



## Scientific Research

## The use of electrolysis water in the salt water used in the production of white cheese to increase shelf life and improve quality properties

Parsa Ghasemi<sup>\*1</sup>, Javad Hessari<sup>\*2</sup>

1- Master's degree student, Department of Food Industry Science and Engineering, Faculty of Agriculture, Tabriz University, Tabriz

2- Professor of Food Technology, Department of Food Industry Science and Engineering, Faculty of Agriculture, Tabriz University, Tabriz

## ARTICLE INFO

## ABSTRACT

## Article History:

Received: 2025/02/02

Review: 2025/11/24

Accepted: 2025/11/25

## Keywords:

Electrolyzed water,  
Iranian white cheese,  
Increased Shelf Life,  
Microbial Properties

DOI: 10.48311/fsct.2026.83973.0

\*Corresponding Author E-

[jhesari@tabrizu.ac.ir](mailto:jhesari@tabrizu.ac.ir)

[Parsa.ghasemi1401@ms.tabrizu.ac.ir](mailto:Parsa.ghasemi1401@ms.tabrizu.ac.ir)

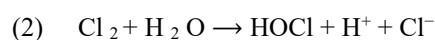
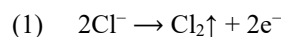
In this study, the effect of Electrolyzed water as a disinfection method in the production of Iranian white cheese was investigated. Electrolyzed water at concentrations of 1%, 5%, and 10% was added to the brine, and sampling was performed on days 1, 30, and 60. Physicochemical, textural, microbiological, and sensory characteristics were evaluated. The results indicated that there was no significant difference in pH among the samples; however, titratable acidity increased significantly with increasing concentrations of electrolyzed water. In the 5% treatment, acidity increased from 0.12 to 0.16. During storage, salt content decreased significantly, while dry matter content showed a significant increase. Significant changes were observed in the L\* and b\* color indices, with a reduction in lightness, whereas the redness index (a\*) showed no significant variation. Total microbial counts and mold growth were reduced in all samples containing electrolyzed water, with the 1% treatment showing the greatest inhibitory effect. The growth of lactic acid bacteria increased in the 1% and 10% treatments, while it decreased in the control. Yeast counts increased over the storage period but decreased with higher concentrations of electrolyzed water. Coliform growth was completely inhibited in the 5% and 10% treatments. From a textural perspective, hardness was higher in the control, while gumminess was greater in the 1% treatment. Sensory evaluation revealed that the 5% treatment achieved the highest overall acceptance score. These findings suggest that electrolyzed water can serve as an effective approach for improving the microbial, textural, and sensory quality of Iranian white cheese.

## 1- Introduction

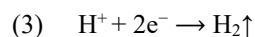
Cheese is defined as a fresh or matured product resulting from milk coagulation, prepared in soft, semi-hard, hard, and very hard varieties, serving as a general term for a group of fermented milk products produced globally with a vast diversity of flavors, textures, and shapes [1]. It is typically made from the curdling of milk (from cows, buffaloes, camels, goats, or sheep) which is acidified by bacterial cultures and subsequently curdled by the addition of rennet or a substitute like acetic acid [2]. Cheeses are highly nutritious, providing valuable sources of high-quality proteins, lipids, vitamins (such as A, B<sub>2</sub>, and B<sub>12</sub>), and minerals (especially calcium and phosphorus) [3]. However, the preservation of cheese presents a major challenge to the industry due to microbial spoilage and consumer concerns regarding the health effects of chemical preservatives, prompting research into high-safety, minimally processed dairy products with favorable environmental and health labels. Cheeses inherently resist microbial attack due to factors such as pH, water activity (aw), salt concentration, nitrites, organic acids, bacteriocin-producing Lactic Acid Bacteria (LAB), ripening, storage temperature, residual enzymes, and chemical composition, all of which influence spoilage differently. Secondary contamination is also a significant factor, frequently occurring after post-pasteurization processing (HTST) and throughout the supply chain via processing equipment, production lines, contaminated air, improper retail handling, and packaging deficiencies [4]. Electrolyzed water (EW) is produced by the electrolysis of a diluted solution of NaCl or a mixture of KCl and MgCl<sub>2</sub> within an electrolytic cell featuring a diaphragm separating the anode and cathode, typically with a voltage set between 9 and 10 volts. During electrolysis, dissolved NaCl in deionized water dissociates into Cl<sup>-</sup> and Na<sup>+</sup> ions; simultaneously, OH<sup>-</sup> and H<sup>+</sup> ions form. Negatively charged ions (Cl<sup>-</sup> and OH<sup>-</sup>) move toward the anode, releasing electrons and forming oxygen gas, chlorine gas, hypochlorite ion, hypochlorous acid, and hydrochloric acid. Conversely, positively charged ions (H<sup>+</sup> and Na<sup>+</sup>) migrate to the cathode, gain electrons, and become hydrogen gas and sodium hydroxide [5]. Acidic and alkaline oxidized electrolyzed water are collected from the positive and negative compartments, respectively [6].

The basic chemical reactions at the anode and cathode can be summarized as follows [7].

At the Anode Side:



And at the Cathode Side:



The effectiveness of the antimicrobial activities of electrolyzed water (EW) depends on several factors, including the specific characteristics of the biological system being targeted. For example, influential factors such as exposure time to EW, the concentration of available chlorine (ACC) [1], and temperature will have different effects on suspensions compared to surfaces. EW also exhibits antimicrobial activities in various biological systems. The presence of chlorine, low pH, and high Oxidation-Reduction Potential (ORP) [2] are the main factors contributing to the antimicrobial activity of acidic electrolyzed water (AEW) [3]. AEW reduces bacterial growth and makes bacterial cells more susceptible to active chlorine by sensitizing their outer membrane to the influx of HOCl. Active chlorine compounds can destroy the membranes of microorganisms, but other modes of chlorine action have also been proposed (e.g., decarboxylation of amino acids, reaction with nucleic acids, and unbalanced metabolism following the degradation of key enzymes). HOCl is the most active chlorine compound because HOCl penetrates the cell membrane and produces hydroxyl radicals, which exert their antimicrobial activity through the oxidation of key metabolic systems. The relative fractions of chlorine compounds (Cl<sub>2</sub>, HOCl, and OCl<sup>-</sup>) are pH-dependent and affect the bactericidal activity of AEW [5]. In summary, EW demonstrates its microbicidal property by attacking multiple cellular targets (cytoderm, outer membrane, and intracellular components). The surface morphology of the cells changes after EW treatment, transitioning from smooth, continuous, and bright to rough, shrunken, and even lysed. Meanwhile, bacterial protective barriers (cell wall and membrane) are attacked and degraded by chlorine species, which can increase membrane permeability and lead to the leakage of intracellular components (K<sup>+</sup>, proteins, and DNA) [8]. The purpose of using electrolyzed water in dairy products, particularly in cheese, is twofold: primarily, to preserve its sensory quality and textural properties while eliminating

pathogenic microorganisms; and secondarily, to reduce the pasteurization process time in order to retain its mineral content.

## 2- Materials and Methods

To evaluate the chemical attributes and antimicrobial efficacy of electrolyzed water (EW) in Iranian white cheese, a series of experiments were systematically conducted as detailed below.

### 1.2. Production of Iranian White Cheese

Iranian white cheese was manufactured at the Nazhoo Dairy facility (Tabriz, Iran) using fresh whole cow milk, which was standardized and pasteurized at 75°C for 15 seconds before being cooled to 33°C. Following pasteurization, the milk was inoculated with a 3% (v/v) mesophilic starter culture and maintained in a cheese vat for 30 minutes, after which microbial rennet (1 g/100 L) was added to induce coagulation over approximately 60 minutes. The resulting curd was subsequently cut, drained of whey, and pressed to form a solid mass, which was then portioned and immersed in an 18% (w/v) brine solution for 4 hours. Finally, the

### 2.5. Color Measurement

The color attributes of the cheese samples were evaluated using a Hunter Lab colorimeter at the Dairy Laboratory of the Faculty of Graduate Studies, University of Tabriz. The CIELAB color space parameters, including L\* (lightness/darkness), a\* (redness/greenness), and b\* (yellowness/blueness), were precisely measured to characterize the optical properties of the treatments [18].

