bacillus cereus* agar medium (Oxoid), supplemented with polymyxin B and egg yolk. *S. typhimurium*: Aseptically (25 g) of each sample was mixed with 225 ml of sterile buffer peptone water (Oxoid) and incubated at 35ºC/24 hrs. One to ten ml mixture was transferred to selenite cysteine broth and incubated at 35 ºC/72 hrs. Plates of *S-S* agar (Oxoid) were streaked and incubated at 35ºC/24 hrs. *B. bifidum* was enumerated on MRS agar (Oxoid) supplement with L-cysteine and lithium chloride (Sigma Chemical Co., USA) and anaerobic incubation at 37ºC/72 h as described by Dave & Shah [28].

Sensory evaluation

Cheese samples with *sumac* extracts were organoleptically tested according to the score card suggested by Davis [29].

Statistical analysis

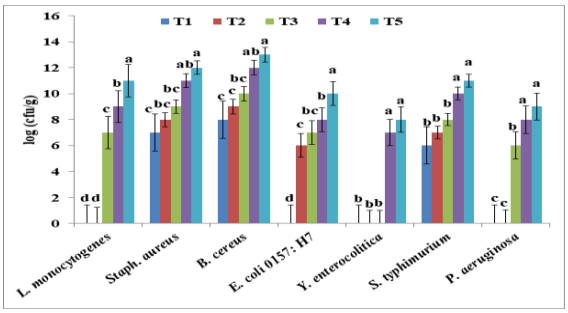
The obtained results were analysed using Statistical analysis and the general linear model (GLM) procedure for SAS software [30], and with using Duncan's multiple ranges was used to separate among three replicates at $p \leq 0.05$. All experiments and analyses were done in triplicate.

Results and discussion

Antimicrobial of *sumac* extract

The antibacterial effect of *sumac* extract on stopping the growing of many strains of pathogenic which is checked through the agar well diffusion method is shown in Figure 1. The inhibitory effect of *sumac* extract was examined against 7 strains (3 gram-positive and 4 gram negatives) and results were shown in Fig. 1. The minimum inhibitory concentration (MIC) from *sumac* extracts ranged from 0.2% (volume/volume (v/v)) to 1% (v/v) for *E. coli*, *B. cereus*, *S. aureus*, *S. typhimurium*, *P. aeruginosa*, *L. monocytogenes*, and *Y. enterocolitica*. This figure shows that the vast range of the recorded antimicrobial areas were from 6 mm to 13 mm, for all verified *sumac* extracts concentrations, against the different pathogenic bacterial examined was achieved. The greatest diameter (13 mm) was acquired by using the *sumac* extract (1%) against *B. cereus*, though; the lowest diameter (8 mm) was purchased for the same *sumac* extract (1%) against *Yersinia enterocolitica*. Similar results were also obtained by Nasar-Abbas et al., [13]. Gram positives were found to be much more sensitive than Gram-negatives. *B.* species (*B. cereus* and *B. satilis*) proved to be the most sensitive among the Gram positives as they managed to survive to only 500 mg/L of the spice followed by *S. aureus.*

The antimicrobial effect was stronger with increasing the proportion of *sumac* extract from 0.2 toward 1.0%. These results were also stated by many investigators (Nasar-Abbas et al., [13], Raodah et al., [31], Rashid et al., [32]; Pajohi-Alatmoti et al., [33].



***T1:** 0.2% of *sumac* extract, **T2:** 0.4% of *sumac* extract, **T3:** 0.6% of *sumac* extract, **T4:** 0.8% of *sumac* extract, **T5:** 1% of *sumac* extract.
Fig. 1 Antimicrobial activity of different concentration of *sumac* extract measured as zone of inhibition (mm).

Chemical analysis of soft cheese

Table (1) shows the chemical composition of soft white cheese made by changed concentrations from ethanolic *sumac* extract. The moisture content of soft cheese ranged from 70.36 to 72.34 % (wet basis). The data approved with discoveries of Saad et al., [26]; Salama et al., [6]. The rise in the total solids in the treatments may be due to the oil (as described in the materials and methods) that used to emulsify and carrier for the *sumac* extract to be homogenized well.

Table. 1. Chemical composition of UF-soft cheese with different concentrations of ethanolic *sumac* extracts.

