Effects of high heat treatment of milk and brine concentration on the quality of Turkish white cheese

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The goal of this study was to determine the effects of high heat treatment of milk and brine concentration on some properties of Turkish white cheese. Cheese made from pasteurised milk (65 °C for 30 min) (P cheese), and cheese from high heat-treated milk (80 °C for 20 min) (HHT cheese) were ripened in 14 or 16 g 100 ml^{-1} NaCl for 90 days at 6–8 °C. Compositional, biochemical and sensorial analyses were carried out along ripening. Compared to the P cheese, the HHT cheese had significantly ($p < 0.01$) higher cheese yield, ash, and salt contents, titratable acidity, WSN/TN and ADV, and lower total solids, protein, and fat contents. The increase in salt concentration in the ripening medium (brine) resulted in an increase in the total solids content, salt absorption and a decrease in the WSN/TN level and ADV ($p < 0.05$). The P cheese received significantly higher scores from panellists for texture and general acceptability and lower scores for off-flavour/odour intensity and saltiness than the HHT cheese ($p < 0.05$). The taste/flavour intensity of the P cheese was rated as high, it was, however, not significant.

Auswirkungen der Milchhocherhitzung und der Salzlakenkonzentration auf die Qualität von türkischem Weißkäse

Ziel dieser Studie war, die Auswirkungen Hocherhitzung der Milch und der Salzlakenkonzentration auf einige Eigenschaft von türkischem Weißkäse zu bestimmen. Käse aus pasteurisierter Milch (65 °C für 30 min) (P-Käse) und Käse aus hocherhitzter Milch (80 °C für 20 min) (HHT-Käse) reiften 90 Tage in 14 oder 16 g 100 ml^{-1} NaCl bei 6–8 °C. Während der Reifung wurden Untersuchungen über Zusammensetzung, Chemie und Sensorik durchgeführt. Im Vergleich zum P-Käse, zeigte der HHT-Käse signifikant ($p < 0,01$) höhere Werte für Ausbeute, Asche- und Salzgehalt, titrierbaren Säuregrad, wasserlöslichen Stickstoff/Gesamtstickstoff (WSN/TN) und ADV und niedrigere Werte bei Gesamttrockenmasse, Eiweiß- und Fettgehalten Die Erhöhung des Salzgehaltes in der Lake führte zu Erhöhungen bei Trockenmasse und Salzabsorption und einer Abnahme des WSN/TN-Level und des ADV ($p < 0,05$). Der P-Käse wurde signifikant besser bewertet in Bezug auf Textur und allgemeine Akzeptanz und schlechter bei Fremdflavour/Geruchsintensität und Salzgeschmack als HHT-Käse ($p < 0,05$). Geschmacks- und Flavourintensität des P-Käses wurde hoch bewertet, jedoch lagen keine signifikanten Unterschiede vor.

51 White cheese (technology and quality) **51 Weißkäse** (Technologie und Qualität)

1. Introduction

In Turkey, white cheese comes in first order in terms of production and consumption (1). It is a kind of ripened soft cheese that is maturated in brine to develop the desired textural and taste/flavour properties (2). Because of poor hygienic milking conditions in Turkey, the microbial count of milk is generally higher than those specified by the Regulatory Organisation. Therefore, the milk used in the production of white cheese is generally high heat-treated for longer times than those applied during regular pasteurisation, in order to reduce high bacterial load of raw milk and to increase cheese yield by thermal denaturation of whey proteins. However, it was reported that denatured whey proteins affect gel formation and nature of the cheese matrix (3–8). Additionally, higher levels of denatured whey proteins in cheese were reported to associate with a higher degree of primary proteolysis (9).

However, the effect of a combination of longer time and high temperature treatment on the quality of Turkish white cheese is not clear. Therefore, the main objective of the study was to investigate the effects of high heat-treatment of milk and brine concentration on the compositional, biochemical, and sensorial properties of Turkish white cheese.

2. Material and methods

2.1 Material

Bovine milk was supplied from the Research and Application Farm of Atatürk University. Commercial rennet and mesophilic lactic cultures were purchased from Mayasan Co. and Peyma-Chr. Hansen's Co., respectively. Experimental cheese types were manufactured in the pilot dairy plant of Atatürk University.