### 2.6. Sensory Evaluation

To determine the overall consumer acceptability of the product, a sensory panel consisting of nine trained evaluators was employed. The panelists were specifically trained to score the samples based on a 5-point hedonic scale (ranging from 1 to 5) for attributes including color and appearance, aroma, texture, flavor, and overall acceptability. On this scale, a score of 1 represented the minimum satisfaction (dislike extremely), while a score of 5 indicated the maximum satisfaction (like extremely).

### 2.7. Texture Profile Analysis (TPA)

The texture profile of the cheese samples was characterized using a texture analyzer (Stable Micro

cheese blocks were packaged in sterile plastic containers filled with 10% brine containing various concentrations of electrolyzed water (EW) and incubated at 15°C; once the pH reached 4.6, the samples were transferred to storage at 8°C for a 60-day ripening and analysis period.

**2.2. Preparation of Treatments** The experimental treatments were prepared by incorporating varying concentrations of electrolyzed water (EW) into a 10% (w/v) brine solution. The control group consisted of pure 10% brine without EW, while treatments T2, T3, and T4 were formulated by substituting the brine with 1%, 5%, and 10% (v/v) of EW, respectively (corresponding to 1, 5, and 10 mL of EW per 100 mL of the final brine mixture). To evaluate the quality changes, sampling was performed at 30-day intervals over a total storage period of 60 days, during which all physicochemical and microbiological analyses were conducted. All experimental procedures were performed in triplicate to ensure the accuracy and reproducibility of the results.

### 2.3. Microbiological Analysis

For microbiological evaluation, a 20 g cheese sample was homogenized with 45 mL of sterile 2% (w/v) sodium citrate solution in a stomacher at 260 rpm for 1.5 minutes to obtain the initial  $10^{-1}$  dilution. Subsequently, a series of decimal dilutions ( $10^{-2}$  to  $10^{-7}$ ) were prepared using test tubes containing 9 mL of sterile physiological saline. A 0.1 mL aliquot of each dilution was then inoculated via the pour-plate method onto Plate Count Agar (PCA), Yeast Extract Glucose Chloramphenicol (YGC) agar, MRS agar, and Violet Red Bile Agar (VRBA) for the enumeration of total aerobic bacteria, molds and yeasts, lactic acid bacteria (LAB), and coliforms, respectively. The incubation conditions were set at 37°C for 48 hours for PCA, 30°C for 48 hours for MRS agar, 25°C for 3–5 days for YGC agar, and 37°C for 24 hours for VRBA [9-12].

### 2.4. Chemical Analysis

Chemical properties of the cheese samples were determined in triplicate to ensure data accuracy. The pH value, titratable acidity, salt content, total solids, fat, and protein content were measured in accordance with the Institute of Standards and Industrial Research of Iran (ISIRI) protocols, specifically methods No. 2852, 1809, 1753, 760, and 9188-1, respectively [13–17].

### 3-Results

#### 3.1. Chemical Analysis

##### 3.1.1. Changes in Nitrogen and Fat Content

As illustrated in Table 1, the nitrogen and fat content of Iranian white cheese remained stable across both the control and experimental samples containing various concentrations of electrolyzed water (EW). No significant fluctuations were observed in these parameters throughout the 60-day storage period at 8°C.

Systems, Model TA.XT Plus, UK). Cheese samples were initially prepared in standardized dimensions of 20 × 20 × 45 mm. The analysis was performed using a 25 mm diameter cylindrical probe. The instrumental settings were configured with a pre-test speed of 1 mm/s, a test speed of 0.5 mm/s, a post-test speed of 1 mm/s, and a penetration depth of 15 mm. Texture attributes, including hardness, cohesiveness, springiness, gumminess, and chewiness, were derived from the resulting force-time deformation curves using Texture Exponent Lite software.

**Table1:** Variations of nitrogen and fat content in Iranian white cheese containing Electrolyzed Water

Sample	nitrogen content	Fat content
Control	11.78±0.005	15±0.07
T <sub>2</sub>	11.25±0.06	16±0.02
T <sub>3</sub>	12.13±0.01	15±0.05
T <sub>4</sub>	11.41±0.02	14.5±0.03

(T<sub>2</sub>): brine containing %1 Electrolyzed Water; (T<sub>3</sub>): brine containing %5 Electrolyzed Water; (T<sub>4</sub>): brine containing %10 Electrolyzed Water

##### 3.1.2. Changes in pH Value

The changes in pH values of the cheese samples during the storage period are summarized in Table 2. No significant differences in pH were observed between the control and the experimental treatments containing various concentrations of electrolyzed water (EW) ( $P > 0.05$ ). The interaction between storage time and EW concentration revealed that the highest pH value in Treatment 2 (1% EW) was recorded on day 1, while the lowest was observed on day 30. Throughout the storage period, the pH values decreased by day 30 and subsequently showed a slight, non-significant increase by day 60. This marginal increase could be attributed to the liberation of amino and carbonyl groups resulting

from proteolytic reactions. Fluctuations in pH can significantly alter the nature of the compounds formed within the cheese matrix. Furthermore, the initial downward trend in pH may be assigned to the decomposition of hypochlorous acid into H<sup>+</sup> and Cl<sup>-</sup>, alongside the production of acetic acid [5]. During the ripening stage, pH typically declines due to lactose fermentation and the generation of amino acids and fatty acids via proteolysis and lipolysis. This reduction is likely driven by lactic acid production by starter cultures and the liberation of H<sup>+</sup> ions during the water electrolysis process. These findings are in agreement with previous research investigating the application of neutral electrolyzed water as a preservative in poultry breast meat [19].

**Table2:** The interaction effect of Electrolyzed Water and storage on pH changes in Iranian white cheese containing different times of Electrolyzed Water

Sample	Storage time (days)		
	1	30	60
Control	5.39±0.01 <sup>ns</sup>	4.58±0.07 <sup>ns</sup>	4.62±0 <sup>ns</sup>
T <sub>2</sub>	5.69±0.47 <sup>ns</sup>	4.14±0 <sup>ns</sup>	4.47±0.06 <sup>ns</sup>
T <sub>3</sub>	5.3±0.11 <sup>ns</sup>	4.33±0 <sup>ns</sup>	4.72±0.01 <sup>ns</sup>
T <sub>4</sub>	5.08±0.47 <sup>ns</sup>	4.34±0 <sup>ns</sup>	4.93±0.02 <sup>ns</sup>

<sup>ns</sup> indicates a non-significant difference at the 0.05 level.

\*The results are reported as the mean of three replicates ± standard deviation

(T<sub>2</sub>): brine containing %1 Electrolyzed Water; (T<sub>3</sub>): brine containing %5 Electrolyzed Water; (T<sub>4</sub>): brine containing %10 Electrolyzed Water.

##### 3.1.3. Changes in Titratable Acidity

The variations in the titratable acidity of Iranian white cheese samples during storage are summarized in Table 3. The analysis of the interaction between storage time and different concentrations of neutral electrolyzed water (NEW) revealed significant differences in acidity levels ( $P < 0.05$ ). Specifically, the interaction effects indicated that throughout the 60-day storage period, the highest and lowest acidity levels in the control samples were recorded on day 30 and day 60,

respectively. Over the course of storage, acidity decreased in the control and T<sub>2</sub> (1% EW) groups, whereas an upward trend was observed in T<sub>3</sub> (5% EW) and T<sub>4</sub> (10% EW). The primary factor contributing to the overall acidity is the production of lactic acid by the starter cultures. Furthermore, the increasing trend in acidity in certain treatments can be attributed to the decomposition of hypochlorous acid into H<sup>+</sup> and Cl<sup>-</sup> ions, as well as the subsequent formation of acetic acid [5].

