



Scientific Research

The effect of edible coating of alginate and different concentrations of mint (*Mentha piperita*) extract on physicochemical, microbial, rheological and organoleptic properties of lactic cheese containing walnuts

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ARTICLE INFO

ABSTRACT

Article History:

Received: 2023/01/27

Review: 2025/11/18

Accepted: 2025/11/26

Keywords:

Lactic cheese,
Edible coating,
Sodium alginate,
Mint extract,
Organoleptic properties.

DOI: 10.48311/fst.2026.83373.0

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In this study, the effect of edible coating of sodium alginate with different levels of mint extract (0, 1, 2.5 and 5%) on physicochemical, microbial, rheological and organoleptic properties of lactic cheese containing walnut powder was investigated. Treatments included five groups: control (without coating), sodium alginate, sodium alginate with concentrations of 1, 2.5 and 5% mint extract. The pH and moisture content of the samples were determined using a digital pH meter and an oven at 100°C for 5 h, respectively. A five-point hedonic test was used to perform sensory testing and a texture analyzer was used to determine textural characteristics. The results showed that with increasing the storage period, the pH and moisture content decreased and the acidity of the samples increased significantly. In evaluating the organoleptic properties, the effect of the studied treatments on all organoleptic properties, except tissue, was significant. The highest taste score was related to the treatment coated with sodium alginate and 2.5% peppermint extract (5) and the lowest taste score was related to the control (4.3). The highest and lowest odor scores were observed in the treatment coated with sodium alginate and 5% of mint extracts (5) and control (4.4), respectively. As the storage period increased, the hardness, cohesiveness, adhesiveness and chewiness of the samples increased. At the end of the storage time, the highest hardness was observed in the control (62.16 g) and the treatments coated with alginate and different levels of mint extract did not show a significant difference in terms of hardness. With increasing storage period, microbial count increased and the highest total microbial count, mold and yeast were related to the control (4.88 and 3.11 logcfu/g) and the lowest was related to the treatment coated with sodium alginate and 5% mint extract (3.24 and 1.98 logcfu/g). In general, the use of edible coating of sodium alginate and mint extract improved the flavor and prevented texture changes and reduced the microbial activity of lactic cheese during storage.

1- Introduction

Today, many advances have been made in packaging. These advances have been made to improve the chemical, microbial and organoleptic quality of food. Researchers are investigating materials that, in addition to increasing the quality and shelf life of food, are biodegradable in nature [1]. The nature of most food coatings is lipid polymers (fatty acids), polysaccharides (cellulose, chitosan, alginate, etc.) [2]. Hydrocolloids are hydrophilic polymers of plant, animal, microbial or synthetic origin that are widely used in the formation of films and food coatings and can help control the transfer of oxygen, carbon dioxide and moisture [3]. Alginate is a salt of alginic acid and a polymer of dimannuroic acid and l-glucuronic acid and is obtained from brown algae belonging to the Phaeophyceae family and is used as a coating [4]. Alginate salts are white to yellowish-brown, odorless powders. Sodium alginate is considered an emulsifier, stabilizer, and thickener. The advantage of alginate in the preparation of edible films is due to its unique colloidal properties and its ability to form strong gels or insoluble polymers in reaction with basic metal cations such as calcium [5]. Polysaccharide-based coatings rarely have antimicrobial or antioxidant effects, and therefore bioactive additives such as antioxidant and antimicrobial compounds are usually included in polysaccharide-based edible coatings to modify their performance [6]. Essential oils and plant extracts are among the most widely used natural compounds and are known as widely used compounds in food preservation technologies due to their antioxidant and antimicrobial properties [7]. Mint (*Mentha spicata*) is a well-known species of the mint family that is widely used in food, traditional medicine, and pharmaceuticals [8]. Research has shown that mint extract has excellent antioxidant potential, comparable to the synthetic antioxidant BHT, and the development of natural preservatives with

both antioxidant and antibacterial activities increases the shelf life of foods [9].

Among dairy products, cheese has the highest protein content. The protein in cheese is of good quality and contains almost all the essential amino acids required by the body. Therefore, cheese is very important from a nutritional point of view [8]. Cheese can be used as the main ingredient of a meal, as a dessert, and as a component of other foods. The rapid growth of cheese consumption is due to its use in various foods [10]. The use of nuts in cheese can improve its nutritional value and, as a beneficial by-product, create an important diversity in the cheese-making industry. It is also common in Iranian food culture to consume cheese with plant products such as walnut kernels [11]. It has also been scientifically proven that walnuts, due to their special composition, play an important role in reducing the amount of total cholesterol and low-density lipoproteins in the blood. Walnuts also contain a significant amount of oil (52-70%) with important and essential acids for the body [12].

