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## Full Length Research Paper

# Effect of different brine concentrations and ripening period on some quality properties of Turkish white pickled cheese

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The aim of this study was to determine the effects of different brine concentrations on some properties of Turkish white cheese. Cheeses made from pasteurized milk (65°C for 30 min) were ripened in 11, 14 and 17 g 100 ml<sup>-1</sup> NaCl for 90 days at 7±1°C. Some physicochemical and biochemical analyses were carried out during storage time. The effects of brine concentrations on total solids, protein, ash, salt, pH, and WSN values were found to be significant (P<0.05). On the contrary, fat, lipolysis, TCA-SN and PTA-SN values of the cheese samples were not significantly affected by the brine concentrations used. On the other hand, the values of protein, ash, salt, pH, lipolysis, WSN, TCA-SN and PTA-SN of the experimental cheeses were significantly (P<0.05, P<0.01) affected by storage time, while the effect of storage period on total solids and fat contents was found to be insignificant (P>0.05).

**Key words:** Turkish white cheese, brine salting, ripening, lipolysis, proteolysis.

## INTRODUCTION

Turkish white pickled cheese is the most popular cheese variety in Turkey, and this cheese is traditionally manufactured from cow, ewe and goat's milk or their mixtures in almost all parts of the country. According to Anonymous (2008) data, milk production in Turkey is about 12 million tonnes per annum and 263,000 tonnes of white cheese are produced annually. There are some studies previously conducted on the Turkish white pickled cheese (Güven and Karaca, 2001; Akin et al., 2003; Dagdemir et al., 2003; Güler and Uraz, 2004; Hayaloglu et al., 2005; Cinbas and Kilic, 2006; Güven et al., 2006; Hayaloglu, 2007; Dagdemir and Ozdemir, 2008).

It is similar to Feta and Teleme cheeses produced in Greece and Middle East (Hayaloglu et al., 2002; Akin et al., 2003; Dagdemir and Ozdemir, 2008). It is a kind of

ripened soft cheese that is matured in brine to develop the desired textural and taste/flavor properties (Celik et al., 2005).

Cheese ripening is a complex process that includes the breakdown of the curd by proteolysis, lipolysis and other enzyme-catalyzed reactions which cause flavor and textural changes typical of different varieties (Contarini and Toppino, 1995). Proteolysis and lipolysis are the most significant biochemical events that occur during cheese ripening. Proteolysis plays a major role in the development of texture and flavor in most rennet curd cheese varieties during ripening (Fox, 1989). Lipolysis is also an important phenomenon in cheese ripening (Chamba and Perreard, 2002) and its low levels contribute to the ripening of some cheese varieties, but excessive levels of lipolysis are undesirable and result in rancidity (Mc Sweeney, 2004).

Salting is a major operation in the manufacture of Turkish white cheese and ensures its characteristic properties. The concentration of salt and its distribution in the cheese mass are important parameters affecting its quality and acceptability (Turhan and Kaletunc, 1992).

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The salt content of cheese differs markedly with variety, ranging from about 0.5 to 0.7% (w/w) in acid curd varieties, such as cottage cheese, and Emmental type cheese, to about 4 to 6% (w/w) in pickled cheeses such as: Domiati and Feta. Salt in cheese serves three major functions (1) it acts as a preservative, (2) contributes directly to flavor, and (3) provides a source of sodium which is important for regulation of blood pressure, water transport into and out of cells, tissue osmolality, and transmission of nerve cell impulses. In addition to these functions, salt exerts a number of important effects on cheese. It is a major determinant of water activity, and thereby exerts control over microbial growth, enzyme activity, biochemical changes during cheese ripening, and the simultaneous development of the desired flavor and aroma. Salt, together with pH and calcium level, has a large effect on the extent of para-casein hydration, or aggregation, which in turn affects the water-binding capacity of the casein matrix, its tendency for syneresis, its rheological and textural characteristics and its cooking properties (Guinee, 2004).

The aim of this study was to determine the effects of different brine concentration and ripening period on some characteristics of Turkish white cheese.

## MATERIALS AND METHODS

Raw cow's milk, with content of 12.4% total solids, 3.4% fat, 3.08% protein, 0.73% ash, 0.176% titratable acidity (as lactic acid) and 6.50 pH, was obtained from the Research and Application Farm of Atatürk University. Commercial rennet and freeze-dried mesophilic lactic culture (*Lactococcus lactis* subsp. *lactis* and *L. lactis* subsp. *cremoris*) were obtained from Peyma Hansen Istanbul, Turkey.