**Table3:** The mutual effect of treatments and different storage times on changes in the acidity of Iranian white cheese containing different concentrations of Electrolyzed Water

Sample	Storage time (days)		
	1	30	60
Control	0.19±0 <sup>b</sup>	0.21±0 <sup>a</sup>	0.09±0.005 <sup>f</sup>
T <sub>2</sub>	0.16±0 <sup>d</sup>	0.18±0 <sup>c</sup>	0.14±0.005 <sup>d</sup>
T <sub>3</sub>	0.12±0 <sup>c</sup>	0.16±0 <sup>d</sup>	0.16±0 <sup>d</sup>
T <sub>4</sub>	0.16±0 <sup>d</sup>	0.19±0 <sup>b</sup>	0.18±0 <sup>c</sup>

\*Different letters indicate a significant difference at the 0.05 level and checking the interaction between samples and storage time.

\*The results are reported as the mean of three replicates ± standard deviation.

(T<sub>2</sub>): brine containing %1 Electrolyzed Water; (T<sub>3</sub>): brine containing %5 Electrolyzed Water; (T<sub>4</sub>): brine containing %10 Electrolyzed Water.

### 3.1.4. Changes in Salt Content

The variations in the salt content of Iranian white cheese samples during storage are summarized in Table 4. The analysis of the interaction between storage time and various concentrations of electrolyzed water (EW) revealed significant differences among the samples ( $P < 0.05$ ). Specifically, the salt content in T<sub>4</sub> (10% EW) was lower compared to the control group and exhibited a continuous downward trend throughout the 60-day storage period. This reduction can be attributed to the increased proportion of EW; as the EW concentration rose, the amount of the initial 10% brine solution was effectively reduced. It is hypothesized that during the electrolysis process, NaCl undergoes decomposition over time, exerting

its antimicrobial and chemical effects through the generation of hypochlorous acid (HOCl) and hypochlorite ions (OCl<sup>-</sup>) [5]. Salt plays a critical role in maintaining the hardness and flavor profile of the cheese. A reduction in the salt ratio tends to cause the cheese matrix to soften or dissolve, as essential minerals that contribute to structural firmness leach into the surrounding brine. Consequently, osmotic pressure causes water from the brine to penetrate the cheese, thereby increasing its moisture content [20]. Furthermore, salt enhances shelf life by lowering the water activity (aw) of the product, which effectively inhibits the growth of spoilage and pathogenic microorganisms, including total viable count, coliforms, and molds and yeasts.

**Table 4:** The interaction effect of treatments and time on changes in the salt content in Iranian white cheese containing different concentrations of Electrolyzed Water

Sample	Storage time (days)		
	1	30	60
Control	0.87±0 <sup>a</sup>	0.86±0.01 <sup>a</sup>	0.76±0.02 <sup>c</sup>
T <sub>2</sub>	0.84±0 <sup>ab</sup>	0.57±0 <sup>c</sup>	0.49±0 <sup>g</sup>
T <sub>3</sub>	0.81±0.02 <sup>b</sup>	0.52±0 <sup>f</sup>	0.48±0.01 <sup>g</sup>
T <sub>4</sub>	0.61±0.03 <sup>d</sup>	0.52±0.005 <sup>f</sup>	0.52±0.01 <sup>ef</sup>

\*Different letters indicate a significant difference at the 0.05 level and checking the interaction between samples and storage time.

\*The results are reported as the mean of three replicates ± standard deviation.

(T<sub>2</sub>): brine containing %1 Electrolyzed Water; (T<sub>3</sub>): brine containing %5 Electrolyzed Water; (T<sub>4</sub>): brine containing %10 Electrolyzed Water.

with a previous study on the efficacy of electrolyzed oxidizing water in controlling *Pseudomonas syringae* in tomato products, which reported no significant differences in relative moisture content during a 7-day storage period ( $P > 0.0001$ ) [21]. Similarly, research evaluating the effects of plasma-activated water and slightly acidic electrolyzed water (SAEW) as thawing media for beef demonstrated that AEW has a negligible impact on moisture loss [22].

### 3.1.5. Changes in Total Solids Content

The variations in the total solids content of Iranian white cheese samples during storage are summarized in Table 5. The analysis of the interaction between storage time and different concentrations of electrolyzed water (EW) indicated an upward trend in total solids across all experimental groups compared to the control. However, despite this increase, no statistically significant differences were observed among the treatments ( $P > 0.05$ ). These findings are consistent

**Table 5:** The interaction effect of treatments and time on changes in dry matter of Iranian white cheese containing different concentrations of Electrolyzed Water

Sample	Storage time (days)		
	1	30	60
Control	32.7±0.17 <sup>ns</sup>	28.3±0.43 <sup>ns</sup>	33.9±1.02 <sup>ns</sup>
T <sub>2</sub>	28.1±0.57 <sup>ns</sup>	30.9±1.61 <sup>ns</sup>	34.2±2.08 <sup>ns</sup>
T <sub>3</sub>	29.6±0.2 <sup>ns</sup>	32.2±1.92 <sup>ns</sup>	31.2±1.92 <sup>ns</sup>
T <sub>4</sub>	30.8±1.33 <sup>ns</sup>	32.2±2.402 <sup>ns</sup>	30.8±1.33 <sup>ns</sup>

<sup>ns</sup> indicates a non-significant difference at the 0.05 level.

\*The results are reported as the mean of three replicates ± standard deviation.

(T<sub>2</sub>): brine containing %1 Electrolyzed Water; (T<sub>3</sub>): brine containing %5 Electrolyzed Water; (T<sub>4</sub>): brine containing %10 Electrolyzed Water.

### 3.2. Microbiological Analysis 3.2.1. Total Viable Count (TVC)

The logarithmic values of the total viable count (TVC) are presented in Table 6. The interaction between storage time and various concentrations of electrolyzed water (EW) showed significant differences in TVC between the control and the experimental treatments ( $P < 0.05$ ). According to Table 6, the microbial population in the control sample exhibited an upward trend throughout the 60-day storage period due to the absence of antimicrobial agents. Conversely, samples treated with EW showed a significant reduction in the total number of microorganisms. It has been reported that the production of exopolysaccharides can lead to biofilm formation around microorganisms, which subsequently increases bacterial resistance against hypochlorite solutions [23]. Generally, the antimicrobial activity of chlorine-based solutions depends on the concentration of hypochlorous acid

present in the water. The chlorine content in EW plays a crucial role in bacterial inactivation. At a pH range of 5.0–6.5, hypochlorous acid is the predominant form of chlorine in neutral electrolyzed water, which has been proven to possess the highest bactericidal activity [24]. Furthermore, the presence of salt in the treatment solution may increase the osmotic pressure in the aqueous phase of the food matrix, leading to bacterial dehydration and subsequent growth inhibition or death [25]. These findings are in alignment with previous studies investigating the efficacy of slightly acidic electrolyzed water for inactivating *Salmonella Enteritidis* on contaminated eggshells, the effectiveness of neutral electrolyzed water in reducing microbial loads in minimally processed vegetables, and the bactericidal impact of slightly acidic electrolyzed water on *Listeria monocytogenes* planktonic cells and biofilms on food-contact surfaces [23, 26, 27].

**Table 6:** Interaction effect of treatments and time on total count in Iranian white cheese containing different concentrations of Electrolyzed Water

Sample	Storage time (days)		
	1	30	60

	1	30	60
Control	8.46±0.1 <sup>cd</sup>	9.27±0.02 <sup>b</sup>	10.64±0.14 <sup>a</sup>
T <sub>2</sub>	8.25±0.05 <sup>ef</sup>	7.33±0.1 <sup>g</sup>	6.87±0.02 <sup>h</sup>
T <sub>3</sub>	8.65±0.05 <sup>c</sup>	8.41±0.2 <sup>e</sup>	6.21±0.05 <sup>i</sup>
T <sub>4</sub>	8.29±0.26 <sup>ef</sup>	8.12±0.01 <sup>f</sup>	6±0 <sup>j</sup>

\*Different letters indicate a significant difference at the 0.05 level and checking the interaction between samples and storage time.