2.2 White cheese making and sampling

White cheese was produced according to the method outlined by UCUNCU (10). Fat content of cow milk (400 l) was standardised to 2.5%, and the milk was divided into two equal parts. One part was pasteurised (P) at 65 °C for 30 min, and the other was heat treated (HHT) at 80 °C for 20 min. Then, the milk was cooled down to 30–32 °C. After ripening for approximately 30 min with starter culture (a blend of *Lc. lactis* subsp. *lactis* and *Lc. lactis* subsp. *cremoris*) at a level of 1 g 100 ml^{-1} and $CaCl_2$ at a level of 0.020 g 100 ml^{-1}. Milk was coagulated with commercial calf rennet (1/10000 strength, 13.3 ml). After the removal of whey, the curd was weighed and cut in blocks of a size of 7x7x7 cm^3, and the fresh cheeses were soaked in brine of 16 g 100 ml^{-1} salt for

6 h. The brined blocks were taken out and left for 12 h uncovered on a cheese table at ambient temperature. The cheese types of each heat treatment were divided into two sub-groups; each sub-group was also divided into 5 parts and placed into different cans filled with brine (14 or 16 g 100 ml^{-1} NaCl). The containers were sealed and ripened at 6–8 °C for 90 days.

From each batch, samples were taken out on day 1, 15, 30, 60 and 90 of ripening. Chemical composition, titratable acidity, water soluble nitrogen/total nitrogen (WSN/TN) and acidity degree value (ADV) were determined. The experiments were replicated twice, and the analyses were carried out in duplicate.

2.3 Methods

Total solids (11), total nitrogen (TN) (12), WSN (13), fat (14) salt (15) and ash (16) contents of the cheeses were measured. For measurement of titratable acidity, a diluted paste of cheese and water (w/v, 1/10) was prepared and filtered. A representative portion of the filtrate was titrated with 0.1 N NaOH using phenolphthalein as an indicator (17). The BDI method was used to determine the degree of lipolysis (ADV) as described in FIL-IDF (18). Cheese yield was expressed in g of cheese curd per 100 g of milk.

A group of 8 trained panellists evaluated the cheese by grading them on a scale of 1 to 9 (1; very poor and 9; very good) at the end of the ripening period. The qualities judged were: texture, saltiness, taste/flavour and off-flavour/odour intensities and general acceptability (19).

To evaluate the differences among cheese types with respect to heat treatment and brine concentrations, the chemical, biochemical and sensorial data were analysed by 2 x 2 factorial design (20). Means with a significant difference were compared using Duncan's multiple range tests. The statistical analysis was carried out by MINITAB statistical software.

3. Results and discussion

Results indicated that the yield of HHT cheese was significantly higher than that of P cheese, and high heat application resulted in an increase in moisture-adjusted cheese yield by 2.54% compared to pasteurisation. MARSHALL (21) reported that approximately 4.5% more total solids were recovered in Cheshire cheese produced from high heat-treated milk (97 °C for 15 s) compared to the control made from P milk. Similar to our results, BANKS *et al.* (22) reported that milk heated at 90 °C for 60 s resulted in an increase of 3.9–4.4% in the moisture-adjusted yield of Cheddar cheese. It was also observed that HHT milk showed longer coagulation time and formed weaker and finer curd, which retained more moisture than the curd from P milk. Therefore, lower mean total solids content (35.86 g 100 g^{-1} cheese) was obtained for HHT cheese. However, the minimum total solids content of the white cheese was specified as 40 g 100 g^{-1} cheese by Turkish Standard Institution (19).

3.1 Chemical composition and biochemical changes

Significant differences ($p<0.01$) were obtained between white cheeses made from P and HHT milk in terms of total solids, protein, fat, ash and salt contents, titratable acidity and WSN/TN level and ADV. Also, significant differences ($p<0.05$) were observed between examined properties of white cheeses ripened at 14 and 16 g 100 ml^{-1} salt, except titratable acidity.