Chemical composition of UF-soft cheese				
Treatment	**Moisture Content**	**Protein Content**	**Ash Content**	**T.S. Content**
C	72.34^{a} ±0.039	12.31^{b} ±0.037	3.44^{a} ±0.041	27.67^{d} ±0.033
T1	70.87^{b} ±0.042	11.36^{a} ±0.036	3.99^{a} ±0.037	29.14^{c} ±0.036
T2	70.82^{bc} ±0.042	12.57^{b} ±0.035	3.15^{b} ±0.035	29.19^{c} ±0.037
T3	70.78^{bc} ±0.042	12.31^{b} ±0.038	3.29^{b} ±0.073	29.22^{cb} ±0.034
T4	70.56^{cd} ±0.042	12.25^{b} ±0.037	3.15^{b} ±0.052	29.41^{ab} ±0.032
T5	70.36^{d} ±0.039	11.36^{a} ±0.036	3.41^{a} ±0.041	29.65^{a} ±0.035

C: control without *sumac* extract**. T1:** 0.2% of *sumac* extract. **T2:** 0.4% of *sumac* extract. **T3:** 0.6% of *sumac* extract. **T4:** 0.8% of *sumac* extract. **T5:** 1% of *sumac* extract. **a, b, c..:** Means within in the same column with different letters differ significantly among periods ($P < 0.05$).

Protein content ranged from 11.36 to 12.57%, the protein content in the soft white cheese is consistent with that approved by Saad et al. [26]. The highest ash content was observed for T1 and control, while there is significant differences were observed between control, T2, T3, and T4 ($p>0.05$). This may be due to the augmented proportion of the added *Sumac* extract as well as the percentage of the oil used to emulsify the extract and confirm its distribution in the final product.

Total solid contents increased with the increasing addition of ethanolic *sumac* extract from T1 to T5. However, this increase was found insignificant ($p>0.05$). This may be due to the addition of oil to emulsify the extract and completely homogenized before added to UF-retentate in treatments. The chemical analysis of the soft white agreed with Saad et al., [26].

Changes in Physicochemical analysis

The pH values of the sample were found to be lower likened to the control, however, these changes were not found to be statistically significant ($p>0.05$) (Table 2). The low pH value of the ethanolic sumac extract (pH 2.5) which includes citric and malic acids [34, 13, 9, 35] may be the reason for the lower pH values of the treated samples. pH results were confirmed by acidity data that was on the opposite side with pH value. The pH values of the samples significantly decreased during the storage period ($p<0.05$). It may be due to the positive effect of *sumac* extract that plays as a prebiotic and enhance the starter culture and probiotic bacteria [36]. The *sumac* extract contains many phytochemical compounds such as tannins, polyphenols, flavonoids, organic acids, and essential oils that play a role in stimulating added bacteria during cheese manufacturing, which helps to develop acidity and decrease the pH [37]. Al-Marazeeq et al. [38] also confirmed that the development of acidity as a result of the addition of the extract is due to the release of extractable organic acids, polyphenols, tannins, and anthocyanins from *sumac*. In addition, the presence of malic acid in the sky as a volatile compound supports acid test, possibly the cause of increased acidity and low pH [39, 40].

The total solid pleased of the cheese samples elevated in all treatments by an increase from extract additions compared with control. Also, it is significantly increased during the storage time ($p<0.05$). The highest total solids were noticed at the end of storage with T5, this may be due to loss in moisture content by evaporated.

Total nitrogen and soluble nitrogen significantly increased as a function of increased extract ratio and increase storage time as presented in Table (2). The total nitrogen increased due to the rise of total solids in the treatments. The addition of *sumac* extract enhanced the activity of protein proteolytic also increases the activity of bacteria (starter culture) added during the manufacture of cheese. These results due to the active enzymes in *Sumac* were exposed to be variate in nature, lipase, and protease, with an important effect on the protein [9].

Texture profile properties

The results in Table (3) show TPA of cheese which contains a different concentration of *sumac* extract compared to those of control cheese during the storage period. All textural properties were the similar propensity among all cheese handlings that elevated by increasing the percentage of *sumac* extract in UF-cheese. The second treatment which T2 content with 0.4 % of *sumac* extract gained larger rheological possessions than other treatments in all storage periods for 30 days. The greater values for all rheological tested of UF-cheese ripening in treatments may be discovered to the differences of moisture gratified and the dense construction along with other different shaped during UF-soft cheese storage. These outcomes are in contract with the grades by Awad et al., [41]. In addition, previous studies reported that the adding of pepper extract did not alter the rheological analysis of Gouda cheese likened with control [42]. Also, Calvo et al., [43] found that rheological properties significantly raised as a import of the low moisture content. The addition of *sumac* extract to wheat bread has improved its quality such as a reduction in the bread volume, lightness, and yellowness of crumb and an rise in the redness of the bread [44].