\*The results are reported as the mean of three replicates ± standard deviation.

(T<sub>2</sub>): brine containing %1 Electrolyzed Water; (T<sub>3</sub>): brine containing %5 Electrolyzed Water; (T<sub>4</sub>): brine containing %10 Electrolyzed Water.

### 3.2.2. Enumeration of Lactic Acid Bacteria (LAB)

The logarithmic counts of lactic acid bacteria are presented in Table 7. The analysis of the interaction between storage time and various concentrations of electrolyzed water (EW) revealed significant differences in LAB populations between the control and the experimental treatments ( $P < 0.05$ ). It was observed that the growth of LAB followed an upward trend in T<sub>2</sub> (1% EW) and T<sub>4</sub> (10% EW), whereas a downward trend was recorded for the

control and T<sub>3</sub> (5% EW) samples. The reduction in certain treatments could potentially be attributed to the high oxidative potential of electrolyzed water, which may have oxidized *Lactobacillus* species—the primary producers of lactic acid leading to the subsequent production of carbon dioxide (CO<sub>2</sub>) within the cheese matrix. Furthermore, the decline in lactic acid levels in some samples may be assigned to high yeast activity, as yeasts can metabolize organic acids, thereby reducing the overall lactic acid concentration [28].

**Table7:** The interaction effect of treatments and time on the amount of starter bacteria in Iranian white cheese containing different concentrations of Electrolyzed Water

Sample	Storage time (days)		
	1	30	60
Control	8.5±0.03 <sup>c</sup>	5.49±0.11 <sup>e</sup>	3.58±0.11 <sup>f</sup>
T <sub>2</sub>	8.57±0.18 <sup>c</sup>	9.6±0.23 <sup>a</sup>	9.05±0.05 <sup>b</sup>
T <sub>3</sub>	8.5±0.12 <sup>c</sup>	8.38±0.08 <sup>c</sup>	7.28±0.2 <sup>d</sup>
T <sub>4</sub>	8.41±0.02 <sup>c</sup>	8.34±0.03 <sup>c</sup>	9.17±0.13 <sup>b</sup>

\*Different letters indicate a significant difference at the 0.05 level and checking the interaction between samples and storage time.

\*The results are reported as the mean of three replicates ± standard deviation.

(T<sub>2</sub>): brine containing %1 Electrolyzed Water; (T<sub>3</sub>): brine containing %5 Electrolyzed Water; (T<sub>4</sub>): brine containing %10 Electrolyzed Water.

### 3.2.3. Enumeration of Molds

The logarithmic counts of molds in Iranian white cheese are presented in Table 8. The analysis of the interaction between storage time and various concentrations of electrolyzed water (EW) revealed significant differences in mold populations between the control and the experimental treatments ( $P < 0.05$ ). As indicated in the results, the mold count exhibited a downward trend over the 60-day storage period, eventually approaching zero by day 60. Treatment 4 (10% EW) demonstrated the most pronounced antifungal effect. Generally, the enhanced antimicrobial activity of electrolyzed water can be attributed to its low pH, high Oxidation-Reduction Potential (ORP), and the

presence of available chlorine [24]. Furthermore, the results suggest that increasing the concentration and contact time of EW effectively eliminated established biofilms, leading to the complete inhibition of mold growth [23]. These findings are consistent with previous research evaluating the synergistic effect of fumaric acid and slightly acidic electrolyzed water on the inactivation of foodborne pathogens and the shelf-life extension of fresh beef [29]. Our results are also in agreement with studies investigating the fungicidal activity of acidic electrolyzed oxidizing water and the potential of EW to inactivate spoilage fungi in bread and cheese, where *Penicillium roqueforti* showed the highest

susceptibility (97.5% reduction) among all tested spoilage fungi [30-31].

**Table 8:** The interaction effect of treatments and time on the amount of mold in Iranian white cheese containing different concentrations of Electrolyzed Water

Sample	Storage time (days)		
	1	30	60
Control	1.15±0.15 <sup>b</sup>	0±0 <sup>d</sup>	1.15±0.15 <sup>a</sup>
T <sub>2</sub>	1.15±0.15 <sup>b</sup>	1.38±0.08 <sup>d</sup>	0±0 <sup>d</sup>
T <sub>3</sub>	1±0 <sup>c</sup>	0±0 <sup>d</sup>	0±0 <sup>d</sup>
T <sub>4</sub>	0±0 <sup>d</sup>	0±0 <sup>d</sup>	0±0 <sup>d</sup>

\*Different letters indicate a significant difference at the 0.05 level and checking the interaction between samples and storage time.

\*The results are reported as the mean of three replicates ± standard deviation.

(T<sub>2</sub>): brine containing %1 Electrolyzed Water; (T<sub>3</sub>): brine containing %5 Electrolyzed Water; (T<sub>4</sub>): brine containing %10 Electrolyzed Water.

#### 4.2.3. Investigation of Yeast Count Results

Table 9 presents the logarithmic yeast counts in Iranian white cheese. As illustrated in the table, the investigation into the interaction between storage time and various concentrations of electrolyzed water (EW) revealed a significant difference ( $P < 0.05$ ) in yeast counts between the control and all experimental samples treated with EW. The data indicates that while yeast counts generally increased over the storage period, they significantly decreased across treatments as the concentration of EW was increased. Specifically, an upward trend was observed during the 60-day storage period, with the highest count recorded in the control sample on day 60. Conversely, within the specified intervals of 30

and 60 days, yeast growth showed a declining trend as the EW concentration increased. This variation can be attributed to the concentration and application time of the electrolyzed water and its efficacy in overcoming the protective biofilm surrounding the microorganisms. These findings are consistent with the results of Buck et al. (2002), who examined the fungicidal activity of acidic electrolyzed oxidizing water, Tango et al. (2014), who investigated the synergistic effect of combined fumaric acid and slightly acidic electrolyzed water on inactivating foodborne pathogens and extending the shelf life of fresh beef, and Lemos et al. (2022), who studied the potential of electrolyzed water to inactivate spoilage fungi in bread and cheese [29, 30, 31].

**Table 9:** The interaction effect of treatments and time on the amount of yeast in Iranian white cheese containing different concentrations of Electrolyzed Water

Sample	Storage time (days)		
	1	30	60
Control	0±0 <sup>h</sup>	7.38±0.005 <sup>b</sup>	7.16±0.09 <sup>c</sup>
T <sub>2</sub>	1.35±0.15 <sup>f</sup>	1.45±0.15 <sup>f</sup>	7.14±0.08 <sup>c</sup>
T <sub>3</sub>	1.38±0.08 <sup>f</sup>	8.8±0.09 <sup>a</sup>	6.25±0.08 <sup>d</sup>
T <sub>4</sub>	1.38±0.03 <sup>f</sup>	1±0 <sup>g</sup>	3.03±0.03 <sup>a</sup>

\*Different letters indicate a significant difference at the 0.05 level and checking the interaction between samples and storage time.

\*The results are reported as the mean of three replicates ± standard deviation.

(T<sub>2</sub>): brine containing %1 Electrolyzed Water; (T<sub>3</sub>): brine containing %5 Electrolyzed Water; (T<sub>4</sub>): brine containing %10 Electrolyzed Water.