Fathi et al. produced a low-fat beneficial processed cheese by replacing walnut powders (5, 10 and 15%) and reported that cheeses combined with walnut powder at the level of 15% had a higher overall acceptance score than other samples and control cheese [12]. In a study, the effect of edible coating of Aloe Vera gel containing lemon peel essential oil on the quality characteristics of cheese samples was investigated. The results showed that the use of edible coating produced with Aloe Vera gel and lower concentrations of lemon peel essential oil improved the appearance and taste of cheese samples during 60 days of storage [13]. Jalilzadeh et al. investigated the effect of edible coating based on whey protein concentrate containing natamycin or lysozyme-xanthan enzyme conjugate on the microbial properties of ultra-filtered white cheese. The results showed that the use of edible coatings based on whey protein as a carrier of natamycin and lysozyme-xanthan conjugate at a concentration of 600 ppm can

be used to increase the microbial quality of ultra-filtered cheese [14].

According to the presented material, it can be concluded that the production of food products with good quality, high nutritional value and long shelf life requires the use of modern and healthy preservation methods such as coating. Therefore, the aim of this study was to investigate the effect of edible coating based on sodium alginate with different levels of mint extract on the physicochemical and sensory properties of lactic cheese containing walnut powder.

2- Material and Methods

2-1- Preparation of sodium alginate solution

5 g of sodium alginate were added to 100 ml of distilled water and then sterilized. After that, the alginate solution was placed in the refrigerator overnight so that the alginate particles could absorb water well. The next day, the alginate solution was transferred from the refrigerator to the laboratory environment, and two percent glycerol was added to it and made uniform using an electric mixer (Pars Khazar, Iran). This solution was used as a coating base [15].

2-2- Preparation of mint extract

Extraction was performed by soaking and using ethanol solvent (50%). Thus, the required amount of mint aerial parts (leaves and soft stems) was dried in the shade and ground. 100 g of plant powder was added to 400 ml of ethanol and stirred for 12 h at room temperature. The obtained mixture was filtered through Whatman filter paper No. 2. The filtered solution was concentrated by rotary vacuum at low temperature to completely remove the solvent [16].

2-3- Preparation of cheese Lactic

cheese samples were prepared at Pegah Dairy Products Factory in Jiroft. The steps were as follows: First, raw milk was standardized (2.5-3% fat), then the temperature of the milk was increased to 96°C. After that, about 2-3% sour buttermilk was added and stirred well. The resulting mixture was kept in a fixed container for a few minutes until clots formed. After clot

formation, dewatering was performed, and then completely broken clots and 15% walnut powder were added to the crushed cheese curd and mixed thoroughly (this amount of walnut had received the highest sensory scores in previous studies). Finally, a weight equal to three times the weight of the clot was placed on it and after 6-7 minutes, the cheese was cut [17].

2-4- Coating of cheeses Lactic

cheese samples were cut into cubic samples (with length, width and height of 3 cm) and their coating was performed by immersion method, during which the cheese samples were immersed for 1 minute in the coating mixture (sodium alginate with different concentrations of mint extract (0, 1, 2.5 and 5%) until all surfaces of the cheeses were completely covered with the coating material. A control sample without coating was also considered. The samples were placed in an incubator under controlled temperature (about 12 °C) for approximately 8 hours until all coatings were dry [18]. Then, the coated samples were packaged in plastic containers in polypropylene bags and evaluated during zero (immediately after coating), 10, 20 and 30 days of storage in the refrigerator (4 °C).

2-5- Tests performed on samples

2-5-1- Acidity measurement

5 g of cheese were poured into a beaker and 50 ml of distilled water was added to it, then it was homogenized. A few drops of phenolphthalein reagent were added and titrated using sodium hydroxide solution (0.1N) until a purple color appeared. The acidity was calculated in terms of lactic acid [10].

2-5-2- pH determination

First, 5 g of cheese were poured into a beaker and 25 ml of distilled water was added to it. Then it was homogenized. The samples were filtered using filter paper. The pH of the samples was measured using a digital pH meter [10].

2-5-3- Moisture content

First, 5 g of cheese were weighed using a digital scale. The weighed pieces were placed in glass plates in an oven at 100°C for 5 h.

After the samples were cooled, they were dried in the desiccator, plates were weighed and the moisture loss rate was calculated according to the following equation [18]:

$$\text{Moisture loss rate: } \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

2-5-4- Sensory evaluation

The samples were first examined for the presence of pathogenic bacteria and then subjected to sensory evaluation. This test was conducted by 20 food industry students and experts from Pegah Factory on the first and thirtieth day of storage, and the average data of these two days was reported. Before the test, explanations were given about the test method and the characteristics to be evaluated, and the evaluators were asked to write on the evaluation sheet if they had any comments about each of the samples. The samples were coded in a completely random manner and the conditions were completely identical for each of the evaluator judges. To increase the accuracy of the evaluator judges, they were asked to drink some mineral water between the two samples. Cheese samples were provided to the evaluators in the form of cubes weighing 15 grams each. In each session, the cheese samples were tested for taste, color, odor, texture, and overall acceptance [19].