### Cheese making

White pickled cheese was manufactured in two replications according to the method outlined by Ucuncu (2002). Raw cows' milk was used in the experiments. Fat content of the milk (250 L) was standardized to 3.3%, pasteurized at 65°C for 30 min, and cooled down to 30 to 32°C and inoculated with a mesophilic starter culture (a blend of *L. lactis* subsp. *lactis* and *L. lactis* subsp. *cremoris*) at a level of %1(w/v). CaCl<sub>2</sub> was added to the milk at a level of 0.20 g/L. The inoculated milk was held for about 30 min. Commercial-liquid calf rennet (strength 1:16000) was added at a level of 12 to 13 ml per 100 L of cheese milk and coagulation took place for 90 min. Following coagulation, the coagulum was cut into cubes and allowed to rest for 10 to 15 min; after a gradual pressure was applied at room temperature for 3 to 4 h. The curd was cut into cubes with a knife and placed in brine (16% NaCl) for about 12 h at 21°C. The cheese blocks were then placed in cans brines, three different concentrations (11, 14 and 17%, w/v) were added to cover the cheese blocks completely and ripened 6 to 8°C for 90 days.

### Physicochemical analysis

Cheese samples were analyzed for total solids, fat (Gerber method), protein (Kjeldahl method), ash, pH and salt (Mohr method)

according to the methods described by Kurt et al. (1996). Lipolysis was measured as acid degree value (ADV) (Case et al., 1985). Water-soluble nitrogen fraction (WSN) was determined by Kjeldahl method as described as follows: 10 g cheese sample was homogenized with 100 ml distilled water and filtered. The nitrogen content of the extracted cheese was expressed as a percentage of total nitrogen (WSN/TN, %), which was described as a ripening index. Trichloroacetic acid-soluble nitrogen (TCA-SN) was determined in the same cheese extract described previously. 10 ml 24% TCA was added to the 10 ml cheese extract, incubated at 4°C for 2 h and the precipitate was filtered through Watman no. 40 paper. Filtrate of the nitrogen was determined according to the Kjeldahl method and TCA-SN was expressed as percentage of total nitrogen (TCA-SN/TN, %). Water-soluble extract (10 ml) was mixed with 7 ml 3.95 M H<sub>2</sub>SO<sub>4</sub> and 3 ml 33% (w/v) phosphotungstic acid (PTA). The mixture was held at 4°C for 12 h and then filtered through Watman no 40 paper. Filtrate of the nitrogen was determined according to the Kjeldahl method and PTA-SN was expressed as percentage of total nitrogen (PTA-SN/TN, %) (Kamaly et al., 1989; Butikofer et al., 1993; Azarina et al., 1997; Katsiari et al., 2000).

### Statistical analysis

Statistical analysis of data for effects of salt concentrations and ripening period on each parameter was estimated by ANOVA using MINITAB® statistical software (MINITAB Inc., State College, PA). Statistically different groups were determined by Duncan's multiple range test.

## RESULTS AND DISCUSSION

### Physicochemical properties of the experimental cheeses

Mean values obtained from the experimental cheeses are presented in Table 1 with their statistical evaluations. It was observed that the total solids, protein, ash, salt and pH contents, except fat content, were significantly ( $P<0.05$ ) affected by salt concentrations used in the experimental cheeses. Except for total solids and fat contents, the effect of storage time on the protein, ash, salt and pH contents was found to be significant statistically ( $P<0.05$ ) (Table 1).