The total solids content of HHT cheese was significantly lower than that of the P cheese (Table 1). It is known that heat treatment of cheese milk at high temperatures provokes an association of κ-casein and β-lactoglobulin, changes calcium phosphate equilibrium, resulting in less shrinkage of the *p*-casein network, and increasing water holding capacity of the *p*-casein whey protein complex; also, coagulation is negatively affected and aggregated micelles tend to retain more water (3, 4). Higher mean total solids content was also obtained for white cheese ripened in 16 g 100 ml^{-1} salt. Increasing salt content of the cheese leads to concomitant reduction in the moisture content. The HHT cheese, ripened in a brine of 14 g 100 ml^{-1} salt, had also a soft slimy layer at the surface probably due to high moisture content. LUCEY and KELLY (4) also reported that the cheese produced from HHT milk is not suitable for long storage due to melting. The total solids content of cheese increased slowly up to 15 days of ripening and then remained nearly constant. However, the total solids content of HHT cheese also increased slowly up to day 15 and then decreased continuously up to the end of ripening (Fig. 1). The P cheese had significantly higher protein content than HHT cheese due to the higher total solids level (Table 1). Protein content of white cheese, especially the cheese prepared from HHT milk, decreased significantly during ripening due to degradation of protein by both microorganisms and indigenous enzymes (5). Almost similar situations were obtained for fat content of both P and HHT cheese types. One of the major processes in white cheese production is salting which ensures the characteristic properties of the cheese, enhances flavour and acts as a preservative (23). The salt level of the HHT cheese was significantly higher than that of the P cheese due to the high moisture content of the cheese. Similarly, salt content of white cheese, ripened in a brine of 14 g 100 ml^{-1} salt, was lower than that of the cheese ripened in a 16 g 100 ml^{-1} salt brine (Table 1). Probably due to the differences between salt contents of the white cheese and brine in the early days of ripening (23), the salt diffusion from brine to the cheese body was fast for the first 30 days of ripening; then it seemed to reach equilibrium (data not shown).

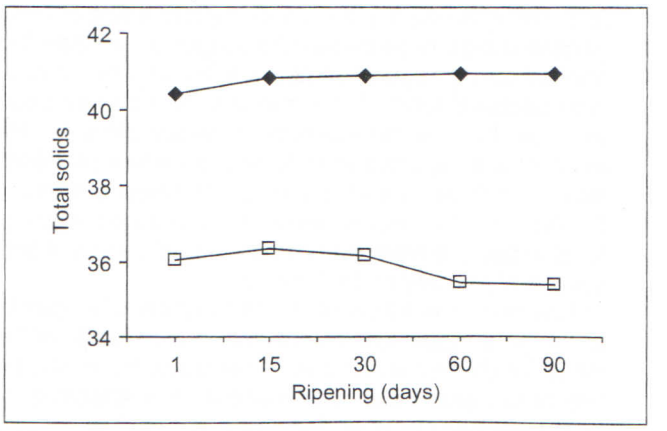


Fig. 1: The mean total solids of white cheese during ripening. (◆) P cheese; (□) HHT cheese.

Table 1: Mean values of the chemical and biochemical properties of the P and HHT cheese types and ripened in a brine of 14 or 16 g 100 ml^{-1} salt

	Total solids content (%)	Protein (%)	Fat (%)	Ash (%)	Salt (%)	Titratable acidity (% LA)	WSN/TN level	ADV (mg KOH g^{-1}-fat)
White cheese types (n=20)								
P cheese	40.77^{a}	14.68^{a}	16.00^{a}	9.98^{b}	8.70^{b}	0.16^{b}	0.06^{b}	0.93^{b}
HHT cheese	35.86^{b}	12.33^{b}	12.95^{b}	10.40^{a}	9.16^{a}	0.29^{a}	0.32^{a}	1.36^{a}
Brine concentration (n=20)								
14 g 100 ml^{-1} salt	37.38^{b}	13.20^{b}	14.18^{b}	9.80^{b}	8.56^{b}	0.23	0.21^{a}	1.21^{a}
16 g 100 ml^{-1} salt	39.25^{a}	13.80^{a}	14.78^{a}	10.58^{a}	9.29^{a}	0.22	0.18^{b}	1.08^{b}

^{a,b}Mean values in the same column and treatment group without a letter or bearing a common letter did not differ significantly ($p<0.05$); n: number of samples. P cheese: cheese made from pasteurised milk; HHT cheese: cheese made from high heat-treated milk (80°C for 20 min); LA: lactic acid; WSN: water soluble nitrogen: TN: total nitrogen; ADV: acidity degree value.

