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Research Article

Usage of Himalayan salt in white cheese production as a brine to improve rheological and sensorial properties

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ABSTRACT

This study aimed to investigate the effects of Himalayan salt on the physicochemical, microbiological, sensory and rheological properties of white cheese. For this purpose, five different brine solutions were prepared as follows; K (Control), B (White Himalayan Salt), K (Red Himalayan Salt), 1:1B (White: Rock salt), 1:1K (Red: Rock salt). While there was no significant difference between the value of dry matter, pH and ash content of the samples, the results of M17 agar were found the highest in the samples prepared with red Himalayan salt ($p<0.05$). The viscoelastic solid character (G') of the samples increased with the addition of White and red Himalayan salt. The data obtained from frequency sweep test were fitted to power law model. The model parameters of K' and K" were found to be 4184.04-9019.83 Pas^n. The cheese samples produced with red Himalayan salt showed significantly higher K' than the samples produced with white Himalayan salt and control sample ($p<0.05$). The using of different Himalayan salt color significantly increased the "*a**" values of the samples, and the "*b**" value decreased during storage period both two Himalayan salt usage. The results of this study indicated that the using of Himalayan salt could improve rheological properties of the white cheese samples without significant changing in sensorial and physicochemical properties.

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INTRODUCTION

White cheese is a semi-hard dairy product produced from sheep, goat, cow's milk or mixtures of these milks. One third of the milk produced worldwide is used for cheese making. Therefore, cheese is considered a universal dairy product and is also among the most consumed foodstuffs in the world [1]. The white cheese is brined, has a slightly acidic and salty taste, and is matured in brine after being stored for one to three months at temperatures between 4°C and 8°C [2].

Rheological, textural and sensory quality characteristics of white cheese are vital qualities playing a role in consumer

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preference. Many factors such as the materials used in cheese formulation and process parameters are effective on the above qualities of white cheese. One of these factors is the brine application during salting of white cheese. Salting is one of the most important steps in making white cheese. Salting process not only affects the taste and texture of cheese, but also changes the course of biochemical reactions that occur during ripening. Brine salting is one of the most common salting methods, and rock salt is generally used for this purpose.

Recently, unrefined edible salts obtained from different geographical regions have taken their place in food markets [3]. The chemical composition of these salts differs according to the geographical region and the method of salt production. Himalayan salt is one of the most known and used unrefined salts. Himalayan salt contains high levels of chlorine (47.70%), sodium (30.66%), oxygen (10.41), sulfur (4.19%), calcium (2.49%), potassium (2.51%), magnesium (1.06%), while low levels of silicon (< Contains 0.35%, aluminum (≤0.23%), iron (≤0.17%), fluorine (≤0.17%) [4]. As can be seen from the studies on the brine concentration, duration and storage temperature of brined cheeses, the salting process has a great effect on the characteristic properties of the cheese [5-7]. Studies on the effect of different Himalayan salts on the quality properties of white cheese are limited in the literature and such studies should be conducted. The aim of this study is to examine the effects of the use of Himalayan salt in the production of white cheese on the chemical, microbiological, sensory and rheological properties of cheese.

MATERIAL AND METHODS

Material

The milk used in cheese production was obtained from local producers in Kırklareli. Himalayan salt and rock salt used in brine were obtained from markets. The media used in microbiological and chemical analyzes were of high purity and were obtained from Merck (Darmstadt, Germany).

Cheese Production

Firstly, the raw milk was pasteurized at 72 °C for 15 minutes and cooled to 32 °C after pateurization. After adding 0.02% $CaCl_2$ solution, rennin enzyme was added to complete the coagulation in 75-90 minutes. After coagulation, it was cut into 1-3 cm cubes and left to rest for 25-30 minutes, then pressed to filter the curd whey.

After the pressing process, the cheese curds were divided into groups and for each group, K(Control), B(White colored Himalayan salt), K (Red colored Himalayan salt), 1:1B (white:rock salt), 1:1K (red:rock salt)) were prepared in 5 different brine. After the cheese taken from the press was cut into molds, it was added to the previously prepared and pasteurized brine and left to mature for 60 days at 4 °C. Cheese production was done in 2 replications. 30., 60. and 90th day analyzes were carried out.