Table. 2. Physicochemical analysis of UF-soft cheese treated made by different concentration of ethanolic *sumac* extract

Treatment	Storage period (Days)				
	pH value				
	0	**7**	**15**	**21**	**30**
C	5.98^{a}±0.034	5.88^{b}±0.032	5.71^{c}±0.037	5.36^{d}±0.035	4.98^{e}±0.033
T1	5.95^{a}±0.033	5.87^{b}±0.033	5.81^{c}±0.035	5.33^{d}±0.036	4.81^{e}±0.037
T2	5.88^{a}±0.035	5.76^{b}±0.035	5.61^{c}±0.034	4.91^{d}±0.032	4.78^{e}±0.036
T3	5.78^{a}±0.037	5.61^{b}±0.033	5.36^{c}±0.035	4.82^{d}±0.036	4.61^{e}±0.037
T4	5.65^{a}±0.035	5.53^{b}±0.034	5.30^{c}±0.036	4.73^{d}±0.034	4.52^{e}±0.033
T5	5.55^{a}±0.036	5.50^{a}±0.036	5.16^{b}±0.035	4.63^{c}±0.037	4.31^{d}±0.039
	Titratable acidity				
	0	**7**	**15**	**21**	**30**
C	0.80^{e}±0.066	0.93^{d}±0.062	0.97^{c}±0.063	0.99^{b}±0.065	1.08^{a}±0.062
T1	0.83^{e}±0.070	0.93^{d}±0.065	0.97^{c}±0.066	1.07^{b}±0.065	1.17^{a}±0.064
T2	0.87^{d}±0.065	0.97^{c}±0.063	1.07^{b}±0.068	1.15^{ab}±0.063	1.20^{a}±0.062
T3	0.91^{d}±0.067	1.20^{c}±0.066	1.27^{bc}±0.065	1.33^{ab}±0.063	1.40^{a}±0.065
T4	0.95^{e}±0.066	1.35^{d}±0.066	1.37^{c}±0.065	1.43^{b}±0.068	1.53^{a}±0.063
T5	0.96^{d}±0.070	1.43^{c}±0.064	1.53^{b}±0.062	1.60^{ab}±0.064	1.63^{a}±0.066
	Total Solids (TS)				
	0	**7**	**15**	**21**	**30**
Control	27.66^{e}±0.037	27.79^{d}±0.034	27.89^{c}±0.035	27.94^{b}±0.036	28.39^{a}±0.033
T1	29.13^{d}±0.039	29.38^{c}±0.037	29.48^{b}±0.033	29.54^{a}±0.035	29.56^{a}±0.032
T2	29.18^{e}±0.036	29.40^{d}±0.036	29.49^{c}±0.034	29.56^{b}±0.032	29.62^{a}±0.036
T3	29.22^{e}±0.037	29.47^{d}±0.035	29.54^{c}±0.033	29.59^{b}±0.036	29.75^{a}±0.034
T4	29.44^{e}±0.039	29.53^{d}±0.033	29.57^{c}±0.034	29.61^{b}±0.038	29.83^{a}±0.035
T5	29.50^{e}±0.035	29.59^{d}±0.036	29.64^{c}±0.032	29.68^{b}±0.037	29.87^{a}±0.034
	Total nitrogen (TN)				
	0	**7**	**15**	**21**	**30**
Control	1.93^{b}±0.041	2.01^{b}±0.039	2.10^{a}±0.035	2.12^{a}±0.041	2.15^{a}±0.043
T1	1.78^{e}±0.044	1.98^{d}±0.037	2.15^{a}±0.039	2.08^{c}±0.037	2.11^{b}±0.042
T2	1.97^{c}±0.043	2.06^{b}±0.038	2.19^{a}±0.037	2.20^{a}±0.041	2.21^{a}±0.038
T3	1.93^{c}±0.044	2.03^{c}±0.039	2.20^{b}±0.041	2.42^{b}±0.039	2.30^{a}±0.039
T4	1.92^{c}±0.041	1.95^{c}±0.037	2.20^{b}±0.042	2.28^{ab}±0.034	2.34^{a}±0.041
T5	1.78^{e}±0.043	2.053^{d}±0.039	2.15^{c}±0.041	2.27^{b}±0.038	2.41^{a}±0.042
	Soluble nitrogen (SN)				
	0	**7**	**15**	**21**	**30**
Control	0.093^{e}±0.32	0.128^{d}±0.30	0.281^{c}±0.31	0.371^{b}±0.30	0.489^{a}±0.27
T1	0.064^{e}±0.35	0.103^{d}±0.31	0.182^{C}±0.29	0.316^{b}±0.30	0.401^{a}±0.30
T2	0.103^{e}±0.32	0.227^{d}±0.33	0.301^{c}±0.28	0.430^{b}±0.30	0.479^{a}±0.29
T3	0.119^{e}±0.34	0.257^{d}±0.29	0.361^{c}±0.30	0.445^{b}±0.31	0.534^{a}±0.29
T4	0.128^{e}±0.35	0.287^{d}±0.31	0.410^{c}±0.32	0.494^{b}±0.30	0.602^{a}±0.32
T5	0.125^{e}±0.32	0.306^{d}±0.32	0.440^{c}±0.27	0.514^{b}±0.25	0.657^{a}±0.28