2-5-5- Texture Analysis

A texture analyzer was used to determine the textural characteristics. Cheese samples were removed from the refrigerator immediately before testing and cut into 20×20×20 mm pieces. Then, the device performed the test at least three times on each sample, each time reaching 50% of the initial height, with the test repetition interval being once every 15 days (day 15-day 30). The characteristics obtained from the texture analyzer included Hardness, Cohesiveness, Adhesiveness, Chewiness and Gumminess [20].

2-5-6-Microbial Cultures

To prepare the sample and dilutions for all microbial cultures, first 1 g of the sample was transferred to 100 ml of physiological serum diluent solution and completely homogenized. 0.1 ml of each of the dilutions was transferred to different culture media with a sterile pipette

and after being placed in an incubator, the culture media was examined in terms of colony count and searching for microorganisms [21].

2-5-6-1 Total bacterial count

Plate Count Agar (PCA) was used for bacterial culture. 0.1 ml of each of the dilutions was transferred to Plate Count Agar with a sterile pipette and cultured by the surface method. After 48 h of incubation in a 37°C, the resulting colonies were counted using a colony counter and the number of bacteria per gram was calculated. Thus, plates containing 30 to 300 colonies were selected as standard plates, counted, and the number of bacteria per gram was calculated as follows [22].

$$\text{Number of bacteria per gram of cheese} = \frac{\text{Average number of countable colonies per plate} \times \text{dilution factor} \times 10}{\text{Average number of countable colonies per plate} \times \text{dilution factor} \times 10}$$

2-5-6-2 Total Mold and yeast counts

For the cultivation of mold and yeast (fungi), YGC agar (Yeast Glucose Chloramphenicol) culture medium was used. 0.1 ml of each of the dilutions was transferred to the culture medium with a sterile pipette as in the previous method, and after 48 to 72 hours in an incubator at 25 ° C, the resulting colonies were counted, which was calculated according to the Iranian National Standard No. 10154 [19].

2-6-Statistical analysis

The experiments were conducted in a completely randomized design based on factorial with three replications and the experimental data were analyzed with SPSS:21 software. Duncan's multiple range test was used to compare the means at a confidence level of 5%.

3- Results and discussion

3-1- Effect of the studied treatments on pH and acidity of cheese samples during the storage period

The results of Table 1 show that with increasing storage time, the pH of the cheese samples decreased significantly. The lowest pH decrease was observed in cheese samples coated with sodium alginate and levels of 2.5 and 5% mint extract. At the end of the storage

period, the lowest pH was observed in the control and the highest in the treatment coated with sodium alginate and 5% mint extract,

which did not show a significant difference with the treatment coated with sodium alginate and 2.5% mint extract ($p > 0.05$).

Table 1- The effect of the studied treatments on the pH of lactic cheese samples containing walnut powder

| Treatments | 1st day | 10th day | 20th day | 30th day |
|-------------------------------|-------------|--------------|--------------|---------------|
| Control (uncoated) | 5.68±0.08bA | 5.46±0.05cB | 5.28±0.06cC | 5.06±0.05cD |
| Sodium alginate | 5.86±0.05aA | 5.67±0.1abB | 5.44±0.05abC | 5.37±0.07abCD |
| Sodium alginate and 1% mint | 5.85±0.05aA | 5.68±0.07abB | 5.48±0.1abBC | 5.36±0.06abCD |
| Sodium alginate and 2.5% mint | 5.83±0.1aA | 5.75±0.05aAB | 5.56±0.07aC | 5.44±0.1aCD |
| Sodium alginate and 5% mint | 5.83±0.1aA | 5.78±0.1aB | 5.60±0.05aBC | 5.49±0.05aD |
| P value | 0.01 | 0.04 | 0.03 | 0.01 |

* In each column, numbers with dissimilar small letters have a significant difference ($p < 0.05$).

* In each row, numbers with dissimilar capital letters have a significant difference ($p < 0.05$).

According to the data in Table 2, it can be seen that both the type of coating treatment and the storage period had a significant effect on the acidity of the cheese samples. On the 30th day of storage, the highest and lowest acidity were for the control and the treatment coated with sodium alginate and 5% mint extract, respectively, which did not show a

significant difference with the treatment coated with sodium alginate plus 1 and 2.5% mint extract. With increasing storage time, the acidity of the treatments increased, and this increase was significant in all the studied treatments on all days of storage. The lowest changes in acidity during the storage period were observed in the cheese samples coated with sodium alginate and 5% mint extract.