Physicochemical Analyzes

Dry matter analysis of white cheese samples was carried out by an oven at 105 °C until they reached constant weight. The ash content was determined according to the burning principle at 550 °C, fat was determined according to the Gerber method, acidity was calculated as % lactic acid and salt determination was determined according to the Mohr method [8].

Rheological Analysis

The dynamic rheological properties of cheese samples were determined with a stress-controlled and temperature-controlled rheometer with a peltier heating system (Anton Paar, MCR 302, Austria). Dynamic rheological properties were determined with parallel plate configuration at 25 °C with a gap of 2 mm between the two plates. Determination of dynamic rheological properties was first determined by linear viscoelastic region amplitude sweep test. Then, frequency scanning test was applied and graphs showing viscoelastic solid (G'), viscoelastic liquid (G") values of the samples were obtained. Numerical values of viscoelastic solid (K'), viscoelastic liquid (K") characters and flow behavior indices (n' and n") values were obtained by subjecting these data to nonlinear regression. The Power Law model was used to model the data. Model applicability level is based on regression coefficient [9].

Color Analysis

Color measurements were performed with a colorimeter (Chroma Meter CR-400, Konica Minolta, Japan). The data were obtained colorimetrically on the C.I.E L*a*b system. The measurements were expressed as L* brightness, a* green-redness, b* blue-yellowness values [10].

Microbiological Analysis

The drop culture method was used for microbiological analyses, and serial dilutions were prepared after 10 g cheese sample taken under aseptic conditions was homogenized with 90 ml dilution liquid (ringer). MRS Agar(Merck) and M17 Agar(Merck) (48 hours at 30 °C) for lactic acid bacteria in determining the microbial load of white cheeses, PCA (Sigma Aldrich) for total mesophilic aerobic bacteria count (48 hours at 30 °C), EMB Agar(Merck)(48 hours at 37°C) was used for coliform group microorganisms and PDA(Merck)(120 hours at 25 °C) was used for yeast-mold count.

Sensorial Analysis

Sensory properties of cheeses were performed by previously trained panelists. The samples were randomly numbered before the analysis, and as a result of the analyzes carried out at 25 °C, the panelists examined the cheeses in terms of appearance, flavor and texture.

Statistical Analysis

The findings obtained from chemical, microbiological and sensory analyzes were evaluated using the analysis of variance technique (ANOVA) using the SPSS 18.0 package program. Differences between samples were determined by Duncan multiple comparison test. Nonlinear regression analysis of the rheological analysis results was performed using the Statistica 8.0 (StatSoft Inc., Tulsa, OK) software package.

RESULTS AND DISCUSSION

Physicochemical Analyzes

The changes in the physicochemical properties of the cheese samples during the 90-day storage period were given in Table 1. As a result of the analysis, it was observed that the storage time and the type of brine used did not have a significant effect on the dry matter values of the cheeses ($p>0.05$). As seen in this study, increases and decreases in the amount of dry matter can be seen in white cheeses due to osmotic pressure during ripening [11,12].

No significant change was observed in the pH values of the cheeses in terms of storage time and brine type ($p>0.05$). Although statistically insignificant, the differences between pH values are thought to be due to the effects of the minerals in the composition of Himalayan salt on the starter culture, solubility and interaction with casein and other macromolecules [13,14].

It was determined that the acidity values increased during maturation in the control group, the acidity values of the samples using Himalayan salt were higher than the control group on the 1st day, and fluctuations were observed on the other days. It is observed that the increase in acidity is more pronounced in the control group samples. The fact that the acidity increases of the samples using Himalayan salt were lower than the control group is thought to be due to the high magnesium content. Calcium and magnesium in the salt used in brine react with lactic acid and cause a decrease in acidity [1]. During storage, non-starter lactic acid bacteria metabolize the residual lactose in cheese and form acidity [15]. Therefore, changes in acidity values can be observed during storage.

Although the use of Himalayan salt did not have a significant effect on the ash content, the ash content was found to be higher than the control group due to the high mineral content of the Himalayan salt ($p>0.05$). The ash content increased especially after the 2nd month. This result could be explained by the penetration of the brine into the cheese. Himalayan salt used in brine caused an increase in the total ash amount [16,17]. While there is a difference between the sample groups in terms of % salt content ($p<0.05$); % salt content of each experimental group during storage did not show a statistically significant difference ($p>0.05$).