C: control without *sumac* extract**. T1:** 0.2% of *sumac* extract. **T2:** 0.4% of *sumac* extract. **T3:** 0.6% of *sumac* extract. **T4:** 0.8% of *sumac* extract. **T5:** 1% of sumac extract. **a, b, c..:** Means within in the same column with different letters differ significantly among periods ($P < 0.05$).

Table. 3. Texture profile of UF-soft cheese made by different concentration from *sumac* extract.

Properties	Storage (days)	Treatments					
		C	**T1**	**T2**	**T3**	**T4**	**T5**
Hardness	**Fresh**	2.80^{b}±0.029	4.8^{a}±0.031	3.50^{b}±0.031	3.5^{a}±0.029	3.70^{a}±0.031	3.60^{a}±0.029
	30	3.60^{a}±0.27	5.0^{b}±0.23	5.80^{a}±0.25	5.3^{b}±0.26	4.10^{b}±0.25	4.40^{b}±0.26
Cohesiveness	**Fresh**	0. 671^{a}±0.025	0.718^{a}±0.027	0.686^{b}±0.025	0.706^{a}±0.026	0.661^{a}±0.025	0.813^{a}±0.027
	30	0.197^{b}±0.24	0.644^{b}±0.23	0.738^{a}±0.24	0.661^{b}±0.25	0.661^{b}±0.24	0.706^{b}±0.23
Springiness	**Fresh**	0.707^{b}±5.1	0.733^{b}±5.4	0.672^{b}±5.1	0.730^{b}±5.3	0.814^{a}±5.1	0.906^{a}±5.4
	30	0. 802^{a}±4.8	0.821^{a}±4.3	0.697^{a}±4.2	0.907^{a}±4.6	0.772^{b}±4.7	0.947^{b}±4.6
Gummiess	**Fresh**	1.879^{a}±2.05	3.446^{a}±2.19	2.401^{b}±2.05	2.471^{b}±2.19	2.446^{a}±2.19	2.927^{a}±2.05
	30	0. 709^{b}±1.94	3.220^{b}±1.95	3.897^{a}±1.89	3.503^{a}±1.93	2.710^{b}±1.91	3.109^{b}±1.93
Chewiness	**Fresh**	1.328^{a}±0.37	2.526^{b}±0.40	1.673^{b}±0.37	1.804^{b}±0.40	1.991^{b}±0.37	2.652^{b}±0.40
	30	0.569^{b}±0.35	2.644^{a}±0.33	2.876^{a}±0.31	3.177^{a}±0.34	2.092^{a}±0.33	2.944^{a}±0.31

C: control without *sumac* extract. T1: 0.2% of *sumac* extract. T2: 0.4% of *sumac* extract. T3: 0.6% of *sumac* extract. T4: 0.8% of *sumac* extract. T5: 1% of *sumac* extract. a, b, c: Means within in the same column with different letters differ significantly among periods ($P < 0.05$).

Bacteriological analysis

Microbial analysis (total starter culture counts of bacteria, mould, and yeast, Enterobacteriaceae, various Pathogenic bacteria count as well as probiotic bacteria) of UF-Soft cheese presented in Table 4. Data indicated that no significance, the result of UF-cheese made with 1% *sumac* extract, the total lactic acid bacteria count (starter cultures), mould and yeast counts, and Enterobacteriaceae counts indicated that the counts increased with the increase of storage period. At the 7th day of the storage period, the count reached its maximum (starter cultures) then it was stored to decrease gradually until the last day of the storage period.