#### 5.2.3. Investigation of Coliform Count Results

Table 10 illustrates the logarithmic coliform counts in Iranian white cheese, where the analysis of the interaction between storage time and various concentrations of Electrolyzed Water (EW) revealed

a significant difference ( $P < 0.05$ ) between the control and all EW-treated experimental samples. While *coliform* counts in the control group increased over the 60-day storage period, a notable declining trend was observed in the treated samples,

eventually approaching zero as the EW concentration and application time increased; this reduction is primarily attributed to the potent germicidal properties of EW and its efficacy in inhibiting biofilm formation. The superior antimicrobial activity of EW is generally linked to its low pH, high Oxidation-Reduction Potential (ORP), and available chlorine content, alongside the presence of peracetic acid and sodium hypochlorite [24]. These findings align with Tango et al. (2014) regarding the synergistic effects of EW and fumaric acid on foodborne pathogens [29], as well as Hricova et al. (2008) on EW applications in the food

industry. Similarly, Sarmadi et al. (2017) demonstrated the efficiency of slightly acidic EW in inactivating *Salmonella Enteritidis* on eggshells, noting that while initial differences were minimal, post-disinfection counts of *E. coli* were lowest in formaldehyde and acidic EW groups, while alkaline and neutral EW treatments showed significant differences ( $P < 0.05$ ) compared to other groups [5, 32]. Furthermore, these results are consistent with Abadias et al. (2008), who confirmed the efficacy of neutral EW in reducing microbial contamination in minimally processed vegetables [27].

**Table 10:** The interaction effect of treatments and time on the amount of coliform in Iranian white cheese containing different concentrations of Electrolyzed Water

Sample	Storage time (days)		
	1	30	60
Control	1.73±0.04 <sup>b</sup>	1.3±0 <sup>c</sup>	3.14±0.03 <sup>a</sup>
T <sub>2</sub>	1.15±0.15 <sup>d</sup>	1±0 <sup>c</sup>	0±0 <sup>f</sup>
T <sub>3</sub>	1±0 <sup>e</sup>	0±0 <sup>f</sup>	0±0 <sup>f</sup>
T <sub>4</sub>	1.15±0.15 <sup>d</sup>	0±0 <sup>f</sup>	0±0 <sup>f</sup>

\*Different letters indicate a significant difference at the 0.05 level and checking the interaction between samples and storage time.

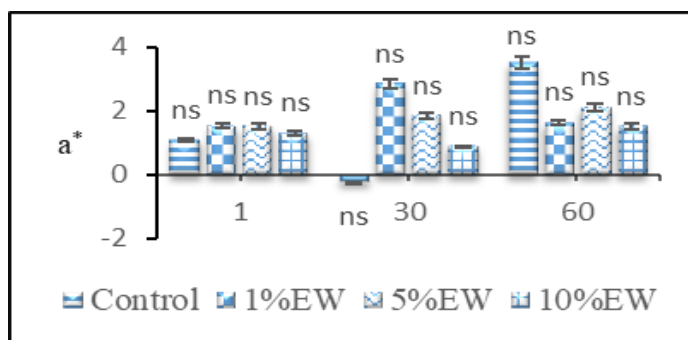
\*The results are reported as the mean of three replicates ± standard deviation.

(T<sub>2</sub>): brine containing %1 Electrolyzed Water; (T<sub>3</sub>): brine containing %5 Electrolyzed Water; (T<sub>4</sub>): brine containing %10 Electrolyzed Water.

### 3.3. Colorimetry

Food color is one of the most critical sensory parameters influencing consumer perception of product quality. As illustrated in Figure 1, the analysis of variance regarding the interaction between storage time and various concentrations of Electrolyzed Water (EW) over a 60-day period revealed a significant impact on the L\* (lightness) index ( $P < 0.05$ ). The results indicated that while the lightness of EW-treated samples decreased over 60 days, the control sample exhibited an initial decrease followed by an increase at day 30. Overall, the samples became darker during storage, which can be attributed to protein hydration, the subsequent reduction of free water, and diminished light scattering [33]. Khouroshehi et al. (2004) similarly reported a decrease in the lightness of Iranian white cheese during storage [34]. In solid products like cheese, light scattering—which depends on the uniformity of molecular and substructural layers—

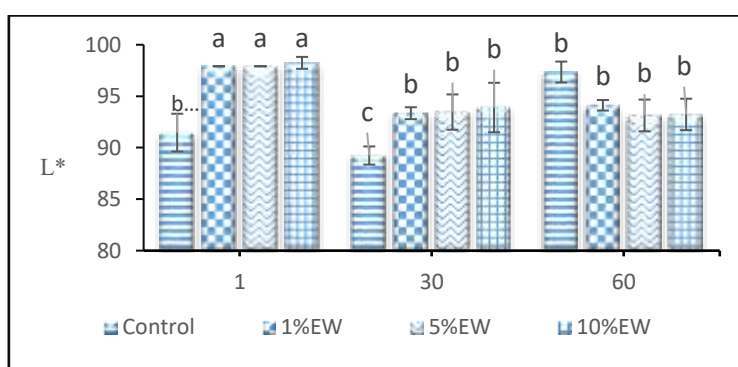
occurs as light passes through surface layers and is dispersed by fat globules and internal pores; a reduction in this scattering leads to decreased lightness [35]. Regarding the a\* index (redness/greenness), as shown in Figure 2, the interaction between storage time and EW concentrations did not significantly affect this parameter ( $P > 0.05$ ). These findings align with Rosario-Pérez et al. (2023), who studied the effect of neutral electrolyzed water (NEW) and NaClO on chicken breast and observed no significant changes in this value [19]. Finally, as depicted in Figure 3, the interaction between time and EW concentrations showed a significant effect on the b\* (yellowness/blueness) index ( $P < 0.05$ ). This is consistent with Liao et al. (2022), who evaluated the use of plasma-activated water (PAW) and slightly acidic EW as a thawing medium for beef and found that slightly acidic EW significantly impacts the b\* index [22].



**Figure 1:** The interaction effect of treatments and time on color component a\* in Iranian white cheese containing different concentrations of Electrolyzed Water

\*ns indicates a non-significant difference at the 0.05 level.

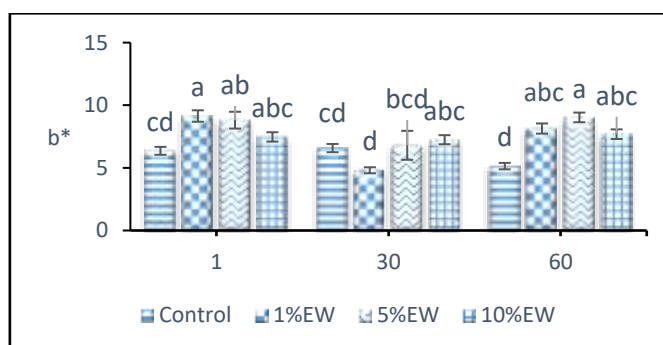
\*The results are reported as the mean of three replicates ± standard deviation



**Figure 2:** The interaction effect of treatments and time on the color component L\* in Iranian white cheese containing different concentrations of Electrolyzed Water

\*Different letters indicate a significant difference at the 0.05 level and checking the interaction between samples and storage time.

\*The results are reported as the mean of three replicates ± standard deviation.



**Figure 3:** The interaction effect of treatments and time on color component b\* in Iranian white cheese containing different concentrations of Electrolyzed Water

\*Different letters indicate a significant difference at the 0.05 level and checking the interaction between samples and storage time.

\*The results are reported as the mean of three replicates ± standard deviation.

### 4.3. Texture Profile Analysis (TPA)

Since cheese texture significantly influences consumer acceptance, it is considered a vital quality parameter. Accordingly, the factors of hardness, cohesiveness, springiness, gumminess, and chewiness were evaluated and compared on days 1 and 30. Hardness represents the maximum force required to compress the sample to 50% of its initial height during the first compression cycle. According to the results in Table 11, among the control and experimental samples treated with various concentrations of electrolyzed water (EW), the highest hardness was recorded in the control sample on day 30, while the lowest was observed in Treatment 4 (10% EW) on the same day. Generally, it can be concluded that cheese hardness exhibited a declining trend over the 30-day storage

period. This reduction in hardness is primarily attributed to proteolysis [28]. When the salt concentration in cheese is significantly reduced, water activity, acidity, and bitterness increase, while firmness decreases [36]. The firmness of cheese during brine storage depends on two main factors: moisture loss, which increases firmness, and proteolysis, which decreases firmness by breaking down casein micelles. Furthermore, the softening of cheese during the ripening period can be explained by the decrease in pH, which leads to the solubilization of calcium phosphate. Consequently, the reduction of calcium bound to casein micelles increases the repulsive forces between them, weakening the structural bonds of the cheese and leading to a softer texture [37].