Table 1. The change of cheese components during storage

		Dry matter (%)	pH	Acidity (%LA)	Ash (%)	Salt (%)
White	1st day	36.3045±6.91^{aA}	5.67±0.45^{aA}	1.73±0.5^{aB}	6.3539±0.52^{bA}	nd
	30th day	31.6023±3.06^{aA}	5.87±0.23^{aA}	1.85±1.49^{bA}	6.4550±0.17^{bA}	15.52±0.59^{aB}
	60th day	29.0948±0.70^{aA}	5.94±0.22^{aA}	2.15±0.64^{abA}	7.4174±0.69^{aA}	14.28±0.33^{aB}
	90th day	29.2046±0.47^{aA}	5.92±0.12^{aA}	2.15±0.64^{abB}	7.9622±1.34^{aA}	15.39±0.89^{aB}
White	1st day	28.2144±19.32^{aA}	5.44±0.51^{aA}	2.63±1.36^{aA}	7.1078±0.24^{bA}	nd
	30th day	30.6614±2.70^{aA}	6.05±0.23^{aA}	1.35±0.21^{bB}	7.4808±0.34^{bA}	16.50±0.78^{aAB}
	60th day	33.3285±2.09^{aA}	6.15±0.17^{aA}	1.93±0.10^{abAB}	9.0384±1.35^{aA}	14.80±1.17^{aAB}
	90th day	29.8254±0.52^{aA}	6.23±0.26^{aA}	1.75±0.21^{abC}	7.3904±1.79^{aA}	16.26±0.73^{aAB}
Red	1st day	34.2950±5.75^{aA}	5.59±0.48^{aA}	2.75±1.50^{aA}	7.3689±0.41^{bA}	nd
	30th day	34.4077±3.67^{aA}	5.76±0.39^{aA}	1.85±0.92^{bA}	7.5005±0.46^{bA}	16.33±1.20^{aAB}
	60th day	34.1190±5.49^{aA}	5.86±0.29^{aA}	1.75±0.58^{abAB}	7.8291±0.66^{aA}	15.62±2.24^{aAB}
	90th day	34.7378±0.89^{aA}	5.95±0.18^{aA}	2.40±0.00^{abA}	8.2608±1.13^{aA}	16.03±0.73^{aAB}
1:1White	1st day	39.5426±8.73^{aA}	5.45±0.66^{aA}	2.80±1.97^{aA}	6.9852±0.27^{bA}	nd
	30th day	32.6995±2.65^{aA}	5.96±0.39^{aA}	1.40±0.71^{bB}	7.3323±0.41^{bA}	15.76±1.69^{aAB}
	60th day	30.6053±1.53^{aA}	5.89±0.35^{aA}	1.78±0.56^{abAB}	7.5500±0.74^{aA}	15.62±1.53^{aAB}
	90th day	32.9833±1.54^{aA}	5.87±0.23^{aA}	2.05±0.35^{abB}	8.2064±1.48^{aA}	15.85±0.30^{aAB}
1:1 Red	1st day	28.8926±18.88^{aA}	5.36±0.72^{aA}	2.38±1.59^{aA}	7.1252±0.12^{bA}	nd
	30th day	37.1442±5.63^{aA}	6.12±0.26^{aA}	1.40±0.42^{bB}	7.6282±0.50^{bA}	16.67±0.45^{aA}
	60th day	33.1877±1.71^{aA}	6.17±019^{aA}	1.23±0.24^{abB}	8.0135±0.67^{aA}	16.56±1.70^{aA}
	90th day	31.9970±3.33^{aA}	6.14±0.06^{aA}	1.60±0.28^{abC}	7.1715±1.52^{aA}	16.32±0.22^{aA}

The different lowercase letters in the same column indicate significant differences in storage time. $p<0.05$
The different capital letters in the same column indicate significant differences between groups. $p<0.05$

Rheological Analysis

The dynamic rheological properties of cheese samples for the 1st day, 1st month and 2nd month analyzes were shown in Figure 1 and Table 2. The salt concentration of the brine is proportional to the hardness of the cheeses, and the hardness value increases with the increase in the amount of salt [12]. It is known that the mineral content along with the salt content significantly affects the rheology of cheese [19]. The minerals are effective in providing the stability of casein micelles with the development of acidity in milk. Mineral ions bind to negatively charged casein micelles. Thus, precipitation of the casein layers is prevented at high salt concentrations [20].

