Effect of Thyme and Garlic Aromatic Waters on Microbiological Properties of Raw Milk Cheese

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In the present study, it was aimed to investigate the effect of brine solutions containing thyme and garlic extracts on physicochemical, microbiological and textural properties of Turkish white cheese made from raw milk during ripening. For this aim, garlic aromatic water (GAW), thyme hydrosol (TH) or their mixture (1:1 v/v) were incorporated into the brine with different salt concentrations (10%, 13% and 16%) at the ratio of 10% and used in the cheese ripening for 90 days. Addition of TH and GAW into the brine caused higher acidity and lower pH values while increase in salt level resulted in higher dry matter (DM) of cheese. Counts of total mesophilic aerobic bacteria (TMAB), yeast-mold (YM), lactoccocci and lactobacilli were fluctuatingly influenced from brine combinations while coagulase positive staphylococci was completely inhibited during the ripening. In general, TH, GAW or their mixture increased hardness, gumminess and chewiness of the cheese at the 1st day while cohesiveness, resilience and springiness values were not significantly (P>0.05) affected.

Key Words: White cheese, ripening, garlic, thyme, aromatic water

Kekik ve Sarımsak Aromatik Sularının Çiğ Süt Peynirinin Mikrobiyolojik Özellikleri Üzerindeki Etkisi

Bu çalışmada, çiğ sütten yapılan Türk beyaz peynirinin olgunlaşma süresince fizikokimyasal, mikrobiyolojik ve tekstürel değişimleri üzerinde kekik ve sarımsak ekstraktı içeren salamura solüsyonlarının etkisinin belirlenmesi amaçlanmıştır. Bu amaçla, sarımsak aromatik suyu (SAS), kekik hidrosolü (KH) ve bunların karışımları (1:1 h/h); farklı tuz konsantrasyonlarındaki (%10, %13 ve %16) salamuralara %10 oranında ilave edilmiş ve peynirin 90 gün boyunca olgunlaşmasında kullanılmıştır. KH ve SAS'nin salamuraya ilavesi daha yüksek asitlik ve daha düşük pH değerlerine sebep olurken artan tuz düzeyi peynirin daha yüksek kuru maddeye (KM) sahip olmasına neden olmuştur. Toplam mezofilik aerobik bakteri (TMAB), maya-küf (MK), lactokoklar ve lactobasiller; salamura kombinasyonlarından değişik düzeylerde etkilenmiş, koagülaz pozitif stafilokoklar ise olgunlaşma sırasında tamamen inhibe olmuştur. Genel olarak, KH, SAS ve bunların karışımları, depolamanın 1. gününde peynirin sertlik, sakızımsılık ve çiğnenebilirlik özelliğini artırırken elastikiyet ve esneklik önemli düzeyde (P>0,05) etkilenmemiştir.

Anahtar kelimeler: Beyaz peynir, olgunlaştırma, sarımsak, kekik, aromatik su

Introduction

Turkey is located in a fortunate area in terms of the high diversity of cheese varieties. Although more than 50 cheese varieties are available in Turkey, Beyaz (white), Tulum and Kashar cheeses dominates this market (Hayaloglu et al., 2007). Among these cheese varieties, white cheese is the most popular one, comprising about 60% of total cheese production of the country (Toufeili and Özer, 2007). White pickled cheese is characterized with its strong acidity and high salt content. Its ripening period in brine ranges from 1 to 12 months (Akın et al., 2003). Production technology of white cheese is similar to that of Feta cheese and it is mainly produced by raw of pasteurized cow's milk, ewe's milk or their mixture.

Although many cheese varieties are commercially produced using heat-treated milk, raw milk cheeses have long been produced by many communities due to their intense and strong aroma and flavor as compared to those produced from heat treated milks (Masoud et al., 2012). A number of groups of microorganisms including *Lactococcus*, *Lactobacillus*, *Leuconostoc*,

Enterococcus, *Streptococcus*, *Micrococcus*, *Staphylococcus*, *Arthrobacter*, *Corynebacterium*, *Brevibacterium*, *Enterobacter*, *Citrobacter* and *Acinetobacter* that have been isolated from raw milk cheeses have been supposed to contribute to their characteristic aroma and flavor formation (Verdier-Metz et al., 2009; Randazzo et al., 2002; Casalta et al., 2009; Gelsomino et al., 2002). On the other hand, higher amounts and diversity of volatile compounds have been detected in raw milk cheeses as compared to pasteurized cheeses (Fernandez-Garcia et al., 2002; Ocak et al., 2015). In addition to aroma, natural microbiota found in the milk also contributes to the other sensory characteristics such as flavor and texture of raw milk cheeses (Yoon et al., 2016).

In the case of dairy products, pasteurization of milk is the basic treatment performed in order to eliminate pathogenic bacteria from the final product. However, although it is assumed that indigenous bacteria and/or ripening in brine could inhibit or inactivate pathogens during ripening of raw milk cheeses (Brooks et al., 2012), these products are generally considered as risky because of the possible contamination of pathogens (Rudolf and Scherer, 2001; Masoud et al., 2012). Several foodborne pathogens such as *Staphylococcus aureus, Escherichia coli* O157:H7 and *Listeria monocytogenes* inoculated to milk have been shown to survive during processing, ripening and/or storage of raw milk cheeses (Masoud et al., 2012; Lindqvist et al., 2002; Bachmann and Spahr, 1995; Morgan et al., 2001).

In recent years, use of synthetic additives in foods has been suspected by consumers and food manufacturers due to their proven and/or potential negative effects on health. Therefore, interest to natural additives and their use in food systems have been increased. Aromatic plants such as garlic and thyme and their extracts have been well demonstrated to have strong antimicrobial activity (Burt, 2004) and successfully been incorporated with cheese with high consumer acceptability (Hayaloglu and Fox, 2008; Leuschner and Ielsch, 2003; Gammariello et al., 2008). In this study, white cheese made from raw cow's milk were ripened in brine solutions containing thyme (*Thymus vulgaris* L.) hydrosol (TH) and garlic (*Allium sativum* L.) aromatic water (GAW) and salt (10%, 13% or 16%) with different concentrations for 90 days and it was aimed to determine the effects of those plant extracts on physicochemical, microbiological and textural properties of the cheese.

Materials and Methods

Materials

Whole cow's milk that was used in cheese making was daily provided from the cow farm of Center of Agricultural Research of Erciyes University, Kayseri, Turkey. General quality criteria (presence/absence of basic materials, peroxide and antibiotics, pH, brix) were monitored during milk reception. Rennet was purchased from Intermak, Konya, Turkey. Thyme (*Thymus vulgaris* L.) and garlic (*Allium sativum* L.) were provided from a local spice wholesaler (Beyza Baharat Ltd.) in Kayseri, Turkey.

Production of aromatic waters

Production of thyme hydrosol (TH) was carried out using the method of (Ozturk et al., 2012) using Clavenger apparatus. Briefly, 100 g of the dried thyme leaves was placed in the distillation flask and incorporated with 500 mL of distilled water. Then the mixture was hydrodistilled until app. 250 mL of hydrosol was obtained. The obtained hydrosols were stored in amber bottles at 4ºC until use.

In order to obtain garlic aromatic water (GAW), a 100 g of dehulled garlic was weighed and mixed with 1 L of distilled water for 3 min using a kitchen mixer (Tefal, China). Then the mixture was kept in refrigerator for 15min and filtered using rough filter paper. The resulting water was used immediately in the analyses without kept.