**Table 11:** The interaction effect of treatments and time on the hardness of Iranian white cheese containing different concentrations of Electrolyzed Water

Sample	Storage time (days)	
	1	30
Control	0.634±0.0005	1.76±0.002
T <sub>2</sub>	1.626±0	1.539±0
T <sub>3</sub>	1.214±0.0005	0.83±0.03
T <sub>4</sub>	0.499±0.001	0.8±0

(T<sub>2</sub>), brine containing %1 Electrolyzed Water; (T<sub>3</sub>), brine containing %5 Electrolyzed Water; (T<sub>4</sub>), brine containing %10 Electrolyzed Water.

### Springiness

Springiness indicates the sample's ability to recover its original state after the application of a deforming force. According to the results in Table 12, a comparison between the control and various experimental samples treated with electrolyzed

water (EW) showed that the highest springiness was observed in Treatment 4 (10% EW) on day 1, whereas the lowest value was recorded for the same treatment on day 30. Overall, a reduction in springiness was observed in all treated samples on day 30 compared to their initial values on day 1.

**Table 12:** The interaction effect of treatments and time on Springiness of Iranian white cheese containing different concentrations of Electrolyzed Water

Sample	Storage time (days)	
	1	30
Control	1.106±0.003	1.112±0.001
T <sub>2</sub>	1.149±0.001	1.138±0.002
T <sub>3</sub>	1.153±0	1.153±0
T <sub>4</sub>	1.161±0.001	1.101±0.01

(T<sub>2</sub>), brine containing %1 Electrolyzed Water; (T<sub>3</sub>), brine containing %5 Electrolyzed Water; (T<sub>4</sub>), brine containing %10 Electrolyzed Water.

### Gumminess

Another parameter investigated was gumminess, which represents the energy required to disintegrate a semi-solid food product to a state ready for swallowing. According to the results in

Table 13, comparing the control and experimental samples treated with various concentrations of electrolyzed water (EW) revealed that the highest gumminess was observed in Treatment 2 (1% EW) on day 1, while the lowest value was recorded for

the control sample on the same day. Generally, it was observed that the gumminess of the treated

samples exhibited a declining trend over the 30-day storage period.

**Table 13:** The interaction effect of treatments and time on the gumminess of Iranian white cheese containing different concentrations of Electrolyzed Water

Sample	Storage time (days)	
	1	30
Control	0.27±0.02	0.87±0.01
T <sub>2</sub>	1.23±0	1.13±0.02
T <sub>3</sub>	0.778±0	0.46±0.04
T <sub>4</sub>	0.305±0.001	0.37±0

(T<sub>2</sub> ).brine containing %1 Electrolyzed Water; (T<sub>3</sub> ).brine containing %5 Electrolyzed Water; (T<sub>4</sub> ).brine containing %10 Electrolyzed Water.

**Cohesiveness**

Another investigated parameter was cohesiveness, which indicates the sample's ability to undergo deformation before structural failure or breaking. According to the results in Table 14, the highest cohesiveness was observed in Treatment 2 (1%

EW), while the lowest value was recorded in the control sample on day 1. Overall, the application of electrolyzed water improved the cohesiveness of the tissue structure [28].

**Table 14:** Interaction effect of treatments and

time on consistency of Iranian white cheese containing different concentrations of Electrolyzed Water

Sample	Storage time (days)	
	1	30
Control	0.426±0	0.493±0.0005
T <sub>2</sub>	0.76±0.03	0.76±0
T <sub>3</sub>	0.641±0.001	0.561±0.0005
T <sub>4</sub>	0.613±0	0.473±0

(T<sub>2</sub> ).brine containing %1 Electrolyzed Water; (T<sub>3</sub> ).brine containing %5 Electrolyzed Water; (T<sub>4</sub> ).brine containing %10 Electrolyzed Water.

**Chewiness**

The final investigated parameter was chewiness, which represents the energy required for mastication and oral digestion of solid food products. According to the results in Table 15, a comparison between the control and various experimental samples treated with electrolyzed

water (EW) showed that the highest chewiness was recorded in Treatment 2 (1% EW) on day 1, while the lowest was observed in Treatment 4 (10% EW) on day 30. Overall, a declining trend was observed among the treated samples over the 30-day period. It can be inferred that a direct relationship exists between hardness and chewiness; thus, factors influencing cheese hardness also significantly impact its chewiness [28].

**Table 15:** The interaction effect of treatments and time on the Chewiness of Iranian white cheese containing different concentrations of Electrolyzed Water

Sample	Storage time (days)	
	1	30
Control	0.31±0.01	0.96±0.02
T <sub>2</sub>	1.36±0.005	1.27±0.005
T <sub>3</sub>	0.88±0.005	0.52±0
T <sub>4</sub>	0.43±0	0.4±0.005

(T<sub>2</sub> ).brine containing %1 Electrolyzed Water; (T<sub>3</sub> ).brine containing %5 Electrolyzed Water; (T<sub>4</sub> ).brine containing %10 Electrolyzed Water.

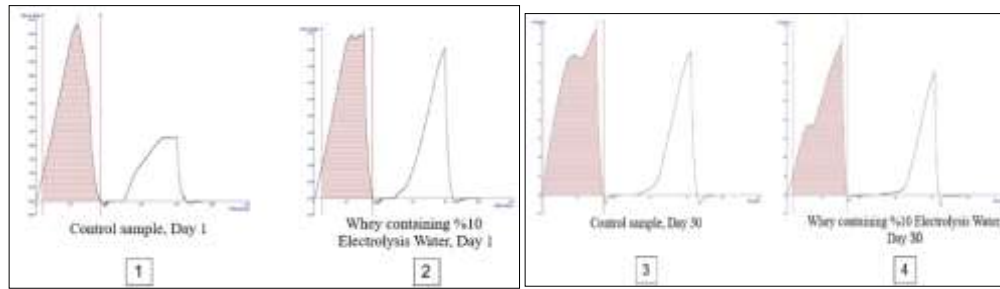
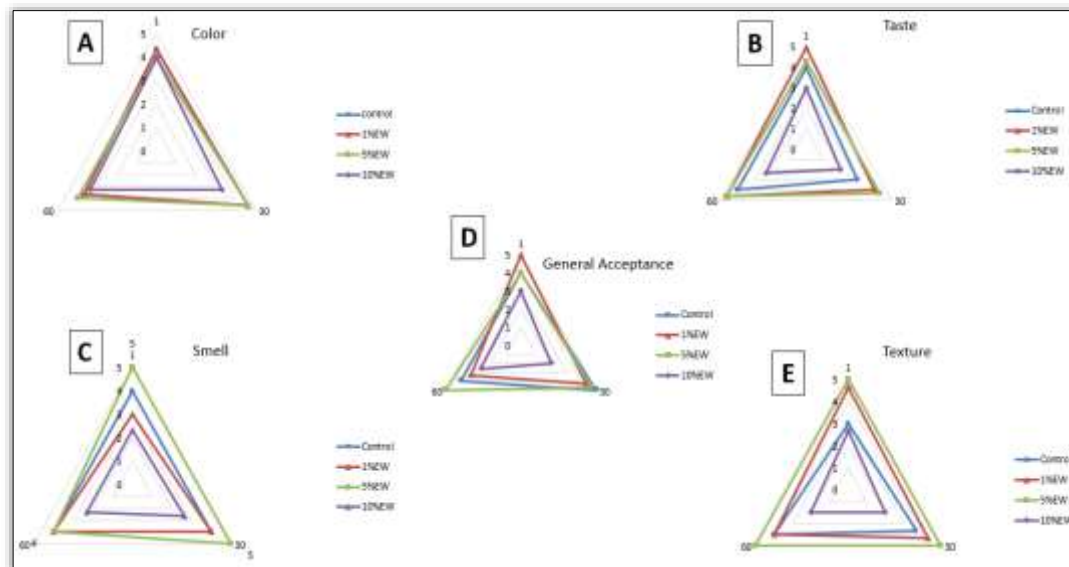