The reduction in the number of starter strains may be due to the sensitivity of these bacteria to the acid produced during the storage period. These outcomes in contract with El-Kholy et al., [45] who showed that adding various concentration from mushroom cheese milk increased the number of lactic acid bacteria in functional fresh soft cheese in comparison with control and this rise was much greater after 7 days of cold storage period.

Regarding the Mould and Yeast, data in Table 4 illustrated that in cheese treatments mould and yeast slowly decreased after 7 days of storage period ($p>0.05$), and reached their least equalize at the end of the storage period in comparison with control, where the counts significantly decreased quickly ($p<0.05$).

The results were compatible with El-Gendy & Marth [46] who mentioned that adding of *L. lactis* to cultures of aspergilli delayed mould development for up to the period of 2 weeks. It is also in accordance to some extent with Wiseman and Marth [47]; Coallier-Ascah & Idziak [48]. Moreover, El-Kholy et al., [45] mentioned that bacteriocin produced by *L. reuteri* shows antimicrobial effect against a vast range of microorganisms.

Data in Table 5, illustrated that Enterobacteriaceae was presented in treatments of control cheese and UF-cheese. Control cheese contained a higher count of Enterobacteriaceae in the time of storage period in comparison with cheese treatments.

Enterobacteriaceae numbers decreased quickly during the cold storage period. After 7 days of treatments, Enterobacteriaceae numbers decreased rapidly in all the treatments until they became undetected. That was applicable for T2, T4, and T6 but after 15 days, which was applicable for all treatments. This result was similar to Kholy et al., [45] the antimicrobial effect on the coliform group in treatment cheese can be a result of the gained high acidity of acidic metabolites in end products.

Different pathogenic strains including *B. cereus*, *S. aureus*, and *S. typhimurium* were used to inoculate the manufactured cheese. The behaviour of *S. aureus* in the manufactured cheese is illustrated in Table (5). Adding *sumac* extract caused a decrease of about five log cycle orders of magnitude during the entire experiment; however, the addition of *sumac* extract and probiotic bacteria caused the disappearance of the pathogen after 21 days for *S. aureus.*

Adding *sumac* extract with *B. cereus* caused was a reason for the decrease of around 4 log cycle orders of magnitude during the whole experiment whereas, adding of *sumac* extracts and probiotic bacteria was a reason for the disappearance of the pathogen after 21 days.

Populations of *S. typhimurium* in control was not affected, only 2 log cycles decreased during the whole period of storage (control). Adding *sumac* extract was the reason for decreasing the count of 4 log cycle orders of magnitude during the entire experiment; whereas, adding both *sumac* extract and probiotic bacteria made the pathogen disappear after 21 days.

The behaviour of *S. aureus* and *B. cereus* in the manufactured cheese is illustrated in Table (5). The population of the bacteria in the control was not affected, as 3 log cycles only decreased in the whole period of storage.

Table (5) showed the effect of soft cheese with *sumac* extract on the viability of probiotic bacteria. At, it can be noticed that their maximum number was increasing at the 7th day of storage then these were a gradually decrease in the trend till the end of storage. Counts of probiotic stayed more than 10^6cfu/gm in all the treatments, until the end of storage.

The reason for the decrease in the count of probiotic strains may be the fact that these bacteria are sensitive to the acid, which is produced at the time of the storage.

The requirements of probiotic food in the Japanese fermented milk should be making sure that at least 10^6-10^7 viable microorganisms/gram must be existing in food [49, 50].

Table (4): Starter culture, mould, and yeast counts and Enterobacteriaceae counts CFU g-1 in soft cheese made by *sumac* extract during the cold storage period