The titratable acidity value of HHT cheese was significantly higher than that of P cheese (Table 1). Results indicated that the time required to remove an sufficient amount of whey from HHT cheese was twice that compared to P cheese under the same pressure. Also, the activity of lactic bacteria continued, and more lactic acid formed in whey removing process. Additionally Fig. 2 indicates that the titratable acidity value of HHT cheese at the beginning of ripening was significantly higher than that of the other cheese type. The titratable acidity value of P cheese increased continuously along with the ripening, while that parameter of other cheese increased rapidly until day 30 of ripening, and then decreased. Presumably, the decrease in titratable acidity of HHT cheese on day 60 and 90 of ripening was due to the degradation of lactic acid by yeasts and the production of ammonia by deamination of free amino acids over the ripening (2, 5).

HHT cheese had higher primary proteolysis (WSN/TN level) than P cheese (Table 1). High primary proteolysis of HHT cheese may be due to significantly higher moisture content of the cheese resulting in a higher MNFS value (73.68% vs. 70.51%) or increased inactivation of plasmin inhibitors. Similar results were reported by KELLY (7) for Cheddar cheese made from UHT milk. Denatured serum proteins remaining in cheese body were degraded easily by indigenous enzymes (5). Also high heat treatment of milk has been reported to result in accelerated β-casein breakdown in cheese (7). Results indicated that the increase in salt concentration in the ripening medium resulted in a decrease in the WSN/TN level of the white cheese. The WSN/TN level of white cheese ripened in 16 g 100 ml^{-1} salt was significantly lower than that of cheese ripened in 14 g 100 ml^{-1} salt (Table 1), probably due to the inhibition effect of salt on both the bacterial growth and enzyme activity (3, 24, 25). KATSIARI *et al.* (24) reported that the reduction in the salt content of cheese body led to an increase in the level of proteolysis, acidity and bitterness, a decrease in firmness and saltiness, and abnormal fermentation may also occur. The WSN/TN level of HHT cheese increased rapidly until day 15 of ripening; and then increased slowly. However, WSN/TN level of P cheese increased linearly along with the ripening (Fig. 3).

Because of longer processing and handling time of the cheese curd as mentioned above, lipolysis degree (ADV) of HHT cheese was significantly higher compared to P cheese (Table 1), probably due to high activity of lipases originated from starter and non-starter bacteria (6). The ADV of P cheese remained constant up to day 15 of ripening, and rapidly increased during the remaining time. However, the ADV of HHT cheese slowly increased up to day 15 of ripening, then continued to increase rapidly up to the end of the period (Fig. 4). Probably due to the inhibition effect of salt on the growth of bacteria and enzyme activity (2, 26, 27), lipolysis level of white cheese ripened in 16 g 100 ml^{-1} salt was low.

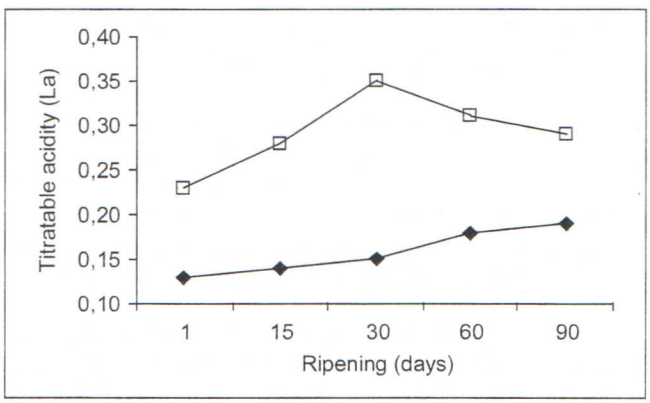


Fig. 2: Mean titratable acidity of white cheese during ripening. (◆) P cheese; (□) HHT cheese.

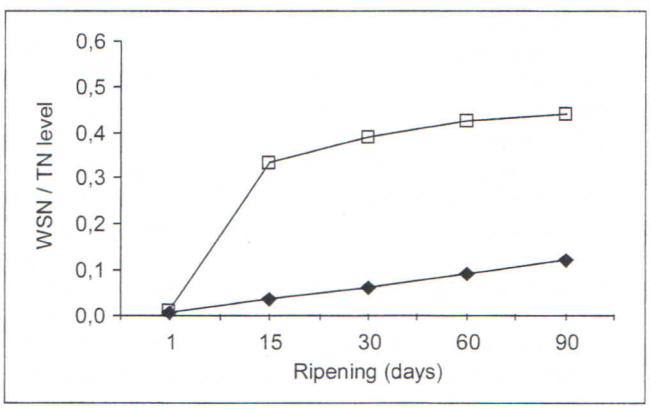


Fig. 3: Mean degree of WSN/TN level of white cheese during ripening. (◆) P cheese; (□) HHT cheese.