Table 2- The effect of the studied treatments on the acidity of lactic cheese samples containing walnut powder

| Treatments | 1st day | 10th day | 20th day | 30th day |
|-------------------------------|-------------|-------------|-------------|-------------|
| Control (uncoated) | 1.16±0.2aD | 1.21±0.1aBC | 1.35±0.1aB | 1.52±0.08aA |
| Sodium alginate | 1.06±0.1bD | 1.16±0.05bC | 1.33±0.05bB | 1.46±0.12bA |
| Sodium alginate and 1% mint | 1.03±0.1bD | 1.18±0.07bC | 1.24±0.06cB | 1.38±0.22cA |
| Sodium alginate and 2.5% mint | 1.04±0.05bD | 1.16±0.1bC | 1.26±0.08cB | 1.33±0.2cA |
| Sodium alginate and 5% mint | 1.05±0.05bD | 1.18±0.05bC | 1.25±0.1cB | 1.31±0.1cA |
| P value | 0.01 | 0.03 | 0.04 | 0.03 |

* In each column, numbers with dissimilar small letters have a significant difference ($p < 0.05$).

* In each row, numbers with dissimilar capital letters have a significant difference ($p < 0.05$).

With increasing storage time, the pH of all samples decreased, which may be due to the activity of lactic acid bacteria of the *Lactobacillus* species that metabolize lactose to lactate and produce acid [23]. These results are consistent with the results of the study by Ramos et al. (2012) who evaluated the pH of cheese coated with whey protein isolate, guar gum, and antimicrobial compounds during 60

days of storage [24]. Jamshidi et al., who used aloe vera gel and Persian gum coating in Iranian white cheese, also reported that during storage, the pH value decreased significantly while the acidity increased [18]. With the passage of storage time, the acidity of the different treatments showed an increasing trend, which is probably due to the increase in lactic acid production by bacteria, which is

consistent with the decreasing trend observed in pH during storage. In a study, El-Sisi et al. showed that the acidity of cheeses coated with chitosan increased during storage [25]. It was also reported in a study that the acidity percentage of cheddar cheese coated with whey protein also increased during ripening [26]. On the 30th day, the lowest titratable acidity was observed in cheeses coated with sodium alginate and mint extract, which may indicate the lowest viability of lactic acid bacteria (starter and non-starter) in these samples; Because the greater activity of lactic acid bacteria leads to greater decomposition of lactose and the production of organic acids such as lactic acid and acetic acid, which consequently increases the percentage of acidity of the product, and mint extract,

Table 3- The effect of the studied treatments on the moisture content (%) of lactic cheese samples containing walnut powder

| Treatments | 1st day | 10th day | 20th day | 30th day |
|-------------------------------|--------------|--------------|--------------|--------------|
| Control (uncoated) | 65.22±1.5aA | 62.66±1.7bB | 57.16±1.1cC | 55.23±1.2cD |
| Sodium alginate | 65.25±1.2aA | 64.70±1.5aAB | 61.55±1.5abC | 59.32±1.5bD |
| Sodium alginate and 1% mint | 65.67±1.4aA | 64.10±1.1aAB | 62.08±2.1aC | 61.25±2.2aCD |
| Sodium alginate and 2.5% mint | 65.20±2.0aA | 64.23±1.5aB | 62.64±2.0aC | 61.45±1.8aCD |
| Sodium alginate and 5% mint | 65.35±1.5 aA | 64.32±1.6aB | 62.71±1.5aC | 61.57±1.5aCD |
| P value | 0.07 | 0.03 | 0.01 | 0.01 |

* In each column, numbers with dissimilar small letters have a significant difference ($p < 0.05$).

* In each row, numbers with dissimilar capital letters have a significant difference ($p < 0.05$).

According to the results, it was observed that the coated cheese samples showed a higher moisture content than the control sample (without coating), and the combined coating of sodium alginate with mint extract had a more effective effect on maintaining the moisture content of the cheese samples than sodium alginate alone. After 60 days of cheese preparation, the moisture content gradually decreased, which is due to the release of some moisture from the cheese tissue and packaging to the outside environment, and the difference between the coated samples is probably due to the composition of the coating and the kinetics of water penetration and outflow into the different coatings [28]. Jamshidi et al. reported in a study that almost all cheeses

probably due to its antimicrobial activity, reduced the growth of these bacteria in cheese samples [27].

3-3- Effect of the studied treatments on the moisture content of cheese samples during the storage period

Table 3 shows the effect of the studied treatments on the moisture content of lactic cheese samples containing walnuts. With increasing storage time, the moisture content of the samples decreased. The coated cheese samples showed a higher moisture content than the control sample (without coating). On the first day of storage, no significant difference was observed in the moisture content of all treatments ($p > 0.05$).

coated with aloe vera gel and Persian gum showed a higher moisture content than the control and uncoated treatment, indicating the positive effect of coating on maintaining moisture and preventing its escape in the cheese during storage [18].