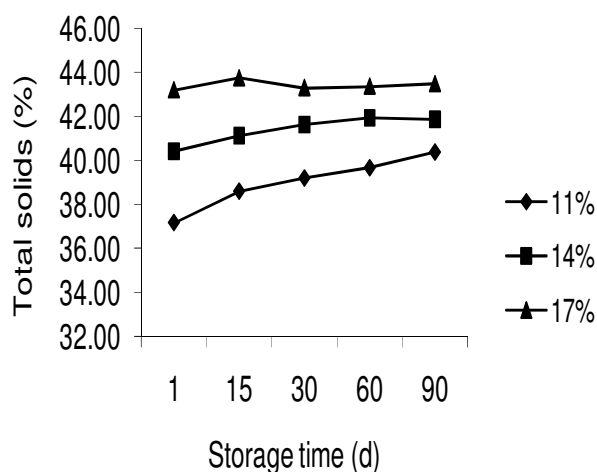
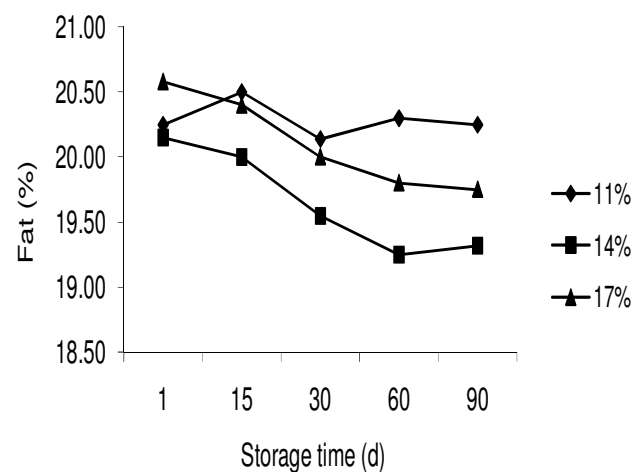
Changes in the total solids content of the cheese samples during storage times are presented in Figure 1. Total solids contents of all cheese samples were slightly increased during storage, but this was insignificant ( $P>0.05$ ) statistically. Different salt percentages in brine were found to have a significant ( $P<0.05$ ) effect on total solids content of the experimental cheeses (Table 1).

The effect of salt concentration in the brine on the fat contents of the experimental cheeses is shown in Figure 2. As shown from the figure, fat contents of the cheese samples decreased during storage period, but this was insignificant ( $P>0.05$ ) statistically. Similarly, salt had no significant ( $P>0.05$ ) effect on fat content of the cheeses (Table1).

**Table 1.** Means values of some physicochemical properties of the experimental cheeses and their statistical evaluations in terms of salt concentration and storage time\*.

Brine concentration (w/v %)	Total solids (%)	Fat (%)	Protein (%)	Ash (%)	Salt (%)	pH
11	39.01 <sup>c</sup>	20.29	12.27 <sup>b</sup>	6.368 <sup>c</sup>	4.58 <sup>a</sup>	4.78 <sup>b</sup>
14	41.40 <sup>b</sup>	19.65	12.30 <sup>ab</sup>	9.103 <sup>b</sup>	6.55 <sup>b</sup>	4.84 <sup>a</sup>
17	43.42 <sup>a</sup>	20.11	12.31 <sup>a</sup>	10.745 <sup>a</sup>	8.26 <sup>c</sup>	4.87 <sup>a</sup>
<b>Storage time (day)</b>						
1	40.26	20.32	12.34 <sup>a</sup>	7.54 <sup>c</sup>	5.17 <sup>c</sup>	5.04 <sup>a</sup>
15	41.16	20.30	12.33 <sup>a</sup>	8.34 <sup>bc</sup>	6.21 <sup>b</sup>	4.87 <sup>d</sup>
30	41.38	19.90	12.29 <sup>b</sup>	8.99 <sup>ab</sup>	6.68 <sup>ab</sup>	4.83 <sup>d</sup>
60	41.66	19.78	12.24 <sup>c</sup>	9.07 <sup>ab</sup>	6.92 <sup>ab</sup>	4.66 <sup>b</sup>
90	41.91	19.77	12.24 <sup>c</sup>	9.75 <sup>a</sup>	7.34 <sup>a</sup>	4.76 <sup>c</sup>

\*, Significant differences were obtained between mean values marked with different letter in the same column and line.

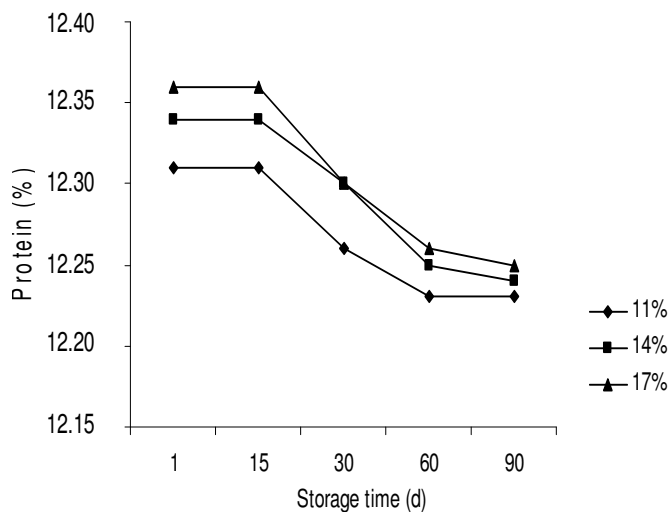
**Figure 1.** Effect of different brine concentrations on total solids of the experimental cheeses during storage.**Figure 2.** Effect of different brine concentrations on fat content of the experimental cheeses during storage.