Preparation of brine with optimum aromatic water concentration

In preliminary studies, in order to determine the optimum TH and GAW concentration, cheese samples were produced using pasteurized milk and they were kept in brine samples containing different concentrations of TH or GAW up to 50% for 1 week. In the results, the cheese sample that was kept in the brine sample containing 10% TH or GAW had the highest sensorial scores. Finally, brine solutions were produced with different salt concentrations (10%, 13% and 16%). The brine samples were pasteurized at 85ºC for 15 min and incorporated with TH, GAW or their mixture (MIX, 1:1 v:v) with the targeted level of 10%. Pasteurized distilled water was used for the

control sample in order to obtain the same salt concentration.

Raw milk cheese making

Raw milk with desired properties were heated to 37 ºC and 0.015% of calf rennet was added. Then the milk was left to coagulation for 60 min. The resulting curd was cut and following a gently stirring to eliminate whey the curd was pressed for 2 h. After pressing, the cheese was cut into pieces (4x4x8cm). Two kilograms of cheese were weighed and put into the plastic containers. Then the brine solutions (1 L) were added into the containers. Raw milk cheese samples were stored at 4±1 ºC for 90 days.

Analyses

The cheese samples were subjected to the analyses at 0^{th}, 15^{th}, 30^{th}, 60^{th} and 90^{th} days of the storage.

Physicochemical analyses

pH values were measured by direct immersion of the probe of the pH meter (Hanna Instruments, USA) into the cheese from 3 different places (Kurt et al., 1996). In order to determine titratable acidity, 10 g of cheese sample was mixed with 90 mL of distilled water and finely homogenized. Following addition of phenolphthalein, the mixture was titrated with 0.1 N NaOH until the permanent pink color. The results were expressed as percent lactic acid. Dry matter was determined by gravimetric method. Total fat was measured following Van Gulic method (ISO, 2008). Percent fat in dry matter (FDM) was calculated after determination of the dry matter content. Salt contents of the cheese samples were determined by Mohr method (Kurt et al., 1996). Ash contents were determined by ashing the samples to constant weight at 550°C (Kurt et al., 1996).

Textural profile analysis

Textural profile analysis (TPA) of the cheese samples was performed using a texture analyzer (TA.XT Plus, Stable Micro Systems Ltd., UK). Cylinder probe with 2 cm diameter was used as probe. Compression speed and total processing time was set as 1 mm/s and 10 s, respectively. The test was performed by compressing 25% of the original size of the cubic cheese samples (2x2x2cm). According to the TPA technique, two sequential compressions were performed and the parameters were measured.

Microbiological analyses

The cheese samples were analyzed in terms of total mesophilic aerobic bacteria (TMAB), total lactobacilli (LB), total lactococci (LC), total yeast-mold (YM), total coliform (TC), *Staphylococcus aureus, Listeria monocytogenes* and *Escherichia coli* O157:H7. For this aim, 10 g of cheese sample was incorporated with Maximum Recovery Diluent (MRD) solutions and serial dilutions were prepared. Plate Count Agar (PCA, Merck, Germany), De Man, Ragosa and Sharp Agar (MRS, Merck, Germany), M17 Agar, Dichloran Rose Bengal Chromphenicol Agar (DRBC, Merck, Germany), Violet Red Bile Agar (VRB, Merck, Germany), Baird Parker Agar (BPA, Merck, Germany) and Oxford Listeria Selective Agar were used for enumeration of TMAB, LB, LC, YM, TC, *S. aureus* and *L. monocytogenes,* respectively. For enumeration of *E. coli* O157:H7, pre-enrichment was performed using mEC broth with novobiocin (Merck, Germany) and SMAC Agar was used. Spread plate technique was performed for determination the microbial counts. Incubation procedures were carried out using the instructions described by Roberts and Greenwood (2003). Results were converted to logarithmical values.

Statistical analysis

Two-way analysis of variance was performed using Windows based statistical analysis software (S.A.S. 8.2, SAS Institute, USA). In order to determine the statistical differences between the data, Duncan's multiple range test were used at 95% significance level. The analyses were carried out in duplicate.

Results and Discussion

Physicochemical properties

In this study, several physicochemical properties of cheese that was made from raw milk and stored at brines containing different concentrations of GAW, TH and their mixture were determined, as seen in Table 1. Significant changes ($P<0.05$) in pH levels occurred by one day of storage. The pH levels of the samples varied from 5.39 and 5.62 while TH13 (containing 10%

TH and 13% salt) had the lowest (P<0.05) pH level at the 1st day. In the meanwhile, ongoing decreases were observed during the storage. At the end of the storage, C10 (control sample stored in the brine containing 10% salt) had the lowest (P<0.05) pH values. At this time, increase in salt concentration enabled higher levels of pH levels while hydrosol and aromatic water did not make a certain effect.

Çizelge 1. Farklı salamura kombinasyonlarında depolanan çiğ süt peynirlerinin fizikokimyasal özellikleri

Table 1. Physicochemical properties of raw milk cheese stored at different brine combinations