The G' values of the samples with different kinds of Himalayan salt are shown in Figure 1. The viscoelastic solid characters (G') of the samples were similar [21]. The G' values, which give an idea about the viscoelastic solid character of the samples, vary depending on the type of salt added. The lowest G' value was seen in the control group samples. This shows that the addition of Himalayan salt causes an increase in the viscoelastic solid character of the cheeses, regardless of the variety. The hardness values of white cheese vary considerably with the use of salt substitutes with different mineral content [22]. It is thought that the Himalayan salt has a higher G' value than the control group due to its high calcium and phosphorus content. The addition red Himalayan salt caused a greater increase in G' value than white Himalayan salt. In studies examining the mineral content of Himalayan salts, it was determined that red Himalayan salt has a higher % potassium value than white Himalayan salt [23,24]. The low ionic strength of potassium chloride had a direct effect on the cheese matrix by affecting the solubility of proteins [25]. It was thought that the higher G' value of the samples using red Himalayan salt can be explained by this factor. Although the acidity of the first day was higher than the control group, it was observed that the acidity of the samples using Himalayan salt in the later stages of storage was lower than the control group. This situation led to the formation of more gel strength and more viscoelastic solid character in the samples using Himalayan salt.

In determining the dynamic rheological properties, the values obtained from the frequency scanning test were modeled with the Power Law model and the K', K" and n' and n" values of each sample were obtained and these values are shown in Table 2. As can be seen, the regression coefficient (R^2) in each case was found above the value of 0.90. This shows that the model could be used successfully in

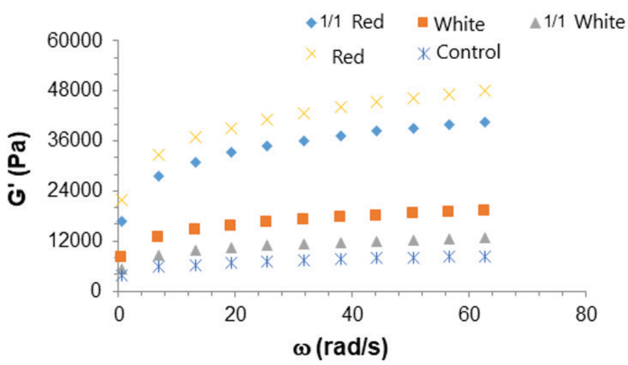

Figure 1. The G' value of the cheese samples.

Table 2. The K', K" ve n' ve n" value of the cheese samples

		K'	K"	n'	n"	R2
Control	1st day	4184.040±106aE	1518.633±336aB	0.168±0.001bC	0.175±0.003aA	0.9992
	30th day	3922.630±882aE	1395.689±301aA	0.182±0.001aA	0.172±0.002aA	0.9998
	60th day	3919.491±155aE	1422.438±960aB	0.157±0.003cC	0.163±0.001bA	0.9992
White	1st day	6006.507±812aC	1967.948±712aB	0.173±0.003aB	0.161±0.006bD	0.9998
	30th day	5927.653±504aC	1840.320±587aA	0.178±0.006aA	0.173±0.023aA	0.9995
	60th day	5337.721±725aC	1748.830±356bB	0.153± 0.002bC	0.143±0.005cC	0.9955
Red	1st day	9019.829±604aA	2806.947±368aA	0.174±0.002aB	0.170±0.016aB	0.9995
	30th day	8817.764±122aA	2516.469±791abA	0.176±0.006aA	0.168±0.008aA	0.9995
	60th day	8048.903±512aA	2504.797±175abA	0.155± 0.011bC	0.152±0.003bB	0.9996
1:1White	1st day	4962.065±153aD	1494.670±410aB	0.177±0.003aA	0.167±0.002aC	0.9995
	30th day	4474.862±1075aD	1395.689±582aA	0.182±0.002aA	0.172±0.005aA	0.9993
	60th day	4592.330±322aD	1383.299±120aCB	0.164±0.015bA	0.154±0.002bB	0.9856
1:1Red	1st day	7110.996±178aB	2116.406±497aAB	0.177±0.006aA	0.162±0.002aD	0.9996
	30th day	6864.463±184aB	2170.473±722aA	0.182±0.000aA	0.167±0.005aA	0.9999
	60th day	6409.583±901aB	1907.649±537aB	0.160±0.002bB	0.146±0.001bC	0.9990