3-4- Effect of the studied treatments on the sensory properties of cheese samples during storage period

According to Table 4, it is observed that the effect of the studied treatments on the sensory properties of lactic cheese samples, other than texture characteristics, is significant. The highest taste score was related to the treatment coated with sodium alginate and 2.5% mint extract and the lowest taste score was related to the control. The highest and lowest odor scores were observed in the treatment coated

with sodium alginate and 5% mint extract and the control, respectively. The control and cheese samples coated with sodium alginate and different concentrations of mint extract did not show a significant difference in terms of texture characteristics ($p>0.05$). In terms of

overall acceptance, the treatment coated with sodium alginate and 2.5% mint extract obtained the highest score.

Table 4- The effect of the studied treatments on the sensory properties of lactic cheese samples containing walnut powder

| Treatments | Taste | odor | color | texture | General acceptance |
|-------------------------------|-------------------|-------------------|-------------------|-------------------|--------------------|
| Control (uncoated) | 4.3 ^c | 4.4 ^{bc} | 5.0 ^a | 4.7 ^{ab} | 4.5 ^b |
| Sodium alginate | 4.5 ^{bc} | 4.6 ^b | 5.0 ^a | 4.7 ^{ab} | 4.7 ^{ab} |
| Sodium alginate and 1% mint | 4.7 ^a | 4.8 ^{ab} | 4.6 ^b | 4.7 ^{ab} | 4.6 ^{ab} |
| Sodium alginate and 2.5% mint | 5.0 ^b | 5.0 ^a | 4.4 ^{bc} | 4.8 ^a | 4.9 ^a |
| Sodium alginate and 5% mint | 4.6 ^c | 5.0 ^a | 4.1 ^c | 4.8 ^a | 4.6 ^{ab} |
| P value | 0.001 | 0.01 | 0.033 | 0.06 | 0.01 |

* In each column, numbers with dissimilar small letters have a significant difference ($p < 0.05$).

The effects of the studied treatments on the sensory properties of the cheese samples were significant, except for the texture characteristics. The treatment coated with sodium alginate and 2.5% mint extract received the highest scores for taste, odor, and overall acceptance.

Abbas et al. reported that adding 0.005 and 0.010 $\mu\text{L}/100\text{ mL}$ of basil essential oil to soft cheese significantly improved the taste of the samples during the fresh stage of the cheese and also during the 60-day storage period. According to this report, the desirability of samples containing low concentration (0.005 $\mu\text{L}/100\text{ mL}$) was higher than that of samples containing high concentration (0.010 $\mu\text{L}/100\text{ mL}$) [29]. Mohammadi et al. reported that 100 mg/kg of basil essential oil, a plant in the mint family, improved the aroma, taste, and acceptability of brine white cheese during production and storage, but 150 and 200 mg/kg of essential oil had a negative effect on the taste and acceptability of cheeses [30]. In

a study by Otero et al., it was reported that the use of edible films containing antimicrobial substances in sheep cheese improved sensory properties compared to uncoated cheese samples [31]. The results of the study by Pieretti et al. showed that cheeses coated with alginate and low concentrations of oregano essential oil had better sensory acceptance than the control sample and higher concentrations of essential oil [32].

3-5- Effect of the studied treatments on the textural characteristics of lactic cheese containing walnut powder

The results of Table 5 show that the hardness of the cheese samples increased with increasing storage period. At the end of the storage period, no significant difference was observed between the control and sodium alginate-coated treatments, as well as between different concentrations of mint extract. On the 30th day, the highest hardness was observed in the control treatments.

Table 5- The effect of the studied treatments on the textural characteristics of lactic cheese samples containing walnut powder

| Textural characteristics | Treatments | 15th day | 30th day |
|--------------------------|--------------------|-------------------|-------------------|
| | Control (uncoated) | 54.45 \pm 1.6aB | 62.16 \pm 3.1aA |
| | Sodium alginate | 46.76 \pm 2.2bB | 51.50 \pm 2.5bA |