pH	Storage (Day)				
	1	15	30	60	90
C10*	5.62±0.01^{aA}	5.39±0.01^{fB}	4.79±0.03^{gC}	4.74±0.02^{gDC}	4.71±0.01^{fD}
C13	5.63±0.00^{aA}	5.49±0.03^{edB}	5.00±0.01^{edC}	4.94±0.01^{eD}	4.90±0.01^{dE}
C16	5.52±0.01^{edB}	5.55±0.01^{bcA}	5.04±0.01^{bacC}	4.99±0.01^{bD}	4.96±0.01^{baE}
GAW10	5.53±0.01^{cdA}	5.52±0.01^{ecdA}	4.95±0.01^{fB}	4.90±0.01^{eC}	4.87±0.01^{eD}
GAW13	5.59±0.02^{baA}	5.58±0.01^{baA}	4.98±0.01^{eB}	4.94±0.01^{bC}	4.91±0.01^{dD}
GAW16	5.48±0.00^{eB}	5.61±0.02^{aA}	5.05±0.01^{bCa}	4.98±0.01^{bD}	4.96±0.01^{baE}
TH10	5.56±0.01^{bcdA}	5.54±0.02^{bcA}	5.01±0.01^{edcB}	4.95±0.01^{ecdC}	4.91±0.01^{dD}
TH13	5.39±0.01^{fB}	5.51±0.02^{ecdA}	5.06±0.02^{aC}	5.02±0.01^{aD}	4.97±0.01^{aE}
TH16	5.60±0.02^{baA}	5.62±0.01^{aA}	5.04±0.01^{bacB}	5.00±0.01^{baC}	4.97±0.01^{aC}
M10	5.61±0.04^{baA}	5.53±0.01^{bcdB}	5.04±0.01^{baC}	4.98±0.01^{bcD}	4.95±0.01^{bcE}
M13	5.42±0.01^{fA}	5.43±0.01^{fA}	5.02±0.00^{bdcB}	4.95±0.00^{edC}	4.91±0.01^{dD}
M16	5.57±0.02^{bcA}	5.48±0.03^{eB}	5.04±0.01^{bacC}	4.97±0.01^{bcdD}	4.94±0.01^{cE}
Titration Acidity (%)	1	15	30	60	90
C10	0.74±0.00^{dD}	1.34±0.01^{aC}	1.44±0.01^{aB}	1.52±0.02^{aA}	1.54±0.02^{aA}
C13	0.74±0.01^{dE}	1.20±0.00^{bD}	1.18±0.01^{bC}	1.16±0.01^{bB}	1.14±0.01^{cA}
C16	0.74±0.00^{dE}	0.94±0.01^{fD}	0.91±0.01^{hC}	0.86±0.01^{fB}	0.82±0.01^{iA}
GAW10	0.79±0.02^{cC}	1.05±0.04^{dB}	1.10±0.01^{cB}	1.16±0.01^{bA}	1.18±0.01^{bA}
GAW13	0.76±0.01^{dcD}	1.11±0.01^{cA}	1.06±0.01^{dB}	1.01±0.01^{cC}	1.00±0.02^{dC}
GAW16	0.85±0.01^{bC}	0.91±0.01^{fB}	0.90±0.00^{hB}	0.90±0.01^{eB}	0.93±0.01^{gfA}
TH10	0.89±0.01^{aE}	1.22±0.01^{bA}	1.10±0.01^{cB}	0.99±0.01^{cC}	0.96±0.01^{efD}
TH13	0.90±0.02^{aD}	1.00±0.01^{eA}	0.96±0.01^{gBA}	0.95±0.00^{dBC}	0.92±0.01^{gDC}
TH16	0.76±0.01^{dcE}	1.06±0.02^{dA}	1.00±0.02^{fB}	0.91±0.01^{eC}	0.87±0.01^{hD}
M10	0.89±0.01^{aD}	1.25±0.01^{bA}	1.11±0.01^{cBC}	0.95±0.02^{d}	0.94±0.01^{gfC}
M13	0.88±0.01^{baC}	1.03±0.01^{edA}	1.03±0.01^{eA}	1.02±0.02^{cA}	0.98±0.00^{edB}
M16	0.74±0.00^{dE}	1.02±0.01^{edA}	0.95±0.01^{gB}	0.81±0.01^{gC}	0.83±0.01^{iD}
DM (%)	1	15	30	60	90
C10	35.44±0.04^{eA}	35.41±0.03^{hA}	35.29±0.12^{hA}	35.25±0.21^{gA}	35.44±0.39^{gA}
C13	38.78±0.03^{cA}	36.99±0.36^{gB}	36.10±0.34^{gC}	34.99±0.12^{gD}	35.13±0.30^{gD}
C16	40.65±0.35^{baA}	40.63±0.20^{bA}	40.79±0.22^{cA}	40.58±0.59^{bA}	40.24±0.10^{bA}
GAW10	38.49±0.17^{cA}	38.42±0.29^{deBA}	38.11±0.04^{feBAC}	37.64±0.36^{edC}	37.82±0.21^{edBC}
GAW13	38.55±0.12^{cA}	38.28±0.29^{feA}	37.39±0.18^{fA}	37.51±1.12^{edA}	37.54±0.27^{efA}
GAW16	40.62±1.22^{baC}	41.12±0.31^{bBC}	42.29±0.47^{bBAC}	42.85±0.65^{aBA}	43.45±0.42^{aA}
TH10	38.64±0.73^{cA}	39.07±0.20^{dcA}	38.22±0.10^{eA}	37.06±0.07^{efB}	36.88±0.10^{fB}
TH13	39.66±0.25^{bacA}	37.53±0.10^{gB}	36.41±0.18^{gC}	35.87±0.47^{gfDC}	35.38±0.15^{fD}
TH16	40.82±0.20^{aA}	39.55±0.38^{cB}	39.43±0.08^{dB}	39.50±0.64^{cbB}	39.38±0.35^{cbB}
M10	36.92±0.49^{dC}	37.62±0.22^{fgC}	38.58±0.14^{eB}	39.51±0.16^{cbA}	39.37±0.14^{cbA}
M13	39.29±0.30^{bcA}	38.61±0.24^{deA}	38.61±0.14^{eA}	38.66±0.38^{cdA}	38.59±0.37^{cdA}
M16	40.52±0.56^{baC}	42.09±0.09^{aB}	43.37±0.52^{aBA}	44.00±0.67^{aA}	43.76±0.50^{aA}

$^{a-g}$: Different letters in the same column indicate significant difference (P<0.05) between the results; $^{A-E}$: Different letters in the same line indicate significant difference (P<0.05) between the results; DM: Dry matter; C: Control; GAW: Garlic aromatic water; TH: Thyme hydrosol; M: Mixture of garlic aromatic water and thyme hydrosol; The numbers present in the samples state salt concentration of the brine.

Çizelge 1 (devam). Farklı salamura kombinasyonlarında depolanan çiğ süt peynirlerinin fizikokimyasal özellikleri

Table 1 (continued). Physicochemical properties of raw milk cheese stored at different brine combinations

Fat (%)	Storage (Day)				
	1	15	30	60	90
C10	18.47±0.06^{fA}	18.47±0.06^{eA}	18.47±0.06^{fA}	17.83±0.12^{fB}	18.43±0.12^{eA}
C13	20.00±0.44^{bcA}	19.07±0.35^{edBA}	18.67±0.21^{efB}	17.60±0.46^{fBC}	18.43±0.40^{eC}
C16	21.10±0.26^{aA}	21.10±0.20^{aA}	21.10±0.26^{aA}	20.50±0.10^{aA}	20.93±0.31^{aA}
GAW10	20.07±0.25^{bcA}	20.07±0.29^{bcA}	19.90±0.10^{bdcA}	19.03±0.12^{dcB}	19.67±0.12^{dcA}
GAW13	19.80±0.20^{dcA}	19.47±0.76^{dcA}	19.03±0.64^{edfA}	18.90±0.50^{dceA}	19.23±0.45^{dceA}
GAW16	19.53±0.31^{dcC}	19.77±0.15^{bdcBC}	20.33±0.32^{bacBA}	20.00±0.26^{baBC}	20.73±0.21^{baA}
TH10	19.50±0.30^{dcA}	19.70±0.26^{bdcA}	19.30±0.10^{edfA}	18.20±0.10^{feB}	18.60±0.10^{eB}
TH13	20.67±0.12^{baA}	19.57±0.21^{dcB}	18.97±0.15^{efC}	18.13±0.35^{feDC}	18.47±0.21^{eD}
TH16	21.23±0.25^{aA}	20.57±0.35^{baBA}	20.50±0.10^{baBA}	20.10±0.30^{baB}	20.53±0.32^{baBA}
M10	18.70±0.26^{feC}	19.07±0.25^{edBC}	19.53±0.21^{edcBA}	19.43±0.15^{bcBA}	19.97±0.15^{bcA}
M13	19.13±0.23^{dfeA}	18.80±0.30^{edA}	18.80±0.40^{efA}	18.33±0.31^{dfeA}	18.83±0.40^{deA}
M16	19.43±0.32^{dceB}	20.17±0.29^{bacBA}	20.80±0.46^{aA}	20.47±0.23^{aA}	20.87±0.38^{aA}
Fat in DM (%)	1	15	30	60	90
C10	52.10±0.11^{aA}	52.15±0.15^{aA}	52.34±0.22^{aA}	50.59±0.10^{baB}	52.02±0.41^{bacA}
C13	51.57±1.16^{aA}	51.56±1.42^{aA}	51.71±1.06^{aA}	50.30±1.14^{baA}	52.47±0.76^{aA}
C16	51.91±0.53^{aA}	51.94±0.74^{aA}	51.73±0.42^{aA}	50.53±0.71^{baA}	52.02±0.75^{bacA}
GAW10	52.14±0.66^{aA}	52.23±0.40^{aA}	52.21±0.28^{aA}	50.57±0.34^{baB}	52.00±0.38^{bacA}
GAW13	51.36±0.67^{aA}	50.85±1.64^{aA}	50.90±1.48^{aA}	50.39±0.38^{baA}	51.23±0.87^{bacA}
GAW16	48.10±0.70^{Ba}	48.07±0.14^{cA}	48.08±0.23^{cA}	46.68±0.25^{cB}	47.72±0.02^{eA}
TH10	50.47±0.21^{aA}	50.42±0.42^{baA}	50.50±0.35^{baA}	49.12±0.19^{bB}	50.44±0.36^{dcA}
TH13	52.10±0.18^{aA}	52.14±0.42^{aA}	52.10±0.59^{aA}	50.55±0.38^{baB}	52.19±0.46^{baA}
TH16	52.02±0.38^{aA}	52.00±0.42^{aA}	51.99±0.32^{aA}	50.88±0.07^{aB}	52.14±0.35^{baA}
M10	50.66±0.38^{aA}	50.68±0.41^{baA}	50.62±0.45^{baA}	49.18±0.30^{bB}	50.72±0.49^{bcA}
M13	48.70±0.91^{bA}	48.69±0.92^{bcA}	48.69±0.94^{bcA}	47.42±0.80^{cA}	48.81±0.92^{edA}
M16	47.96±0.19^{bA}	47.92±0.62^{cBA}	47.96±0.64^{cA}	46.52±0.65^{cB}	47.69±0.32^{eBA}
Salt (%)	1	15	30	60	90
C10	2.65±0.05^{hgD}	3.15±0.02^{gC}	3.22±0.01^{eBC}	3.31±0.02^{gBA}	3.32±0.06^{fA}
C13	3.82±0.03^{cD}	4.11±0.03^{fC}	4.20±0.02^{dcCB}	4.28±0.04^{eB}	4.38±0.06^{dcA}
C16	4.03±0.06^{aE}	4.69±0.02^{cD}	4.83±0.02^{aC}	5.00±0.02^{aB}	5.20±0.06^{aA}
GAW10	2.71±0.01^{gD}	3.17±0.02^{gC}	3.20±0.02^{eBC}	3.24±0.01^{hgBA}	3.27±0.02^{fA}
GAW13	3.60±0.00^{dD}	4.21±0.00^{eA}	4.14±0.01^{dB}	4.16±0.01^{fBC}	4.12±0.03^{eC}
GAW16	3.91±0.02^{bC}	4.83±0.03^{bB}	4.83±0.03^{aB}	4.89±0.01^{bA}	4.89±0.02^{bA}
TH10	2.82±0.03^{fD}	3.14±0.03^{gC}	3.21±0.01^{eB}	3.25±0.01^{hgBA}	3.29±0.03^{fA}
TH13	3.62±0.03^{dE}	4.08±0.03^{fD}	4.23±0.02^{cC}	4.36±0.02$_{dB}$	4.43±0.03^{cA}
TH16	4.01±0.01^{aB}	4.90±0.02^{aA}	4.88±0.04^{aA}	4.85±0.04^{bA}	4.89±0.04^{bA}
M10	2.61±0.02^{hB}	3.19±0.02^{gA}	3.21±0.03^{eA}	3.23±0.03^{hA}	3.21±0.06^{fA}
M13	3.42±0.03^{eC}	4.10±0.00^{fB}	4.15±0.03^{dB}	4.25±0.02^{eA}	4.26±0.06^{dA}
M16	3.81±0.02^{cE}	4.43±0.03^{dD}	4.55±0.03^{bC}	4.75±0.05^{cB}	4.97±0.06^{bA}