The different lowercase letters in the same column indicate significant differences in storage time. p<0.05
The different capital letters in the same column indicate significant differences between groups. p<0.05

modeling dynamic rheological parameters. K' values were higher than K" values in all samples. This result showed that the solid character of all the samples was higher than the liquid character, as expected. In addition, it was observed that the parameters of the dynamic rheological properties of the samples were affected by the type of salt used and the storage time. A certain decrease was observed in the K' and K" values of the samples during the storage period. This can be explained by the enzymatic hydrolysis of αs casein as a result of salt addition and proteolysis during storage. During storage, the protein matrix turns into a softer structure [26].

Color Analysis

The use of Himalayan salt in different colors affected the color analysis results as expected ($p<0.05$). The color changes of cheese samples during storage were shown in Table 3. While the "L*" value did not show a significant difference between the sample groups, the "b*" value significantly decreased during storage. The "a*" values increased significantly during storage and the most significant change was observed in the samples prepared with red Himalayan salt. A significant redness was detected in the colors of the samples in which red Himalayan salt was used in the formulation. While it is expected that the "a" value is high in the samples using red Himalayan salt, the "a" values of the samples using white Himalayan salt were found to be lower. The "a" value in the control group samples was close to the samples prepared with white Himalayan salt. The difference in the mineral composition of the salts may have been the cause of the color difference between the samples. In particular, it was reported that the impurity of Himalayan salt is higher than refined salt [27].

Microbiological Analysis

The change in the microbial count results of cheese samples during storage was shown in Table 4. MRS agar and M17 agar count results of the samples using Himalayan salt were not significantly affected by the use of Himalayan salt ($p>0.05$). When the MRS agar count increased during storage time. This results showed parallelism with the acidity values of the samples. Likewise, some increases and decreases were observed in M17 agar count results during storage, but it was determined that the counting results of the control group samples were lower. It was thought that the mineral content of Himalayan salt encourages the growth of lactococci because of the high M17 agar count results in the samples using red Himalayan salt. While the numbers

Table 3. The color changes of cheese samples during storage

		Color parameters		
		L*	a*	b*
Control	1st day	89.510±3.00^{bA}	2.100±0.55^{cB}	6.770±0.08^{aA}
	30th day	88.785±3.05^{bA}	2.370±0.57^{bAB}	5.735±0.08^{bA}
	60th day	89.910±0.16^{aA}	2.295±0.15^{abB}	6.090±0.42^{aA}
	90th day	88.650±0.10$^{a\ A}$	2.280±0.12^{aB}	5.980±0.61^{bA}
White	1st day	88.260±1.33^{bA}	1.960±0.09^{cAB}	7.300±1.8^{aA}
	30th day	88.365±1.42b^{A}	2.690±0.07^{bAB}	6.015±1.70^{bA}
	60th day	89.705±0.30^{aA}	2.615±0.45^{abAB}	6.465±0.71^{aA}
	90th day	88.240±0.91^{aA}	2.845±0.04^{aAB}	4.890±0.03^{bA}
Red	1st day	87.390±0.06^{bA}	2.070±0.78^{cA}	7.320±0.90^{aA}
	30th day	86.930±0.07^{bA}	2.710±0.72^{bA}	4.195±1.00^{bA}
	60th day	89.955±1.44^{aA}	3.405±0.80^{abA}	6.050±0.47^{aA}
	90th day	89.575±1.94^{aA}	3.515±0.26^{aA}	5.295±0.30^{bA}
1:1White	1st day	87.700±0.78^{bA}	1.990±0.46^{cAB}	5.220±0.32^{aA}
	30th day	87.245±0.71^{bA}	2.365±0.37^{bAB}	3.905±0.30^{bA}
	60th day	88.720±0.59^{aA}	2.510±0.45^{abAB}	5.855±0.25^{aA}
	90th day	89.270±2.63^{aA}	2.815±0.01^{aAB}	4.980±0.25^{bA}
1:1 Red	1st day	87.560±0.45^{bA}	2.280±0.29^{cAB}	7.330±0.95^{aA}
	30th day	86.995±0.54^{bA}	3.075±0.23^{bAB}	5.870±0.86^{bA}
	60th day	87.865±0.49^{aA}	2.580±0.40^{abAB}	5.635±2.11^{aA}
	90th day	90.565±0.42^{aA}	3.015±0.01^{aAB}	5.065±1.24^{bA}