The changes of the protein contents of the experimental cheeses are shown in Figure 3. As seen from the figure, the protein contents decreased after 15 days up to 60 days of storage and then remained constant during the rest of the aging. The effects of salt concentrations and storage period were found to be significant ( $P < 0.05$ ) (Table 1). This was probably due to hydrolysis of proteins to water soluble nitrogenous compounds and to the diffusion of these products into the brine (Abd El-Salam et al., 1993).

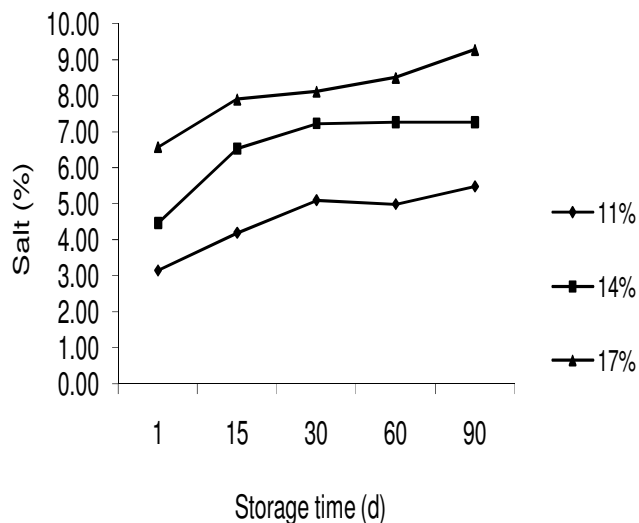
Ash values of the cheese samples are shown in Table 1 and Figure 4. As shown in the Table 1 and Figure 4, the different brine concentrations and storage times affected ( $P < 0.01$ ) the ash content during the ripening period. These results can be explained by influences of the moisture loss from the cheese samples along storage time and salt concentrations used.

The amounts of the salt contents in the cheeses were affected ( $P < 0.01$ ) by the brine concentrations and storage times (Table 1). As expected, the salt contents of the examined samples were increased with increase in the brine concentrations used in the experiments. The values of salt concentrations were increased (Figure 5) up to 30 days of storage, and then remained almost constant during the rest of the storage period. This can be explained by the lost of moisture from the samples at this period. Some authors suggested that the salt penetration was almost completed within 14 to 30 days of ripening (Pavia et al., 2000; Kaya, 2002).

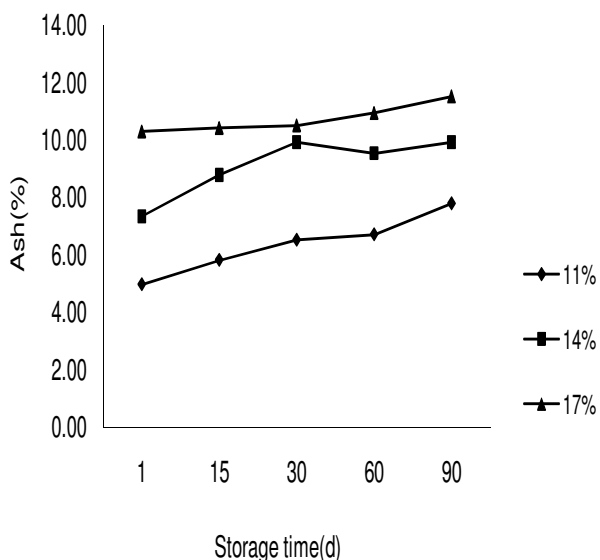
The pH of the experimental cheeses were affected by salt concentrations as well as storage time ( $P < 0.01$ ). It was observed that the pH values increased with the increasing salt concentrations of the cheese samples (Figure 6). This increase could be attributed to the