$^{a\text{-}g}$: Different letters in the same column indicate significant difference (P<0.05) between the results; $^{A\text{-}E}$: Different letters in the same line indicate significant difference (P<0.05) between the results; DM: Dry matter; C: Control; GAW: Garlic aromatic water; TH: Thyme hydrosol; M: Mixture of garlic aromatic water and thyme hydrosol; The numbers present in the samples state salt concentration of the brine.

Çizelge 1 (devam). Farklı salamura kombinasyonlarında depolanan çiğ süt peynirlerinin fizikokimyasal özellikleri

Table 1 (continued). Physicochemical properties of raw milk cheese stored at different brine combinations

Ash (%)	Storage (Day)				
	1	15	30	60	90
C10	3.17±0.07^{fC}	3.81±0.04^{gB}	3.89±0.05^{edBA}	3.96±0.07^{cBA}	4.01±0.04^{feA}
C13	4.41±0.06^{bcA}	4.44±0.60^{efdA}	4.88±0.06^{bA}	4.68±0.59^{bA}	5.12±0.09^{cA}
C16	4.61±0.04^{baE}	5.42±0.04^{baD}	5.54±0.04^{aC}	5.74±0.03^{aB}	5.99±0.05^{aA}
GAW10	3.42±0.05^{eB}	4.03±0.08^{efdA}	4.07±0.09^{dA}	4.13±0.07^{cA}	4.17±0.08^{eA}
GAW13	4.33±0.04^{cB}	5.08±0.04^{bcA}	4.96±0.06^{bA}	5.04±0.05^{bA}	4.96±0.07^{dcA}
GAW16	4.01±0.03^{dB}	4.91±0.06^{bcdA}	4.91±0.05^{bA}	4.98±0.05^{bA}	5.00±0.04^{dcA}
TH10	3.32±0.06^{feB}	3.76±0.06^{gA}	3.77±0.03^{eA}	3.80±0.04^{cA}	3.84±0.03^{fA}
TH13	3.93±0.10^{dD}	4.55±0.06^{ecdC}	4.65±0.06^{cBC}	4.78±0.04^{bBA}	4.91±0.05^{dcA}
TH16	4.73±0.06^{aB}	5.75±0.06^{aA}	5.69±0.05^{aA}	5.75±0.05^{aA}	5.75±0.06^{bA}
M10	3.21±0.04^{feB}	3.90±0.05^{fgA}	3.94±0.06^{edA}	4.00±0.06^{cA}	3.99±0.04^{feA}
M13	3.87±0.19^{dB}	4.59±0.13^{cdA}	4.77±0.14^{cbA}	4.87±0.18^{bA}	4.89±0.17^{dA}
M16	4.64±0.06^{baD}	5.45±0.06^{baC}	5.54±0.08^{aC}	5.83±0.05^{aB}	6.06±0.05^{aA}

$^{a-g}$: Different letters in the same column indicate significant difference (P<0.05) between the results; $^{A-E}$: Different letters in the same line indicate significant difference (P<0.05) between the results; DM: Dry matter; C: Control; GAW: Garlic aromatic water; TH: Thyme hydrosol; M: Mixture of garlic aromatic water and thyme hydrosol; The numbers present in the samples state salt concentration of the brine.

Watkinson *et al.* (2001) found that initial pH levels of semi-hard cheese samples (2 days old) were ranging from 5.20 and 6.22, that was relatively in accordance with our results. Öner et al. (2006) also reported that pH levels of Turkish type white cheese showed decrease up to 90 days of ripening while initial pH level was also lower than our pH findings. Considering titration acidity, the fastest increase was observed at the sample coded as C10 during the storage. Increasing salt concentration and incorporation of TH, GAW or their mixture provided lower levels of acidity at the end of the storage (Table 1) while M16 and C16 samples had the lowest (P<0.05) final titration acidity levels. Titration acidity values of the cheese samples were correlated with their pH levels. Higher acidity values were observed by Öner et al. (2006), probably due to the production of more acidic cheese.

Dry matter (DM) contents of the raw milk cheese samples ripened in brines containing TH, GAW and their mixture were shown in Table 1. In the first day, salt concentration of the brine was the most efficient factor affecting the DM levels, indicating that increasing salt concentration caused higher water diffusion from cheese (Kasımoğlu et al., 2004). DM of the samples ranged from 35.44% (C10) to 40.82% at the first day. G16, M10 and M16 had higher (P<0.05) DM contents at the end of the storage than at 1st day while presence of the aromatic waters/hydrosols in the brine did not make a direct effect on DM contents. Salt concentration is the main determinant for change in moisture contents of cheeses during ripening in brine. Because NaCl moves from the brine into the cheese structure as a result of osmotic pressure and thereby causing increase in DM of cheese. This action continues until the osmotic pressure equilibrium (Guinee and Fox, 1993). Our findings support this phenomenon. Turkish Food Codex (2015) specifies that DM content of brine ripened cheeses must be minimum 40%, indicating that DM levels of the cheese samples ripened in brines with lower levels of salt concentration were not in conformity with the codex.