The different lowercase letters in the same column indicate significant differences in storage time. $p<0.05$
The different capital letters in the same column indicate significant differences between groups. $p<0.05$

Table 4. The microbial count results of cheese samples (log kob/g)

		MRS	M17	TMAB	Mold-yeast	Coliform
Control	1st day	3.35±2.27^{bA}	5.97±0.78^{abB}	5.56±0.11^{cAB}	0.41±0.58^{abA}	1.60±2.27^{cA}
	30th day	5.46±0.15^{aA}	6.34±0.31^{aB}	6.00±0.00^{aAB}	0.50±0.71^{bA}	5.22±0.47^{aA}
	60th day	5.65±0.12^{aA}	6.06±0.11^{aB}	5.93±0.07^{abAB}	0.68±0.97a^{A}	1.91±2.70^{bA}
	90th day	6.03±0.05^{bA}	6.23±0.29^{bB}	6.25±0.26^{bcAB}	0.41±0.58^{abA}	2.64±0.48^{cA}
White	1st day	3.14±0.93^{bA}	6.18±0.32^{abB}	5.58±0.08^{cAB}	0.26±0.37^{abA}	2.45±3.47^{cA}
	30th day	5.42±0.10^{aA}	6.50±0.19^{aB}	6.64±1.16^{aAB}	0.26±0.37^{bA}	5.28±0.16^{aA}
	60th day	5.51±0.72^{aA}	6.02±0.30^{aB}	6.08±0.09^{abAB}	0.67±0.21^{aA}	3.68±0.17^{bA}
	90th day	5.06±0.09^{bA}	5.75±0.63^{bB}	6.04±0.49^{bcAB}	0.00±0.00^{abA}	1.97±0.64^{bA}
Red	1st day	3.00±1.32^{bA}	6.63±0.46^{abA}	5.77±0.02^{cA}	0.41±0.58^{abA}	3.54±2.43^{cA}
	30th day	5.24±0.65^{aA}	8.43±0.25^{aA}	8.51±0.65^{aA}	0.00±0.00^{bA}	5.15±0.56^{aA}
	60th day	4.26±2.77^{aA}	8.79±0.95^{aA}	6.53±0.44^{abA}	0.52±0.00^{aA}	4.48±1.19^{bA}
	90th day	5.12±0.00^{bA}	5.76±0.56^{bA}	5.74±0.87^{bcA}	0.56±0.80^{abA}	2.56±0.62^{bA}
1:1White	1st day	2.35±0.36^{bA}	6.27±0.45^{abAB}	5.26±0.37^{cB}	0.26±0.37^{abA}	2.06±2.92^{cA}
	30th day	5.49±0.25^{aA}	6.15±0.68^{aAB}	5.75±0.11^{aB}	0.00±0.00^{bA}	4.99±0.45^{aA}
	60th day	5.22±0.28^{aA}	7.75±2.47^{aAB}	6.30±0.43^{abB}	0.61±0.86^{aA}	4.48±0.84^{bA}
	90th day	3.83±2.59^{bA}	5.77±0.35^{bAB}	5.98±0.32^{bcB}	0.00±0.00^{abA}	1.82±0.43^{bA}
1:1 Red	1st day	2.73±1.93^{bA}	6.08±0.79^{abB}	5.31±0.69^{cB}	0.65±0.92a^{bA}	1.76±2.49^{cA}
	30th day	5.21±0.52^{aA}	7.46±1.32^{aB}	5.58±0.51^{aB}	0.00±0.00^{bA}	4.63±0.37^{aA}
	60th day	2.87±1.91^{aA}	6.02±0.71^{aB}	6.00±0.67^{abB}	0.61±0.86^{aA}	3.05±1.30^{bA}
	90th day	5.23±0.67^{bA}	5.81±0.35^{bB}	5.49±0.26^{bcB}	0.56±0.80a^{bA}	2.51±0.72^{bA}