Figure 4,5: Cheese texture profile diagram containing Electrolyzed Water

**5.3. Sensory Evaluation**

The sensory quality of cheese is influenced by several factors, including animal genetics, the milk production environment, processing technologies, and the chemical and microbiological characteristics of the raw materials [38]. In this study, the sensory evaluation of the cheese was conducted based on five indices: texture, flavor, aroma, color, and overall acceptability. According to the panelists' scores, Figures A, B, C, D, and E illustrate the interaction between storage time and various concentrations of electrolyzed water (EW) regarding color, flavor, aroma, texture, and overall acceptability, respectively. The results indicated no

significant differences ( $P > 0.05$ ) among all treatments over the 60-day period in terms of color, flavor, texture, and overall acceptability. However, as shown in Figure C, a significant difference ( $P < 0.05$ ) was observed in the aroma between the control and the experimental samples treated with different EW concentrations. The highest score was attributed to Treatment 3 (5% EW), while the lowest score was recorded for Treatment 4 (10% EW). Specifically, in Treatment 4, a bitter taste was detected on day 60, and in Treatment 2 (1% EW), a salty taste was predominant. Nevertheless, among all experimental samples, the best flavor profile was reported for Treatment 3 (5% EW).



**Figure 6:** Variation of sensory scores for Iranian white cheese containing different concentrations of Electrolyzed Water: days 1-30-60 (Figs. A-E). Data are mean of 9 panelists scores (n=9).

## 4-Conclusion

Iranian white cheese is one of the most important and widely consumed dairy products. To extend its shelf life, electrolyzed water (EW) was utilized at concentrations of 1%, 5%, and 10%. The results demonstrated that the populations of coliforms and fungi in the treated samples generally decreased as the storage period progressed. Furthermore, this study revealed that the qualitative, sensory, and microbiological characteristics of cheese stored in whey containing 5% EW were superior to those of other treatments, with no significant quality degradation observed in the treated samples. Consequently, further research is warranted to explore the application of electrolyzed water as a non-thermal and innovative technology in the formulation of various dairy products.

## Funding

The author declares that he / she has not received any funding.

## Author Contributions

All activities were carried out by the author.

## Competing Interests

The author confirms that he / she has no financial conflicts of interest or competing interests in this study.

## Acknowledgements

The authors would like to express their sincere gratitude to the Vice-chancellor for Research and Technology of Agricultural Sciences and Natural Resources University of Khuzestan for supporting this study (1403.38).

## 5-References

- [1] Faccia, M., Gambacorta, G., Martemucci, G., Difonzo, G., & D'Alessandro, A. G. (2019). Chemical-sensory traits of fresh cheese made by enzymatic coagulation of donkey milk. *Foods*, 9(1), 16.
- [2] Lajnaf, R., Feki, S., Ameer, S. B., Attia, H., Kammoun, T., Ayadi, M. A., & Masmoudi, H. (2023). Recent advances in selective allergies to

mammalian milk proteins not associated with Cow's Milk Proteins Allergy. *Food and Chemical Toxicology*, 113929.

[3] Feeney, E. L., Lamichhane, P., & Sheehan, J. J. (2021). The cheese matrix: understanding the impact of cheese structure on aspects of cardiovascular health—a food science and a human nutrition perspective. *International Journal of Dairy Technology*, 74(4), 656-670.

[4] Ali, A. M. M., Sant'Ana, A. S., & Bavisetty, S. C. B. (2022). Sustainable preservation of cheese: Advanced technologies, physicochemical properties and sensory attributes. *Trends in Food Science & Technology*, 129, 306-326.

[5] Hricova, D., Stephan, R., & Zweifel, C. (2008). Electrolyzed water and its application in the food industry. *Journal of Food Protection*, 71(9), 1934-1947.

[6] Morita, C., Sano, K., Morimatsu, S., Kiura, H., Goto, T., Kohno, T., ... & Katsuoka, Y. (2000). Disinfection potential of electrolyzed solutions containing sodium chloride at low concentrations. *Journal of Virological Methods*, 85(1-2), 163-174.

[7] Issa-Zacharia, A. (2024). Application of Slightly Acidic Electrolyzed Water as a Potential Sanitizer in the Food Industry. *Journal of Food Quality*, 2024(1), 5559753.

[8] Zhao, L., Li, S., & Yang, H. (2021). Recent advances on research of electrolyzed water and its applications. *Current Opinion in Food Science*, 41, 180-188.

[9] Institute of Standards and Industrial Research of Iran. no: 8248, Counting of microorganisms by total counting at 30 °C. Karaj: ISIRI;1384

[10] National Iranian Standard, 10154, (2007). Milk and its products - counting units forming colonies of mildew or yeast colony count in a plate at 25 ° C. Institute of Standards and Industrial Research of Iran

[11] Institute of Standards and Industrial Research of Iran, (2007), Milk products – Enumeration of presumptive *Lactobacillus acidophilus* on a selective medium – Colonycount technique at 37°C. ISIRI 9616.

[12] National Iranian Standard, 2 and 1-5486. Milk and its products - Total counting of forms Part I - National Standard of Iran, 6806-3. Column counting method at 30 ° C (without reinforcement). Institute of Standards and Industrial Research of Iran.

- [13] ISIRI. 2006. Institute of Standards and Industrial Research of Iran. Milk and dairy products: Determination of fat acidity and pH. ISIRI number 2852.
- [14] Institute of Standards and Industrial Research of Iran (ISIRI)., 1977, of measuring the amount of salt methods. Iranian National Standardization Organization (INSO). Standard No. 1809.
- [15] ISIRI. 2002. Institute of Standards and Industrial Research of Iran. Cheese and processed cheese- determination of total solids (Reference method). ISIRI number 1753.
- [16] ISIRI. 1968. Institute of Standards and Industrial Research of Iran. Determination of cheese and processed cheese fat content (Reference method). ISIRI number 760.
- [17] ISIRI. 2015. Institute of Standards and Industrial Research of Iran. Milk and dairy products: Determination of nitrogen content Part 1: calculation of crude protein using Kjeldahl method. ISIRI number 9188-1.
- [18] Izadi,Z., Nasirpour,A., Grossi, Gh. A. (2012). Studying the distribution of phytosterols and color changes in yogurt enriched with phytosterols by gas chromatography and Photoshop software. Iran Food Science and Industry Research Journal, 8(3).
- [19] Rosario-Pérez, P. J., Rodríguez-Sollano, H. E., Ramírez-Orejuel, J. C., Severiano-Pérez, P., & Cano-Buendía, J. A. (2023). Neutral Electrolyzed Water in Chicken Breast—A Preservative Option in Poultry Industry. *Foods*, 12(10), 1970.
- [20] Cankurt, H. (2019). The effects of adding different stabilizers in brine on the physicochemical, sensory, microbiological and textural properties of white cheese. *Foods*, 8(4), 133.
- [21] Mexicano, L., Medina, T., Mexicano, A., & Carmona, J. C. (2024). Electrolyzed Oxidizing Water in Controlling *Pseudomonas syringae* pv. tomato in Tomato Crops. *Agronomy*, 14(3), 597.
- [22] Liao, Xinyu, et al. "Plasma-activated water (PAW) and slightly acidic electrolyzed water (SAEW) as beef thawing media for enhancing microbiological safety." *Lwt* 117 (2020): 108649.
- [23] Hao, J., Zhang, J., Zheng, X., & Zhao, D. (2022). Bactericidal efficacy of slightly acidic electrolyzed water (SAEW) against *Listeria monocytogenes* planktonic cells and biofilm on food-contact surfaces. *Food Quality and Safety*, 6, fyab038.
- [24] Cui, X., Shang, Y., Shi, Z., Xin, H., & Cao, W. (2009). Physicochemical properties and bactericidal efficiency of neutral and acidic electrolyzed water under different storage conditions. *Journal of Food Engineering*, 91(4), 582-586.
- [25] Akan, E., Yerlikaya, O., & Kinik, O. (2017). Importance of salt in dairy products and sodium reduction strategies in food and dairy products. *Agro Food Industry Hi-Tech*, 28(2), 60-62
- [26] Cao, W., Zhu, Z. W., Shi, Z. X., Wang, C. Y., & Li, B. M. (2009). Efficiency of slightly acidic electrolyzed water for inactivation of *Salmonella enteritidis* and its contaminated shell eggs. *International Journal of Food Microbiology*, 130(2), 88-93.
- [27] Abadias, M., Usall, J., Oliveira, M., Alegre, I., & Viñas, I. (2008). Efficacy of neutral electrolyzed water (NEW) for reducing microbial contamination on minimally-processed vegetables. *International journal of food microbiology*, 123(1-2), 151-158.
- [28] Esmer, O. K., Balkir, P., Seekin, A. K., & Irkin, R. (2009). The effect of modified atmosphere and vacuum packaging on the physicochemical, microbiological, sensory and textural properties of Crottin de Chavignol cheese. *Food Science and Technology Research*, 15(4), 367-376.
- [29] Tango, C. N., Mansur, A. R., Kim, G. H., & Oh, D. H. (2014). Synergetic effect of combined fumaric acid and slightly acidic electrolysed water on the inactivation of food-borne pathogens and extending the shelf life of fresh beef. *Journal of applied Microbiology*, 117(6), 1709-1720.
- [30] Buck, J. W., Van Iersel, M. W., Oetting, R. D., & Hung, Y. C. (2002). In vitro fungicidal activity of acidic electrolyzed oxidizing water. *Plant Disease*, 86(3), 278-281.
- [31] Lemos, J. G., Stefanello, A., Garcia, M. V., Furian, A. F., Cichoski, A. J., & Copetti, M. V. (2022). Potential of electrolyzed water to inactivate bread and cheese spoilage fungi. *Food Research International*, 162, 111931.