Fat levels of the cheese samples ranged from 18.47% to 21.23% at the 1st day of the storage (Table 1). Increasing salt level in brine cause higher (P<0.05) fat content, as expected. Changes in fat contents were not more than 2% during the storage while some of them were statistically significant (P<0.05). Fat in DM (FDM) is another important parameter that gives idea about the quality of cheese. Increase of brine salt concentration caused decrease the FDM of the cheese samples except for the samples ripened in TH supplemented brines. According to Turkish Food Codex (2015), cheese samples FDM levels of which are higher than 45% are considered as full fat products. In this study, all the samples had minimum 47% FDM levels during their storage

period in brine for 90 days. Our findings were in accordance with the reports of Öner et al. (2006).

Ash contents of the cheese samples followed a similar trend to their salt contents during the storage, as seen in Table 1. Extending storage of the cheese in the brine increased the ash concentration. C16 and M16 samples had the highest (P<0.05) ash contents at 90th day. The samples had initial salt levels ranging from 2.65% to 4.03% while they increased significantly (P<0.05) depending on the extending storage period and increasing brine salt concentration (Table 1). At the end of the storage C16 sample had the highest (P<0.05) salt content. The cheese samples were in accordance with Turkish Food Codex (2015) in terms of their salt contents. Salt plays important role in many aspects of cheese. The first role of salt is its contribution to minimization of spoilage and pathogenic bacteria. It also contributes textural and sensory properties of cheese (Guinee and Fox, 1993).

Microbiological properties

In this study, microbiological properties, namely populations of total mesophilic aerobic bacteria (TMAB), total coliform (TC) bacteria, total yeast-mold (TYM), coagulase positive *Staphylococcus aureus* (CPSA), *Lactobacillus* spp. and *Lactococcus* spp. present in the cheese samples stored at the brines containing different levels of salt and hydrosol types were determined. The results are indicated in Table 2. As known, raw milk can be contaminated with foodborne pathogens by several ways such as udders of infected animals, contamination from the dairy environment and processing facilities (Jakobsen et al., 2011). Contamination of milk with several pathogens such as *Listeria monocytogenes* and *S. aureus* has been reported by previous researchers (D'Amico and Donnelly, 2010; Moshtaghi and Mohamadpour, 2007; Jayarao et al., 2006). In this study, *Clostridium perfringens, L. monocytogenes* and *E. coli* O157:H7 were not detected in the raw milk and cheese samples produced in any stage of processing and ripening.

TMAB counts of the cheese samples ranged from 7.42 to 9.09 log at the 1st day of the storage while they were all between 7 and 8 logs at the 90th day. The supplementation of TH, GAW or their mixture into the brine did not significantly (P>0.05) affect TMAB counts (Table 1). In TC counts, significant (P>0.05) decreases were observed during the storage for all the samples. The highest inhibition occurred in the sample M16 with the inhibition effect of thyme and garlic. Considering yeast-mold counts, the population of the samples GAW10 and GAW13 was completely inhibited within the storage for 60 days. Other samples stored in the brines containing GAW, TH or their mixture (1:1 v:v) had higher (P<0.05) yeast-mold counts at the end of the storage than at the 1st day (Table 1). Population of coagulase positive staphylococci decreased significantly (P<0.05) during the storage and was under detection limits as from the 60th day for all samples.

When checking the results about the Lactobacillus sp. population that was indicated in Table 1, it could be seen that significantly (P<0.05) higher numbers for the samples (C16, TH16, GAW16 and M16) stored in the brine with the salt concentration of 16% were observed as compared to the samples containing lower levels of salt. However, higher reductions (P<0.05) on *Lactobacillus* population were observed at those samples during the storage. The lowest population (5.75 log) was belonging to the sample C16 at the end of the storage. In the case of *Lactococcus* spp., the initial population ranged from 6.51 to 7.04 log while significant increases (P<0.05) occurred within the storage period except for the population of one sample (C16).

Microbiological properties of cheese can differ depending on various factors such as processing conditions, cheese composition, initial microbial load, salt concentration of brine, length and temperature of ripening etc. In this study, counts of TMAB and YM were fluctuant while TC, *Staphylococcus* and *Lactobacillus* numbers decreased during ripening. On the other hand, *Lactococcus* was the unique group of microorganisms increasing the population and predominating the media. Öner et al. (2006) found that altough all microbial groups (TMAB, TC, YM, TPAB (total psychrophilic aerobic bacteria), lactococci and lactobacilli) continued their presence in cheese, microbial counts proggressively decreased during ripening. Manolopoulou et al. (2003) investigated change in microbial population of traditional Feta cheese produced in 3 different dairies during whole ripening period. They found that thermophilic cocci, mesophilic lactococci, thermophilic lactobacilli, nonstarter lactic acid bacteria, presumptive *Leuconostoc*, enterococci and micrococci reached their highest levels during the first 16 days and then declined approximately 1–2 log units until the end of ripening while the

remaining groups (yeasts, coliforms and *Escherichia coli*) were the highest at day 4.

Çizelge 2. Farklı salamura kombinasyonlarında depolanan çiğ süt peynirlerinin mikrobiyolojik özellikleri

Table 2. Microbiological properties of raw milk cheese stored at different brine combinations