The different lowercase letters in the same column indicate significant differences in storage time. $p<0.05$
The different capital letters in the same column indicate significant differences between groups. $p<0.05$

Table 5. The sensory evaluation results of cheese samples

	30th			60th			90th		
	Appearance	Taste	Texture	Appearance	Taste	Texture	Appearance	Taste	Texture
Control	3.8±1.14^{aB}	4.4±0.70^{aB}	3.9±0.19^{aB}	3.6±0.85^{aB}	3.8±0.70^{bAB}	3.5±0.45^{abB}	3.4±0.55^{aB}	3.0±0.75^{bA}	3.2±0.45^{bA}
White	3.8±0.63^{aAB}	4.3±0.82^{aAB}	3.7±0.82^{aB}	3.8±0.52^{aAB}	4.0±0.60^{bAB}	3.8±0.70^{abAB}	3.7±0.48^{aAB}	4.0±0.82^{bA}	3.5±0.53^{bA}
Red	4.6±0.70^{aA}	4.9±0.32^{aA}	4.8±0.42^{aA}	4.2±0.25^{aA}	4.5±0.25^{bA}	4.5±0.25^{abA}	3.9±0.99^{aA}	4.3±0.67^{bA}	4.1±0.99^{bA}
1:1White	4.0±1.05^{aAB}	4.2±0.79^{aAB}	3.8±0.29^{aB}	3.9±0.79^{aAB}	3.9±0.62^{bAB}	3.6±0.30^{abB}	3.8±0.92^{aAB}	3.5±0.53^{bA}	3.4±0.52^{bA}
1:1Red	4.5±0.53^{aAB}	4.2±0.63^{aAB}	4.4±0.70^{aAB}	4.2±0.85^{aAB}	3.5±0.34^{bB}	4.2±0.65^{abAB}	3.8±0.42^{aAB}	3.2±0.63^{bA}	3.6±0.52^{bA}

The different lowercase letters in the same line indicate significant differences in storage time. $p<0.05$
The different capital letters in the column line indicate significant differences between groups. $p<0.05$

of lactic acid bacteria growing on MRS and M17 agar are low [28], the numbers of lactobacilli show parallelism [29]. The initial result of total mesophilic aerobic bacteria count and mold-yeast count of samples were found as 5.56-5.77 and 0.00-0.65 for 1stday. Compared to the literature, it was determined that the coliform bacteria counts were relatively high, which is thought to be due to the low pasteurization temperature. It was determined that coliform counts were lower than some studies [30]. In addition, it was observed that the microorganisms were inhibited after the 2nd and 3rd months with the developing acidity.

Sensory Analysis

Sensory analyzes of white cheese samples were performed by the panelists, and the findings were shown in Table 5. The cheeses using red and white Himalayan salt had a harder structure than the control group. The high salt rate used in the study caused an increase in the sensory hardness of the cheeses. It was observed that cheeses produced using Himalayan salt have the hardest structure. It was stated by the panelists that the use of white Himalayan salt creates a slightly sandy and bitter taste in cheese, and on the other hand, red Himalayan salt does not have an effect on taste, but adds hardness to the structure. The palpable salt taste of cheeses using Himalayan salt was found to be very high. Although the same amount of salt was used, it was determined that the samples using Himalayan salt had an intense salt taste compared to the control group. A dramatic decrease was observed in the texture scores of all samples during storage. This result can be explained by the softening in the structure of samples because of the proteolytic activity. The application of different salt type might have been effective in the proteolytic activity [27].

CONCLUSION

In this study, the effects of the use of Himalayan salt in cheese brine on the sensory, structural and physicochemical properties of cheese were investigated. There was no significant difference between the physicochemical properties of the sample groups, except for the acidity and salt ratios. M17 agar count results were found to be high in samples using red Himalayan salt, and it is thought that the mineral content of Himalayan salt affects the growth of microorganisms. The addition of Himalayan salt caused an increase in the viscoelastic solid character of the samples. There are many diseases due to excessive salt consumption, and studies on reducing sodium content in products have gained momentum in recent years. In this context, it has been seen that the use of Himalayan salt in cheese brines is a good alternative. The results of this study suggested that the using of Himalayan salt could improve rheological properties of the white cheese samples without significant changing in sensorial and physicochemical properties.

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

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