| | | | |
|--------------------------|-------------------------------|-------------|--------------|
| Hardness (g) | Sodium alginate and 1% mint | 43.63±1.5cB | 47.30±2.3cA |
| | Sodium alginate and 2.5% mint | 43.33±2.4cB | 45.35±1.5cdA |
| | Sodium alginate and 5% mint | 43.55±1.7cB | 45.23±2.4cdA |
| | P value | 0.01 | 0.001 |
| Adhesiveness (Mj) | Control (uncoated) | 0.75±0.2cB | 0.96±0.1cA |
| | Sodium alginate | 1.12±0.2bB | 1.36±0.2bA |
| | Sodium alginate and 1% mint | 1.23±0.5aB | 1.45±0.3aA |
| | Sodium alginate and 2.5% mint | 1.22±0.1aB | 1.46±0.1aA |
| | Sodium alginate and 5% mint | 1.24±0.5aB | 1.46±0.4aA |
| | P value | 0.01 | 0.01 |
| Cohesiveness (Mj) | Control (uncoated) | 0.20±0.02aB | 0.35±0.01aA |
| | Sodium alginate | 0.21±0.05aB | 0.25±0.05bA |
| | Sodium alginate and 1% mint | 0.15±0.05bB | 0.21±0.02cA |
| | Sodium alginate and 2.5% mint | 0.14±0.03bB | 0.20±0.01cA |
| | Sodium alginate and 5% mint | 0.15±0.05bB | 0.20±0.04cA |
| | P value | 0.01 | 0.016 |
| Gumminess (g) | Control (uncoated) | 2.33±0.4bB | 5.33±0.1cA |
| | Sodium alginate | 2.67±0.2bB | 5.66±0.4cA |
| | Sodium alginate and 1% mint | 2.66±0.5bB | 4.33±0.4bA |
| | Sodium alginate and 2.5% mint | 3.33±0.2aB | 6.66±0.6aA |
| | Sodium alginate and 5% mint | 3.34±0.1aB | 6.33±0.5aA |
| | P value | 0.011 | 0.024 |
| Chewiness (g) | Control (uncoated) | 0.25±0.04bB | 0.65±0.05cA |
| | Sodium alginate | 0.46±0.05bB | 1.05±0.06cA |
| | Sodium alginate and 1% mint | 0.55±0.05bB | 1.13±0.07bA |
| | Sodium alginate and 2.5% mint | 0.68±0.07aB | 1.17±0.05aA |
| | Sodium alginate and 5% mint | 0.69±0.03aB | 1.16±0.06aA |
| | P value | 0.021 | 0.033 |

* In each column for each factor, numbers with dissimilar small letters have a significant difference ($p < 0.05$).

* In each row, numbers with dissimilar capital letters have a significant difference ($p < 0.05$).

According to the data in Table 5, it can be seen that the storage period had a significant effect on the adhesiveness of lactic cheese samples and the adhesion of the samples increased during the storage period. At the end of the storage period, the highest adhesiveness was observed in cheese samples coated with sodium alginate and 5% mint extract, which did not show a significant difference with the treatments coated with sodium alginate and

concentrations of 2.5 and 1% mint extract ($p > 0.05$). The lowest adhesion was also related to the control treatment. It was also observed that at the end of the storage period, the highest adhesion was related to the control treatment. The treatments coated with sodium alginate and different concentrations of mint extract did not show a significant difference in terms of cohesiveness ($p > 0.05$).

At the end of the storage period, the highest and lowest gumminess content was observed

in the sodium alginate coated treatment with 2.5 and 5% mint extract concentrations and the control, respectively, which did not show a significant difference with the sodium alginate coated treatment ($p > 0.05$). The gumminess of the cheese samples increased significantly with increasing storage period.

The data in Table 5 show that the chewiness content of the cheese samples increased with increasing storage period. On the 30th day of storage, the lowest chewiness was observed in the control, and the highest chewiness was related to the alginate coated treatments with 1, 2.5 and 5% mint extract concentrations.

The results of the textural characteristics of the cheese samples showed that the hardness of the cheese samples increased with increasing storage period, which could be due to moisture loss during the storage period. Another reason for the increase in hardness of cheese samples during storage is probably related to the increase in protein-protein interactions [33]. It was also observed that the coated samples had lower hardness than the control sample. It seems that the presence of more moisture in the coatings and greater hydration may have caused the decrease in hardness of the cheese samples [34]. In a study, Pieretti et al. (2019) investigated the effect of the use of edible coatings based on alginate and rosemary and oregano essential oils on the textural properties of fresh cheese and reported that at the end of the storage period, the coated samples had lower hardness than the control [32]. At the end of the storage period, the highest adhesiveness was observed in cheese samples coated with sodium alginate and different concentrations of mint extract, and the lowest cohesiveness was related to the control treatment. In the study by Wang et al., cheddar cheese samples coated with whey protein isolate nanofibrils and carvacrol showed greater adhesion than uncoated samples [35]. With increasing storage period, the adhesiveness of the samples increased, and at the end of the storage, the highest adhesiveness was observed in the control, and the treatments coated with sodium alginate and different concentrations of mint extract

did not show a significant difference in terms of cohesiveness. In the study on coated cheddar samples, the cohesiveness of the coated cheese samples increased with increasing storage period, while no significant difference was observed in the other samples [35].