TMAB	Microbiological population (log 10 cfu/g)				
	1st day	15th day	30th day	60th day	90th day
C10	7.44±0.04^{fD}	7.91±0.02^{baA}	7.46±0.03^{baDC}	7.51±0.04^{aC}	7.79±0.01^{cbB}
C13	7.56±0.03^{efA}	7.56±0.04^{gA}	7.44±0.03^{bacB}	7.48±0.08^{baBA}	7.44±0.04^{fB}
C16	8.11±0.10^{cA}	7.64±0.05^{gfB}	5.92±0.03^{fC}	5.96±0.04^{gC}	7.68±0.04^{edB}
GAW10	8.62±0.03^{bA}	7.80±0.04^{dcB}	7.32±0.02^{baC}	7.40±0.05^{bdacC}	7.78±0.03^{cbB}
GAW13	7.42±0.03^{fB}	7.78±0.02^{dceA}	7.46±0.04^{dcC}	7.35±0.05^{bdcC}	7.83±0.03^{bA}
GAW16	9.09±0.09^{aA}	7.63±0.04^{gfC}	7.41±0.03^{bdacD}	7.44±0.04^{bacD}	7.72±0.03^{cdB}
TH10	7.55±0.05^{efB}	7.68±0.02^{feA}	7.50±0.05^{aB}	7.42±0.03^{bdacB}	7.42±0.03^{fC}
TH13	7.67±0.06^{edB}	7.70±0.05^{dfeB}	7.31±0.03^{dC}	7.34±0.02^{dcC}	7.84±0.04^{bA}
TH16	7.83±0.15^{dA}	7.81±0.03^{bcA}	7.19±0.07^{eCB}	7.14±0.04^{fC}	7.32±0.02^{gB}
M10	7.49±0.05^{efC}	8.01±0.03^{aA}	7.41±0.03^{dD}	7.30±0.05^{deD}	7.93±0.03^{aB}
M13	7.53±0.03^{efB}	7.66±0.05^{gfA}	7.38±0.03^{bdcC}	7.39±0.07^{bdacC}	7.49±0.01^{fB}
M16	9.09±0.09^{aA}	7.39±0.03^{hC}	7.18±0.03^{eD}	7.17±0.04^{feD}	7.60±0.02^{eB}
Total coliform	1st day	15th day	30th day	60th day	90th day
C10	6.18±0.00^{dB}	5.42±0.06^{cbE}	6.48±0.05^{aA}	5.71±0.02^{gC}	5.55±0.05^{aD}
C13	6.83±0.07^{bacB}	5.38±0.07^{cbC}	4.73±0.12^{fD}	7.13±0.04^{bA}	4.78±0.03^{fD}
C16	7.28±0.04^{aA}	5.45±0.05^{cbC}	5.01±0.06^{eD}	7.09±0.09^{bB}	4.77±0.02^{fE}
GAW10	7.23±0.06^{baA}	4.82±0.13^{dD}	4.31±0.05^{bB}	5.68±0.03^{gC}	4.75±0.03^{fD}
GAW13	6.78±0.03^{bacA}	4.30±0.04^{eE}	6.21±0.04^{cC}	6.32±0.02^{eB}	5.16±0.01^{cD}
GAW16	7.31±0.02^{aA}	4.15±0.15^{eD}	5.22±0.05^{cB}	7.31±0.03^{aA}	5.04±0.04^{dC}
TH10	6.85±0.04^{bacA}	4.90±0.05^{dE}	5.39±0.07^{cD}	6.65±0.05^{cB}	5.49±0.01^{aC}
TH13	6.67±0.06^{dcA}	5.51±0.06^{bC}	5.36±0.03^{cD}	6.49±0.01^{dB}	4.88±0.03^{eE}
TH16	6.73±0.04^{bcB}	5.24±0.11^{cC}	4.18±0.03^{gD}	7.35±0.05^{aA}	5.18±0.03^{cC}
M10	6.17±0.02$^{d\ B}$	5.39±0.06^{cbC}	4.31±0.05^{gE}	6.35±0.05^{eA}	5.27±0.03^{bD}
M13	6.83±0.07^{bacA}	5.89±0.11^{aD}	6.10±0.05^{bC}	6.71±0.02^{cB}	4.88±0.03^{eE}
M16	7.16±0.61^{bacA}	5.33±0.08^{cbC}	5.10±0.10^{deDC}	6.01±0.03^{fB}	4.63±0.03^{Ge}
Yeast-mold	1st day	15th day	30th day	60th day	90th day
C10	4.51±0.07^{aB}	4.58±0.06^{aB}	4.74±0.04^{cA}	3.86±0.08^{fC}	3.91±0.01^{gC}
C13	3.55±0.05^{dC}	3.54±0.02^{dC}	5.33±0.02^{bA}	5.07±0.08^{cB}	5.03±0.05^{bB}
C16	4.43±0.06^{aC}	4.44±0.04^{baC}	5.53±0.04^{aB}	5.78±0.04^{aA}	4.13±0.05^{fD}
GAW10	2.95±0.05^{fA}	3.01±0.06^{eA}	2.69±0.09^{gB}	<1.00^{gC}	<1.00^{hC}
GAW13	2.68±0.03^{gB}	2.66±0.05^{fB}	2.89±0.04^{fA}	<1.00^{gC}	<1.00^{hC}
GAW16	2.33±0.02^{iD}	2.08±0.08^{gE}	2.54±0.06^{gC}	5.04±0.04^{cA}	4.38±0.04^{dB}
TH10	4.19±0.06^{bC}	4.28±0.12^{bC}	5.37±0.03^{bA}	5.32±0.04^{bA}	4.63±0.03^{cB}
TH13	2.53±0.03^{hD}	2.53±0.07^{fD}	5.64±0.04^{aA}	5.31±0.02^{bB}	4.64±0.04^{cC}
TH16	4.02±0.08^{cC}	3.99±0.11^{cC}	5.36±0.02^{bB}	3.73±0.04^{fD}	5.50±0.03^{aA}
M10	3.20±0.03^{eB}	3.20±0.03^{eB}	3.07±0.10^{eC}	4.64±0.05^{dA}	4.70±0.03^{cA}
M13	2.53±0.03^{hC}	2.58±0.11^{fC}	4.33±0.03^{dBA}	4.39±0.04^{eA}	4.22±0.04^{feB}
M16	2.73±0.07^{gD}	2.69±0.09^{fD}	4.89±0.06^{cB}	5.36±0.05^{bA}	4.26±0.05^{Ec}

$^{a\text{-}g}$: Different letters in the same column indicate significant difference (P<0.05) between the results; $^{A\text{-}E}$: Different letters in the same line indicate significant difference (P<0.05) between the results; DM: Dry matter; C: Control; GAW: Garlic aromatic water; TH: Thyme hydrosol; M: Mixture of garlic aromatic water and thyme hydrosol; The numbers present in the samples state salt concentration of the brine.

Çizelge 2 (devam). Farklı salamura kombinasyonlarında depolanan çiğ süt peynirlerinin mikrobiyolojik özellikleri

Table 2 (continued). Microbiological properties of raw milk cheese stored at different brine combinations