Treatments		Storage time				
		0	**7**	**15**	**21**	**30**
C	Starter culture	$43x10^{6b}$±0.009	$83\ x10^{6\ a}$±0.01	$39\ x10^{6c}$±0.009	$16\ x10^{6d}$±0.01	$88\ x10^{5e}$±0.008
	Mould & Yeast	$63x10^{1d}$±0.01	$85\ x10^{1c}$±0.017	$52x10^{2a}$±0.012	$26x10^{2b}$±0.013	$3\ x10^{2e}$±0.017
	Enterobacteriaceae	$33\ x10^{1a}$±0.02	$30\ x10^{1a}$±0.03	$26\ x10^{1a}$±0.05	$17\ x10^{1b}$±0.02	$4\ x10^{1c}$±0.04
T1	Starter culture	$51\ x10^{6b}$±0.01	$76\ x10^{6a}$±0.03	$28\ x10^{6c}$±0.02	$82\ x10^{5d}$±0.04	$65\ x10^{5e}$±0.01
	Mould & Yeast	$49x10^{1a}$±0.08	$76\ x10^{1c}$±0.05	$57x10^{1b}$±0.06	$42x10^{1d}$±0.02	$19x10^{1e}$±0.08
	Enterobacteriaceae	$26\ x10^{1a}$±0.01	$20\ x10^{1b}$±0.03	$11\ x10^{1c}$±0.05	Nil^{d}	Nil^{d}
T2	Starter culture	$83\ x10^{6c}$±0.01	$35\ x10^{7a}$±0.03	$91\ x10^{6b}$±0.07	$74\ x10^{6c}$±0.02	$23\ x10^{6d}$±0.05
	Mould & Yeast	$27x10^{1b}$±0.01	$34\ x10^{1a}$±0.03	$29x10^{1a}$±0.05	$13x10^{1c}$±0.04	Nil^{d}
	Enterobacteriaceae	$10\ x10^{1a}$±0.02	$4\ x10^{1b}$±0.01	Nil^{c}	Nil^{c}	Nil^{c}
T3	Starter culture	$74\ x10^{6b}$±0.01	$98\ x10^{6a}$±0.03	$46\ x10^{6c}$±0.06	$7\ x10^{6d}$±0.02	$74\ x10^{5d}$±0.01
	Mould & Yeast	$21x10^{1c}$±0.01	$28\ x10^{1b}$±0.03	$43x10^{1a}$	$29x10^{1b}$±0.01	$17x10^{1d}$±0.01
	Enterobacteriaceae	$27\ x10^{1a}$±0.02	$20\ x10^{1b}$±0.01	$12\ x10^{1c}$±0.02	Nil^{d}	Nil^{d}
T4	Starter culture	$89\ x10^{6b}$±0.02	$23\ x10^{7a}$±0.02	$95\ x10^{6b}$±0.01	$65\ x10^{6c}$±0.03	$18\ x10^{6d}$±0.01
	Mould & Yeast	$11x10^{1c}$±0.03	$44\ x10^{1a}$±0.06	$35x10^{1a}$±0.04	$17x10^{1b}$±0.01	$3\ x10^{1d}$±0.03
	Enterobacteriaceae	$9\ x10^{1a}$±0.05	$3\ x10^{1b}$±0.06	Nil^{c}	Nil^{c}	Nil^{c}
T5	Starter culture	$52\ x10^{6b}$±0.01	$71\ x10^{6a}$±0.008	$29\ x10^{6c}$±0.01	$87x10^{5d}$±0.007	$79\ x10^{5e}$±0.009
	Mould & Yeast	$44x10^{1b}$±0.01	$68\ x10^{1a}$±0.02	$53x10^{1a}$±0.05	$24x10^{1c}$±0.03	Nil^{d}
	Enterobacteriaceae	$25\ x10^{1a}$±0.02	$18\ x10^{1b}$±0.03	$12\ x10^{1c}$±0.01	Nil^{d}	Nil^{d}
T6	Starter culture	$76\ x10^{6b}$±0.01	$19\ x10^{7a}$±0.03	$88\ x10^{6b}$±0.04	$57\ x10^{6c}$±0.02	$12\ x10^{6d}$±0.02
	Mould & Yeast	$34x10^{1c}$±0.01	$52\ x10^{1a}$±0.01	$39x10^{1b}$±0.03	$11x10^{1d}$±0.02	Nil^{e}
	Enterobacteriaceae	$19\ x10^{1a}$±0.07	$3\ x10^{1b}$±0.09	Nil^{c}	Nil^{c}	Nil^{c}

C; control, **T1** (Sta.+ *sumac* extract), **T2;** (Sta. + *sumac* extract + *B. bifidum*)**, T3;** (B.c + *sumac* extract), **T4;** (B.c + *sumac* extract + *B. bifidum*), **T5;** (Sal.+ *sumac* extract), **T6;** (Sal.+ *sumac* extract + *B. bifidum*).

Table (5): Behaviour of pathogenic bacteria and *Bifidobacterium bifidium* count CFU g^{-1} in soft cheese fortified with *sumac* extract during the cold storage period.