With increasing storage time, the gumminess of the coated and control cheese samples increased. This is in accordance with the hardness and gumminess characteristics. On the 30th day of storage, the highest gumminess was associated with the treatment coated with sodium alginate and concentrations of 1, 2.5 and 5% mint extract. From a sensory perspective, it is perceived that more energy is required to chew the coated samples. In a study on cheese samples coated with starch and carvacrol, it was reported that the gumminess of the samples increased with increasing storage period and the coated samples had greater chewability than the control [36].

3-6- Effect of the studied treatments on the microbial count of lactic cheese samples during the storage time

Effect of the studied treatments on the total microbial count of lactic cheese samples

The effect of the studied treatments on the total microbial count of lactic cheese samples is given in Table 6. According to the data in this table, both the storage time and the coating treatments showed a significant effect on the total microbial count. The total microbial count increased with increasing the storage time. The lowest bacterial count was observed in the treatment coated with sodium alginate and 5% mint extract. In general, the coated treatments showed a lower bacterial count than the control, and the total microbial count decreased with increasing the concentration of mint extract in the coatings.

Table 6- The effect of the studied treatments on the total count (log cfu/g) of lactic cheese samples containing walnut powder

| Treatments | 1st day | 10th day | 20th day | 30th day |
|-------------------------------|-------------|------------|------------|------------|
| Control (uncoated) | 3.87±0.2aC | 3.88±0.3aC | 4.14±0.5aB | 4.88±0.1aA |
| Sodium alginate | 3.53±0.3bD | 3.73±0.1bC | 3.90±0.3bB | 4.14±0.2bA |
| Sodium alginate and 1% mint | 3.26±0.1cD | 3.45±0.2cC | 3.66±0.4cB | 3.90±0.3cA |
| Sodium alginate and 2.5% mint | 2.89±0.3dD | 2.97±0.3dC | 3.34±0.1dB | 3.67±0.5dA |
| Sodium alginate and 5% mint | 2.52±0.1 eD | 2.63±0.2eC | 2.92±0.5eB | 3.24±0.1eA |
| P value | 0.001 | 0.01 | 0.012 | 0.01 |

* In each column, numbers with dissimilar small letters have a significant difference ($p < 0.05$).

* In each row, numbers with dissimilar capital letters have a significant difference ($p < 0.05$).

Effect of the studied treatments on the total mold and yeast counts of lactic cheese samples

According to Table 7, the effect of the studied treatments and storage period on the total mold and yeast counts of cheese samples is

Table 7- The effect of the studied treatments on the total mold and yeast count (log cfu/g) of lactic cheese samples containing walnut powder

| Treatments | 1st day | 10th day | 20th day | 30th day |
|-------------------------------|------------|------------|-------------|------------|
| Control (uncoated) | 2.11±0.2aD | 2.55±0.1aC | 2.98±0.1aB | 3.11±0.1aA |
| Sodium alginate | 2.07±0.3bD | 2.55±0.1bC | 2.76±0.2bB | 3.01±0.3bA |
| Sodium alginate and 1% mint | 1.30±0.1cD | 2.01±0.2cC | 2.44±0.14cB | 2.45±0.2cA |
| Sodium alginate and 2.5% mint | 0.00dD | 1.85±0.3dC | 2.06±0.2dB | 2.07±0.2dA |
| Sodium alginate and 5% mint | 0.00dC | 0.00eC | 1.76±0.1eB | 1.98±0.1eA |
| P value | 0.015 | 0.022 | 0.01 | 0.001 |

* In each column, numbers with dissimilar small letters have a significant difference ($p < 0.05$).

* In each row, numbers with dissimilar capital letters have a significant difference ($p < 0.05$).

In general, the coated treatments showed lower microbial counts and lower mold and yeast counts than the control. The antimicrobial properties of mint extracts have been reported in various studies [37, 38]. The antimicrobial properties of mint extract are related to its active ingredients. Previous studies have shown that mint has antibacterial effects on the growth of gram-negative and gram-positive bacteria [39]. The antibacterial activity of mint extracts and essential oils can be influenced by terpene hydrocarbons, but other components can also play a role in this activity [40]. The antimicrobial activity of mint can be related to the compounds carone

and limonene. The mechanism of action of carone is to destabilize the phospholipid bilayer structure, interact with enzymes and membrane proteins, and act as a proton exchanger to reduce the pH between the membranes [41]. In a study, the antimicrobial effect of edible coatings containing different concentrations of oregano essential oil on low-fat cheese was studied. The results showed that coatings containing concentrations of more than 1.5% oregano essential oil caused a greater reduction in the microbial population during 15 days of refrigerated storage [42].