Coagulase (+)	Microbiological population (log 10 cfu/g)				
Staphylococci	1st day	15th day	30th day	60th day	90th day
C10	5.18±0.01^{fA}	4.19±0.04^{edB}	3.47±0.02^{bC}	<1.00^{aD}	<1.00^{aD}
C13	5.89±0.03^{bA}	3.97±0.07^{fB}	3.74±0.04^{aC}	<1.00^{aD}	<1.00^{aD}
C16	5.32±0.03^{eA}	4.33±0.08^{bcdB}	2.98±0.03^{cC}	<1.00^{aD}	<1.00^{aD}
GAW10	5.24±0.06^{feA}	4.22±0.02^{ecdB}	3.39±0.09^{cC}	<1.00^{aD}	<1.00^{aD}
GAW13	5.80±0.02^{bA}	4.02±0.06^{fB}	3.00±0.00^{bC}	<1.00^{aD}	<1.00^{aD}
GAW16	5.31±0.02^{eA}	4.04±0.04^{fB}	3.40±0.09^{bC}	<1.00^{aD}	<1.00^{aD}
TH10	5.83±0.07^{bA}	4.34±0.02^{bcB}	3.74±0.04^{aC}	<1.00^{aD}	<1.00^{aD}
TH13	5.67±0.06^{cA}	4.52±0.05^{aB}	3.75±0.05^{aC}	<1.00^{aD}	<1.00^{aD}
TH16	6.74±0.04^{aA}	4.29±0.02^{bcdB}	3.01±0.02^{cC}	<1.00^{aD}	<1.00^{aD}
M10	5.20±0.04^{feA}	4.31±0.01^{bcdB}	3.37±0.09^{bC}	<1.00^{aD}	<1.00^{aD}
M13	5.86±0.03^{bA}	4.38±0.06^{baB}	3.39±0.09^{bC}	<1.00^{aD}	<1.00^{aD}
M16	5.51±0.03^{dA}	4.10±0.05^{efB}	2.99±0.01^{cC}	<1.00^{aD}	<1.00^{aD}
Lactobacillus					
sp.	1st day	15th day	30th day	60th day	90th day
C10	7.78±0.03^{dA}	6.90±0.04^{aD}	7.17±0.03^{bcB}	7.19±0.04^{bB}	7.11±0.01^{Bc}
C13	7.45±0.04^{gA}	6.60±0.02^{bC}	6.90±0.05^{dB}	6.91±0.02^{cB}	6.91±0.04^{cB}
C16	8.51±0.03^{bA}	5.53±0.06^{fC}	5.83±0.06^{gB}	5.82±0.03^{fB}	5.75±0.05^{fB}
GAW10	8.43±0.05^{bA}	6.41±0.07^{cD}	7.20±0.08^{bB}	7.12±0.07^{bCB}	7.05±0.06^{bC}
GAW13	7.77±0.02^{edA}	6.31±0.01^{cC}	6.92±0.03^{dB}	6.90±0.02^{cB}	6.89±0.05^{cB}
GAW16	9.39±0.02^{aA}	5.62±0.02^{fC}	6.08±0.07^{fB}	6.08±0.05^{eB}	6.12±0.03^{dB}
TH10	7.69±0.01^{edfA}	6.98±0.03^{aC}	7.36±0.04^{aB}	7.31±0.06^{aB}	7.29±0.08^{aB}
TH13	7.61±0.02^{fA}	5.82±0.03^{eD}	6.93±0.07^{dB}	6.84±0.05^{cC}	6.88±0.03^{cCB}
TH16	8.17±0.01^{cA}	6.01±0.09^{dB}	6.03±0.03^{fB}	6.01±0.04^{eB}	5.96±0.06^{eB}
M10	7.74±0.04^{edA}	6.10±0.02^{dC}	7.04±0.03^{bB}	7.06±0.04^{bB}	7.08±0.03^{bB}
M13	7.68±0.02^{efA}	6.60±0.05^{bD}	7.23±0.04^{baB}	7.16±0.04^{bC}	7.13±0.05^{bC}
M16	9.43±0.04^{aA}	5.77±0.02^{eD}	6.31±0.03^{eB}	6.26±0.03^{dCB}	6.23±0.03^{Dc}
Lactococcus					
sp.	1st day	15th day	30th day	60th day	90th day
C10	6.68±0.03^{cbdD}	7.17±0.03^{bdacC}	7.40±0.02^{bacA}	7.36±0.04^{baBA}	7.30±0.06^{baB}
C13	6.62±0.03^{cedC}	7.08±0.04^{deB}	7.23±0.06^{edA}	7.23±0.03^{dcA}	7.23±0.04^{bcdA}
C16	6.54±0.06^{edC}	7.17±0.03^{bdacA}	6.65±0.05^{gB}	6.62±0.03^{hB}	6.51±0.02^{gC}
GAW10	6.71±0.12^{cbD}	7.18±0.03^{bdacC}	7.49±0.06^{baB}	7.43±0.04^{aBA}	7.41±0.02^{aB}
GAW13	6.79±0.07^{bC}	7.21±0.04^{bacA}	7.19±0.04^{eBA}	7.15±0.03^{deBA}	7.12±0.02^{dB}
GAW16	6.74±0.04^{cbD}	7.00±0.03^{eC}	7.28±0.07^{edcA}	7.18±0.03^{deB}	7.18±0.02^{cdB}
TH10	6.51±0.03^{eD}	7.22±0.03^{bacC}	7.52±0.04^{aA}	7.37±0.06^{baB}	7.39±0.03^{aB}
TH13	7.04±0.06^{aB}	6.40±0.03^{fC}	7.17±0.06^{eA}	7.07±0.03^{eB}	7.16±0.02^{cdA}
TH16	6.31±0.01^{fA}	7.25±0.07^{baA}	6.91±0.04^{fB}	6.78±0.03^{gC}	6.78±0.08^{fC}
M10	6.52±0.04^{eD}	7.27±0.03^{aB}	7.36±0.04^{bdcA}	7.29±0.04^{bcB}	7.19±0.03^{bcdC}
M13	6.83±0.12^{bD}	7.14±0.04^{bdcC}	7.40±0.02^{bacA}	7.36±0.02^{baA}	7.25±0.03^{bcB}
M16	6.60±0.15^{cedC}	7.14±0.04^{dcA}	6.97±0.06^{fB}	6.94±0.07^{fB}	6.98±0.07^{Eb}

$^{a-g}$: Different letters in the same column indicate significant difference (P<0.05) between the results; $^{A-E}$: Different letters in the same line indicate significant difference (P<0.05) between the results; DM: Dry matter; C: Control; GAW: Garlic aromatic water; TH: Thyme hydrosol; M: Mixture of garlic aromatic water and thyme hydrosol; The numbers present in the samples state salt concentration of the brine.

Çizelge 3. Farklı salamura kombinasyonlarında depolanan çiğ süt peynirlerinin tekstürel özellikleri
Table 3. Textural properties of raw milk cheese stored at different brine combinations