Treatments		Storage time				
		0	**7**	**15**	**21**	**30**
C_1 (Sta.)		$23\ x10^{6a}$ ±0.013	$91\ x10^{5b}$±0.014	$29\ x10^{5c}$±0.012	$64\ x10^{4d}$±0.013	$89\ x10^{3e}$±0.012
T_1 (Sta.)		$16\ x10^{6a}$±0.046	$72\ x10^{4b}$±0.043	$43\ x10^{3c}$±0.042	$50\ x10^{2d}$±0.047	$3\ x10^{1e}$±0.045
T2	Sta.	$63\ x10^{5a}$±0.017	$11\ x10^{4b}$±0.018	$9\ x10^{3c}$±0.016	$73\ x10^{1d}$±0.017	Nil^{e}
	Bif. bifidium	$11\ x10^{7a}$±0.014	$35\ x10^{7b}$±0.016	$17\ x10^{7c}$±0.015	$84\ x10^{6d}$±0.013	$28\ x10^{6e}$±0.017
C2 (B.c.)		$10\ x10^{5a}$±0.051	$3\ x10^{5b}$±0.053	$7\ x10^{4c}$±0.052	$5\ x10^{3d}$±0.055	$9\ x10^{2e}$±0.053
T3 (B.c.)		$4\ x10^{5a}$±0.08	$8\ x10^{4b}$±0.071	$1\ x10^{3c}$±0.078	$3\ x10^{2d}$±0.081	$2\ x10^{1e}$±0.082
T4	B.c.	$3\ x10^{5a}$±0.058	$6\ x10^{4b}$±0.053	$3\ x10^{2c}$±0.051	Nil^{d}	Nil^{d}
	Bif. bifidium	$65\ x10^{7b}$±0.005	$93\ x10^{7a}$±0.003	$39\ x10^{7c}$±0.006	$97\ x10^{6d}$±0.007	$57\ x10^{6e}$±0.005
C3 (Sal.)		$57\ x10^{5a}$±0.013	$11\ x10^{5b}$±0.014	$48\ x10^{4c}$±0.012	$97\ x10^{3d}$±0.014	$24\ x10^{3e}$±0.013
T5 (Sal.)		$69\ x10^{5a}$±0.01	$45\ x10^{4b}$±0.031	$63\ x10^{2c}$±0.02	$39\ x10^{1d}$±0.011	Nil^{e}
T6	Sal.	$54\ x10^{5a}$±0.014	$29\ x10^{4b}$±0.012	$33\ x10^{2c}$±0.013	$11\ x10^{1d}$±0.015	Nil^{e}
	Bif. bifidium	$13\ x10^{7c}$±0.012	$43\ x10^{7a}$±0.012	$19\ x10^{7b}$±0.015	$82\ x10^{6d}$±0.013	$45\ x10^{6e}$±0.012

C1: (control + Sta.), T1: (Sta.+ *sumac* extract), T2: (Sta. + *sumac* extract + *B. bifidum*), C2: (control + B.c), T3: (B.c + *sumac* extract), T4: (B.c + *sumac* extract + *B. bifidum*), C3: (control + Sal.), T5: (Sal.+ *sumac* extract) T6: (Sal.+ *sumac* extract + *B. bifidum*).

Sensory evaluation

From long time, kind taste and flavour have been sensorial characteristics used for serving in the select and increase the deliciousness of good foods [51]. The results of overall scores of the sensory interpretation of UF-cheese treatments were presented in Table (6). The observed total score of flavour, appearance, and body and texture of UF-cheese treatments contained *sumac* extract in T2 were significantly ($p \leq 0.05$) than the control treatment with significantly ($p \leq 0.05$) differences in experimental cheese treatments contained *sumac* extract after 15 days till the end of the storage period.

The supplementation of *sumac* extract positively affected flavour of UF-cheese treatments by 0.4 and 0.6 % concentration compared to control cheese and other treatments as shown in Table 6, which due to the volatile compound's a content of *sumac* extract. Pino et al. [52] identifying more than 125 compounds, these compounds have belonged to numerous chemical classes such as phenols, aldehydes, acids, ketones, alcohols, ethers, nitrogen compounds, aromatic hydrocarbons, alkanes, esters, and lactones. Also, it could be observed from Table 6, no significantly ($p > 0.05$) differences of texture and body of treatments Uf-cheeses which contain *sumac* extract compared with control treatment, these findings confirmed with texture profile analysis, and in Table 6. The consequences exhibited the UF-cheese scores for T2 and T3 cheeses treatments were significantly ($p \leq 0.05$) higher than those of the control treatment, it could be due to homogeneity of the color of *sumac* extract and their diffusion which boosted the taste and appearance of UF-soft cheese.