4- Conclusion

In general, the results of this study showed

that coated cheese samples showed a higher moisture content than the control (without coating). However, increasing the concentration of mint extract in the coatings did not affect the maintenance of moisture during the storage time. In terms of sensory characteristics, the treatment coated with sodium alginate with 2.5% mint extract obtained the highest taste, odor, and overall acceptance scores. In the study of textural characteristics, it was found that the hardness of the cheese samples increased with increasing storage period. The coated treatments had lower hardness compared to the control. The coated samples showed lower total microbial, mold, and yeast counts than the control, and with increasing mint extract concentration in the coatings, the total microbial, mold, and yeast counts decreased.

Data Availability

The data used to support the finding of this study are available from the corresponding author upon request.

Conflict Of Interest

The authors have no conflicts interest to report.

Funding Statement

The researchers did not receive any specific grant from funding agencies the public, commercial or not-for-profit sectors.

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مجله علوم و صنایع غذایی ایران

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مقاله علمی-پژوهشی

استفاده از پوشش خوراکی آلژینات و غلظت‌های مختلف عصاره نعناع بر خصوصیات فیزیکوشیمیایی، میکروبی، رئولوژیکی و ارگانولپتیکی پنیر لاکتیکی حاوی گردو

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چکیده

اطلاعات مقاله

در این مطالعه تأثیر پوشش خوراکی آلژینات سدیم به همراه سطوح مختلف عصاره نعناع (۰، ۱، ۲/۵ و ۵ درصد) بر ویژگی‌های فیزیکوشیمیایی، میکروبی، رئولوژیکی و ارگانولپتیکی پنیر لاکتیکی حاوی پودر گردو مورد بررسی قرار گرفت. تیمارها شامل پنج گروه شاهد (بدون پوشش)، آلژینات سدیم، آلژینات سدیم به همراه غلظت‌های ۱، ۲/۵ و ۵ درصد عصاره نعناع بودند. pH نمونه‌ها با استفاده از دستگاه pH متر دیجیتال و میزان رطوبت استفاده از آن در دمای ۱۰۰ °C به مدت ۵ ساعت تعیین شد. برای انجام آزمون حسی تست هدونیک پنج نقطه ای و برای تعیین ویژگی‌های بافتی دستگاه تکسچر آنالیزر مورد استفاده قرار گرفت. نتایج نشان داد با افزایش دوره نگهداری، pH و میزان رطوبت کاهش و اسیدیته نمونه‌ها بطور معنی‌داری افزایش یافت. در ارزیابی خواص حسی تأثیر تیمارهای مورد مطالعه بر همه ویژگی‌های ارگانولپتیکی، به غیر از ویژگی بافت معنی‌دار بود. بیشترین امتیاز طعم مربوط به تیمار پوشش داده شده با آلژینات سدیم و ۲/۵ درصد عصاره نعناع (۵) و کمترین امتیاز طعم مربوط به تیمار شاهد (۴.۳) بود. بیشترین و کمترین امتیاز بو به ترتیب در تیمار پوشش دهی شده با آلژینات سدیم و ۵ درصد عصاره نعناع (۵) و شاهد (۴/۴) مشاهده شد. با افزایش دوره نگهداری سختی، پیوستگی، چسبندگی و آدامسی بودن نمونه‌ها افزایش یافت. در پایان دوره نگهداری بیشترین میزان سختی در تیمار شاهد (۶۲/۱۶g) مشاهده شد و تیمارهای پوشش داده‌شده با سطوح مختلف عصاره نعناع تفاوت معنی‌داری از لحاظ سختی نشان ندادند. با افزایش دوره نگهداری شمارش میکروبی افزایش یافت و بیشترین شمارش کلی میکروبی و کپک و مخمر مربوط به تیمار شاهد (۴/۸۸ logcfu/g) و (۳/۱۱ logcfu/g) و کمترین میزان مربوط به تیمار پوشش داده شده با آلژینات سدیم و ۵ درصد عصاره نعناع (۳/۲۴ logcfu/g) و (۱/۹۸ logcfu/g) بود. به طور کلی استفاده از پوشش خوراکی آلژینات سدیم و عصاره نعناع باعث بهبود عطر و طعم و جلوگیری از تغییرات بافتی و کاهش فعالیت میکروبی پنیر لاکتیکی در طول دوره نگهداری گردید.

تاریخ‌های مقاله:

تاریخ دریافت: ۱۴۰۱/۱۱/۰۷

تاریخ داوری: ۱۴۰۴/۰۸/۲۷

تاریخ پذیرش: ۱۴۰۴/۰۹/۰۵

کلمات کلیدی:

پنیر لاکتیکی،
پوشش خوراکی،
آلژینات سدیم،
عصاره نعناع،
ویژگی‌های ارگانولپتیکی

DOI: 10.48311/fsct.2026.83373.0

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