- [32] Sarmadi, M., Gholami Ahangaran, M., and Fathi Hafeshjani, A. (2017). Investigating the effectiveness of electrolyzed water in the disinfection of fertilized eggs in hatchery. *Iranian Veterinary Journal (Shahid Chamran University of Ahvaz)*, 14(1), 48-54. SID <https://sid.ir/paper/364917/fa>
- [33] Sheehan, J. J., Huppertz, T., Hayes, M. G., Kelly, A. L., Beresford, T. P., & Guinee, T. P. (2005). High pressure treatment of reduced-fat Mozzarella cheese: Effects on functional and rheological properties. *Innovative Food Science & Emerging Technologies*, 6(1), 73-81.
- [34] Khosrowshahi, A., Madadlou, A., zadeh Mousavi, M. E., & Emam-Djomeh, Z. (2006). Monitoring the chemical and textural changes during ripening of Iranian White cheese made with different concentrations of starter. *Journal of dairy science*, 89(9), 3318-3325.
- [35] Rahimi, J., Khosrowshahi, A., Madadlou, A., & Aziznia, S. (2007). Texture of low-fat Iranian white cheese as influenced by gum tragacanth as a fat replacer. *Journal of dairy science*, 90(9), 4058-4070.
- [36] Heydari Moqtadar, H., Ahmadi, I. (2016). Investigating the effect of different levels of NaCl and KCl salts on the mechanical and rheological properties of Iranian white cheese. *Food Industry Research*, 26(2), 191-205.
- [37] Cooke, D., Khosrowshahi, A., & Mcsweeney, P. (2013). Effect of gum tragacanth on the rheological and functional properties of full-fat and half-fat Cheddar cheese. *Dairy Science & Technology*, 93(1), 45-62.
- [38] Fekadu, B., Soryal, K., Zeng, S., Van Hekken, D., Bah, B., & Villaquiran, M. (2005). Changes in goat milk composition during lactation and their effect on yield and quality of hard and semi-hard cheeses. *Small Ruminant Research*, 59(1), 55-63.



## مجله علوم و صنایع غذایی ایران

سایت مجله: [www.fsct.modares.ac.ir](http://www.fsct.modares.ac.ir)

### مقاله علمی-پژوهشی

استفاده از آب الکترولیز در آب نمک مورد استفاده در تولید پنیر سفید جهت افزایش ماندگاری و بهبود خواص کیفی

پارسا قاسمی<sup>۱\*</sup>، جواد حصاری<sup>۲\*</sup>

۱-دانش آموخته کارشناسی ارشد، گروه علوم و مهندسی صنایع غذایی، دانشکده کشاورزی، دانشگاه تبریز، تبریز

۲- استاد تکنولوژی مواد غذایی، گروه علوم و مهندسی صنایع غذایی، دانشکده کشاورزی، دانشگاه تبریز، تبریز

چکیده	اطلاعات مقاله
در این پژوهش، اثر استفاده از آب الکترولیز به عنوان روش ضدعفونی در تولید پنیر سفید ایرانی بررسی شد. غلظت‌های مختلف آب الکترولیز (۱، ۵ و ۱۰ درصد) به آب نمک افزوده و نمونه‌برداری در روزهای ۱، ۳۰ و ۶۰ انجام شد. ویژگی‌های فیزیکوشیمیایی، بافتی، میکروبی و حسی ارزیابی گردید. نتایج نشان داد pH بین نمونه‌ها تفاوت معنی‌داری نداشت، اما اسیدیته با افزایش غلظت آب الکترولیز به طور معنی‌داری افزایش یافت؛ به طوری که در نمونه ۵٪، اسیدیته از ۰/۱۲ به ۰/۱۶ تغییر کرد. درصد نمک طی نگهداری به طور معنی‌داری کاهش و درصد ماده خشک افزایش یافت. شاخص‌های رنگی $L^*$ و $b^*$ تغییر معنی‌دار داشتند و روشنایی نمونه‌ها کاهش یافت، اما شاخص قرمزی ( $a^*$ ) تغییر معنی‌داری نشان نداد. شمارش کلی میکروب‌ها و رشد کپک در تمام نمونه‌های حاوی آب الکترولیز کاهش یافت و نمونه حاوی ۱٪ آب الکترولیز بیشترین اثر را داشت. رشد باکتری‌های اسیدلاکتیک در غلظت‌های ۱٪ و ۱۰٪ افزایش و در کنترل کاهش یافت. رشد مخمر با گذشت زمان افزایش، ولی با افزایش غلظت آب الکترولیز کاهش پیدا کرد. رشد کلیفرم در نمونه‌های ۵٪ و ۱۰٪ کاملاً متوقف شد. از نظر بافت، سختی پنیر در کنترل بیشتر و صمغیت در نمونه ۱٪ بالاتر بود. ارزیابی حسی نشان داد نمونه ۵٪ بهترین امتیاز پذیرش کلی را کسب کرد. نتایج این مطالعه نشان می‌دهد آب الکترولیز شده می‌تواند روشی مؤثر برای بهبود کیفیت میکروبی، بافتی و حسی پنیر سفید ایرانی باشد.	<p>تاریخ های مقاله :</p> <p>تاریخ دریافت: ۱۴۰۳/۱۱/۱۴</p> <p>تاریخ داوری: ۱۴۰۴/۰۹/۰۳</p> <p>تاریخ پذیرش: ۱۴۰۴/۰۹/۰۴</p> <p>کلمات کلیدی:</p> <p>آب الکترولیز شده، پنیر سفید ایرانی، افزایش ماندگاری، خواص میکروبی</p> <p>DOI: 10.48311/fsct.2026.83978.0</p> <p>* مسئول مکاتبات:</p> <p>jhesari@tabrizu.ac.ir</p> <p>Parsa.ghasemi1401@ms.tabrizu.ac.ir</p>