Table. 6. Sensory evaluation of UF-cheese treated with different concentration from *sumac* extract

Organoleptic properties	Ripening period (days)	Cheese treatments					
		C	T1	T2	T3	T4	T5
Appearance (10)	Fresh	6.25^{c}±0.16	6.00^{c}±0.28	6.58^{c}±0.17	7.17^{d}±0.12	7.42^{d}±0.05	5.30^{d}±0.14
	7	7.08b±0.15	7.17b±0.23	7.00c±0.15	7.50d±0.14	8.00c±0.06	6.00c±0.13
	15	7.58ab±13	7.75ab±0.25	7.67b±0.16	8.17c±0.13	8.58b±0.04	6.33c±0.16
	21	7.67a±0.14	8.50a±0.23	8.86a±0.14	8.92b±0.17	8.67b±0.03	6.83b±0.15
	30	8.08a±0.13	8.50a±0.22	9.17a±0.17	9.50a±0.13	9.00a±0.06	7.33a±0.13
Body and texture (40)	Fresh	28.58d±0.15	25.67c±0.61	29.17e±0.28	27.50c±0.45	27.83c±0.47	26.17d±0.28
	7	29.53c±0.17	26.33c±0.53	30.83d±0.25	28.33bc±0.43	28.67bc±0.45	27.67c±0.27
	15	31.67b±0.16	30.00b±0.54	32.77c±0.27	29.50b±0.41	29.83b±0.47	28.00c±0.23
	21	33.25a±0.14	32.00a±0.61	34.00b±0.26	31.42a±0.39	32.00a±0.46	29.00b±0.27
	30	33.72a±0.13	32.17a±0.62	35.00a±0.25	32.83a±0.42	31.83a±0.48	30.67a±0.29
Flavour (50)	Fresh	31.83d±0.24	30.17e±0.15	31.08c±0.25	32.25d±0.26	31.00d±0.13	31.17c±0.27
	7	32.67c±0.23	31.50d±0.17	32.00c±0.23	33.75c±0.25	33.00c±0.15	31.83c±0.26
	15	33.68b±0.25	32.00c±0.16	33.58b±0.27	35.33b±0.25	33.58b±0.17	32.85b±0.25
	21	34.50a±0.27	33.25b±0.15	34.50b±0.25	36.67a±0.24	34.00b±0.12	34.33a±0.28
	30	35.00a±0.24	33.83a±0.14	36.17a±0.26	37.33a±0.26	34.83a±0.13	35.00a±0.26
Total (100)	Fresh	66.67e±0.41	61.83d±0.77	66.83e±0.41	67.00e±0.65	66.25d±0.58	62.63e±0.41
	7	69.28d±0.42	64.67c±0.75	69.83d±0.45	69.58d±0.64	69.67c±0.53	65.5d±0.43
	15	72.93c±0.39	69.75b±0.58	74.02c±0.42	73.00c±0.62	72.00b±054	67.18c±0.47
	21	75.42b±0.42	73.75a±0.71	77.36b±0.41	77.00b±0.66	74.67a±0.52	70.25b±0.39
	30	76.80a±0.41	74.50a±0.69	80.00a±0.45	79.67a±0.65	75.67a±0.57	72.83a±0.40

C: control without *sumac* extract**, T1:** 0.2% of *sumac* extract, **T2:** 0.4% of *sumac* extract, **T3:** 0.6% of *sumac* extract, **T4:** 0.8% of *sumac* extract, **T5:** 1% of *sumac* extract. **a, b, c.. :** Means within in the same column with different letters differ significantly among periods ($P < 0.05$).

Conclusion

Using *Sumac* extract as a natural preservative is very helpful in dairy products applications, as it can increase the duration of preservation and improve the chemical and sensory properties, and microbiological quality of the product. According to this study, *Sumac* extract can be successfully added to fermented dairy products to increase their conservation time and increase their content of effective phytochemicals in addition to the possibility of evaluating their effect on the immune system according to the latest developments in the world of the COVID-19 pandemic and the impact of nutrition and its relationship to immunity and viral infections.

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