3.2 *Sensory evaluation*

With respect to all parameters, except taste/flavour intensity, significant differences ($p<0.05$) were observed between P and HHT cheese types, while differences were not obtained between the scores of all examined sensorial properties of white cheese ripened in a brine of 14 or 16 g 100 ml^{-1} salt. High heat treatment of milk negatively affected the sensorial properties of white cheese (Table 2).

Table 2: Mean values of the sensorial properties of P and HHT cheese types and ripened in a brine of 14 or 16 g 100 ml^{-1} salt

	Texture*	Taste / flavour intensity*	Off-flavour / odour intensity**	Saltiness***	General acceptability*
White cheese types (n=20)					
P cheese	7.56^{a}	7.36	6.54^{a}	6.88^{a}	7.96^{a}
HHT cheese	5.98^{b}	6.96	4.60^{b}	4.65^{b}	6.64^{b}
Brine concentration (n=20)					
14 g 100 ml^{-1} salt	6.45	7.23	5.70	6.67	7.08
16 g 100 ml^{-1} salt	7.08	7.08	5.36	5.89	7.52

^{a,b}Mean values in the same column and treatment group without a letter or bearing a common letter did not differ significantly ($p<0.05$); P cheese: The cheese made from pasteurised milk; HHT cheese: The cheese made from high heat-treated milk (80°C for 20 min); *1: very poor, 9: very good; ** 1: too much, 9: too few; ***1: very salty, 9: normal.

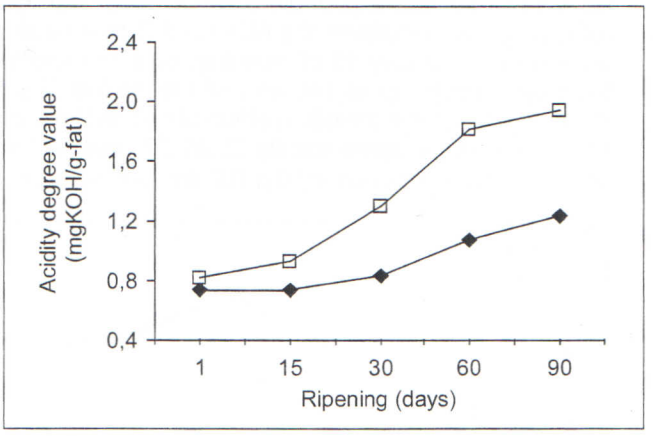


Fig. 4: Mean degree of acidity degree value of white cheese during ripening. (♦) P cheese; (□) HHT cheese.

The texture of the P cheese was well accepted and scored significantly higher than that of HHT cheese type by panellists. The score of taste/ flavour intensity of P cheese was numerically higher than that of HHT cheese. The taste/flavour intensity of both P and HHT cheese types were good. Some textural and flavour defects were also reported by some authors for semi-hard and hard cheeses made from high heat-treated milk (21, 22). Probably due to the higher microbial fermentation and enzymatic activity (*i.e.* high lipolysis and proteolysis levels), the off-flavour/odour intensity of the HHT cheese was rated as high. Proteolysis has an obvious role in determining texture, flavour and availability of flavour precursors in all matured cheese varieties (6). BANKS *et al.* (22) reported that Cheddar cheese flavour intensity was generally reduced in cheese prepared from HHT milk. Additionally, HHT cheese was found very salty by panellists, due probably to the high moisture content of the cheese. With respect to general acceptability, panellists preferred P cheese. On the other hand, texture, saltiness and general acceptability of white cheese ripened in 16 g 100 ml^{-1} salt were scored slightly higher than the cheese stored in 14 g 100 g^{-1} salt.

4. Conclusions

Overall results indicates that high heat application of cheese milk resulted in an increase of white cheese yield. However, the application negatively affected quality of HHT cheese. The levels of proteolysis and lipolysis of HHT cheese increased rapidly during ripening. Additionally, the HHT cheese was less accepted with respect to P cheese by panellists. It was also observed that HHT cheese was not appropriate for long term ripening (90 d); therefore it should be kept in high salt concentration (16 g 100 g^{-1} salt) for short term ripening.

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