Sample	Hardness (g)			Cohesiveness		
	1st day	15th day	30th day	1st day	15th day	30th day
C10	271.84±12.80^{hA}	251.90±15.55^{edB}	75.03±5.56^{hC}	0.85±0.02^{aA}	0.83±0.01^{aA}	0.79±0.01^{aA}
C13	352.18±12.48^{gfA}	295.79±17.14^{dB}	244.43±9.85^{fgC}	0.84±0.01^{aA}	0.85±0.01^{aA}	0.81±0.02^{aA}
C16	475.40±11.27^{cbB}	378.96±16.51^{cA}	613.60±27.61^{aC}	0.85±0.01^{aA}	0.85±0.01^{aA}	0.82±0.02^{aA}
GAW10	541.59±44.18^{aA}	233.86±13.01^{eC}	296.00±26.85^{eB}	0.85±0.02^{aA}	0.85±0.01^{aA}	0.83±0.03^{aA}
GAW13	495.03±23.06^{bA}	352.00±27.72^{cC}	395.61±27.97^{cdB}	0.85±0.01^{aA}	0.86±0.03^{aA}	0.82±0.03^{aA}
GAW16	322.23±21.62^{gB}	282.93±19.17^{edC}	465.07±14.70^{bA}	0.84±0.01^{aA}	0.84±0.01^{aA}	0.82±0.01^{aA}
TH10	375.80±13.50^{efA}	268.54±22.22^{edB}	196.75±26.83^{gC}	0.85±0.01^{aA}	0.85±0.02^{aA}	0.80±0.01^{aA}
TH13	432.01±18.96^{cdA}	381.72±25.48^{cB}	387.36±26.11^{cdB}	0.84±0.00^{aA}	0.84±0.01^{aA}	0.82±0.04^{aA}
TH16	582.00±25.08^{aC}	782.48±26.73^{aA}	629.97±33.51^{aB}	0.86±0.02^{aA}	0.86±0.02^{aA}	0.83±0.05^{aA}
M10	369.12±16.52^{efA}	277.38±28.11^{edB}	265.87±10.36^{feB}	0.85±0.01^{aA}	0.85±0.02^{aA}	0.82±0.03^{aA}
M13	333.63±8.66^{gfB}	244.24±25.44^{eC}	425.60±24.47^{cbA}	0.85±0.01^{aA}	0.84±0.01^{aA}	0.79±0.01^{aA}
M16	408.88±12.38^{edB}	698.19±27.36^{bA}	367.73±20.85^{dC}	0.85±0.01^{aA}	0.85±0.01^{aA}	0.84±0.02^{aA}
	Gumminess (g)			Resilience		
	1st day	15th day	30th day	1st day	15th day	30th day
C10	230.95±14.91^{iA}	210.25±12.95^{eB}	59.08±4.58^{gC}	0.50±0.01^{baA}	0.49±0.02^{baA}	0.41±0.01^{cB}
C13	294.24±10.34^{hgB}	251.19±13.57^{dC}	346.24±14.57^{cbA}	0.45±0.01^{cB}	0.50±0.01^{baA}	0.46±0.02^{bB}
C16	405.31±12.32^{dcB}	323.11±14.35^{cA}	504.93±17.70^{aC}	0.50±0.02^{baA}	0.50±0.03^{baA}	0.50±0.01^{aA}
GAW10	459.97±43.49^{baA}	198.16±11.35^{eC}	243.89±16.92^{dB}	0.50±0.01^{baA}	0.48±0.01^{bA}	0.45±0.01^{bB}
GAW13	418.80±17.06^{bcA}	302.82±17.14^{cB}	323.91±21.72^{cB}	0.50±0.02^{baA}	0.49±0.03^{baA}	0.45±0.01^{bB}
GAW16	269.66±16.70^{hiB}	237.72±18.95^{edC}	379.92±16.94^{bA}	0.49±0.02^{bA}	0.50±0.01^{baA}	0.47±0.02^{baB}
TH10	320.97±9.18^{fgA}	229.03±17.66^{edB}	157.02±20.60^{fC}	0.49±0.00^{bA}	0.49±0.01^{baA}	0.45±0.03^{bB}
TH13	364.63±15.75^{deA}	321.89±22.50^{cB}	318.94±20.27^{cB}	0.50±0.01^{baA}	0.50±0.01^{baA}	0.45±0.03^{bB}
TH16	498.62±25.83^{aC}	670.53±21.09^{aA}	520.62±35.56^{aB}	0.50±0.01^{baA}	0.51±0.01^{aA}	0.46±0.04^{bB}
M10	313.16±12.30^{fgA}	236.37±24.87^{edB}	218.00±8.29^{edB}	0.52±0.01^{aA}	0.50±0.02^{baA}	0.45±0.01^{bB}
M13	284.10±7.38^{hgA}	205.87±20.64^{eB}	193.37±6.46^{efB}	0.49±0.02^{bA}	0.49±0.02^{baA}	0.45±0.02^{bB}
M16	347.34±13.42^{feB}	591.84±18.90^{bA}	309.32±13.54^{cC}	0.49±0.01^{bA}	0.50±0.01^{baA}	0.48±0.02^{bA}
	Chewiness (g x mm)			Springiness (mm)		
	1st day	15th day	30th day	1st day	15th day	30th day
C10	218.03±17.98^{iA}	198.17±12.65^{feB}	54.91±3.80^{gC}	0.94±0.02^{aA}	0.94±0.01^{aA}	0.93±0.02^{aA}
C13	277.40±10.85^{hgB}	236.38±11.63^{deC}	319.69±12.24^{cbA}	0.94±0.00^{aA}	0.94±0.01^{aA}	0.92±0.01^{aA}
C16	381.76±15.54^{dcB}	307.16±14.00^{cA}	466.85±19.44^{aC}	0.94±0.01^{aA}	0.95±0.01^{aA}	0.92±0.01^{aA}
GAW10	434.47±45.56^{baA}	186.93±11.89^{eC}	228.71±15.51^{dB}	0.94±0.01^{aA}	0.94±0.01^{aA}	0.94±0.02^{aA}
GAW13	392.41±18.21^{bcA}	272.21±34.16^{dcC}	302.88±23.12^{cB}	0.94±0.01^{aA}	0.90±0.07^{bB}	0.93±0.01^{aA}
GAW16	252.00±16.16^{ihB}	227.90±23.90^{feC}	351.63±16.43^{bA}	0.93±0.01^{aA}	0.96±0.03^{aA}	0.93±0.02^{aA}
TH10	302.04±8.53^{fegA}	218.05±17.11^{feB}	146.39±18.14^{fC}	0.94±0.00^{aA}	0.95±0.02^{aA}	0.93±0.01^{aA}
TH13	343.18±16.36^{deA}	303.80±21.18^{cB}	299.28±20.64^{cB}	0.94±0.01^{aA}	0.94±0.01^{aA}	0.94±0.02^{aA}
TH16	468.38±25.64^{aC}	631.36±22.96^{aA}	490.12±40.78^{aB}	0.94±0.01^{aA}	0.94±0.00^{aA}	0.94±0.02^{aA}
M10	294.86±11.31^{fhgA}	224.63±25.08^{feB}	203.44±9.38^{edB}	0.94±0.01^{aA}	0.95±0.02^{aA}	0.93±0.01^{aA}
M13	267.34±6.34^{hgA}	194.39±19.05^{feB}	179.04±6.19^{efB}	0.95±0.00^{aA}	0.94±0.01^{aA}	0.93±0.00^{aA}
M16	324.86±13.07^{feB}	562.17±18.19^{bA}	291.66±13.35^{cC}	0.94±0.01^{aA}	0.95±0.02^{aA}	0.94±0.01^{aA}

$^{a-g}$: Different letters in the same column indicate significant difference (P<0.05) between the results; $^{A-E}$: Different letters in the same line indicate significant difference (P<0.05) between the results; DM: Dry matter; C: Control; GAW: Garlic aromatic water; TH: Thyme hydrosol; M: Mixture of garlic aromatic water and thyme hydrosol; The numbers present in the samples state salt concentration of the brine.

Textural properties

Table 3 shows the textural properties of raw milk cheese samples stored in different brine combinations. Measurements could not be done because of the fragile texture of the cheese samples within the 60th day of the storage. As seen in Table 3, hardness values ranged from 271.84 to 582.00 g at the first day. C10 sample had the lowest (P<0.05) hardness values at all storage days. This shows incorporation of plant

aromatic waters into brine increased hardness of the cheese. Except for the samples stored in the brine containing GAW, increase in salt concentration caused increase in the hardness. Hardness of TH16 was the highest during the storage while at the 30th day, it was followed by C16 and GAW16, respectively. Hardness values were affected from the salt concentration of brine especially at the first day. This indicates that rapid salt diffusion occurred as soon as the cheese ripening started. Salt findings presented in Table 1 supports this idea.

Change in gumminess and chewiness properties of the samples are also indicated in Table 3. A similar trend with the hardness values was observed for gumminess and chewiness. Gumminess and chewiness of C10, TH10, TH13, M10 and M13 samples significantly ($P<0.05$) decreased during the storage while C10 always had the lowest ($P<0.05$) gumminess values. At the 1st, 15th and 30th days, TH16 had the highest ($P<0.05$) gumminess and chewiness vaues. At the beginning of the storage, those parameters decreased depending on the salt concentration in the brine while a contrast case occurred at the 30th day. Considering resilience, springiness and cohesiveness properties, the differences between the samples were insignificant ($P>0.05$) (Table 1).

Textural properties of white cheeses can be significantly influenced from ripening conditions and cheese physicochemical properties such as milk composition, salt concentration, ripening duration and pH value of cheese. For instance, cheese produced from low fat milks had lower textural properties (Tunick et al., 1993; Romeih et al., 2002). Madadlou et al. (2007) reported that Iranian white cheese samples ripened in weaker brines (9% and 13%) had a dense microstructure with large protein aggregates while the cheese ripened in the strongest brine (17%) had a casein network with more homogenous protein aggregates. In several studies, effects of extracts of several plants on textural properties of cheese have also been investigated. Licón et al. (2012) showed that pasteurized ewe milk pressed cheeses with saffron were firmer and more elastic but less prone to fracture. El-Aziz et al. (2015) found that addition of aquaeous ginger extract or ethanol ginger extract to brine caused decrease in hardness of Egyptian white cheese. In another study, fortification of soft cheese with ginger extract caused a gradual increase in cohesiveness and a gradual decrease in hardness in both pickled and un-pickled soft cheeses while it had no significant effect on cheese springiness (El-Aziz et al., 2012).

Conclusion

This study investigated the application potential of garlic aromatic water (GAW) and thyme hydrosol (TH) as a component of brine solution for Turkish white cheese prepared from raw cow's milk. Brine combinations containing GAW, TH or their mixture (10% v/v) were prepared with different salt concentrations (10%, 13% or 16%). Addition of aromatic waters and salt concentration affected physicochemical, microbiological and textural properties of cheese. Acidity of the cheese increased with TH or GAW addition while salt concentration was the main determinant for DM content. Counts of lactobacilli were higher than that of lactococci at the 1st day of the ripening while lactococci numbers increased during the ripening period. Hardness, chewiness and gumminess properties of the raw milk cheeses increased depending on the addition of GAW, TH or their mixture and increasing salt concentration.

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