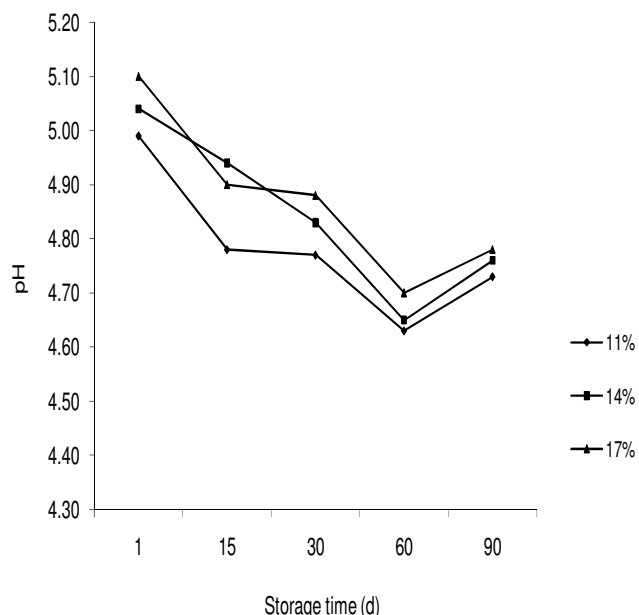
**Figure 3.** Effect of different brine concentrations on protein content of the experimental cheeses during storage.



**Figure 5.** Effect of different brine concentrations on salt content of the experimental cheeses during storage.



**Figure 4.** Effect of different brine concentrations on ash content of the experimental cheeses during storage.



**Figure 6.** Effect of different brine concentrations on pH value of the experimental cheeses during storage.

inhibitory effect of salt concentration on the activities of lactic acid bacteria (Pastorino et al., 2003). On the other hand, the pH values of the cheese samples were decreased up to 60 days of ripening and then slightly increased again during the rest of ripening (Figure 6). This change was found significant ( $P < 0.01$ ) statistically. This may be explained by the formation of some new buffer compounds and the production of ammonia from free amino acids (Kosikowski, 1982; Fox et al., 1993; Azarnia et al., 1997).

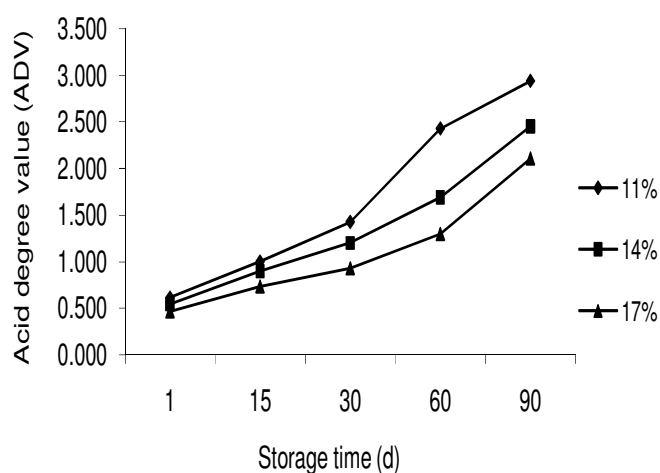
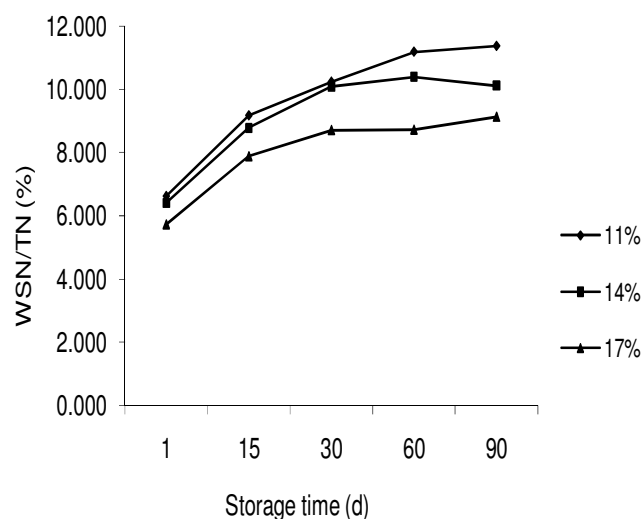
**Biochemical properties of experimental cheeses**

Acid degree value (ADV) was used in this study as the index of lipolysis. The ADV levels of all the cheeses increased significantly ( $P < 0.05$ ) after 30 days of storage (Table 2). This indicated that the level of lipolysis was positively correlated with cheese aging (During et al., 2000). These results are similar to those observed by

**Table 2.** Means values of some biochemical properties of the experimental cheeses and their statistical evaluations in terms of salt concentration and storage time\*.

Brine concentration (w/v %)	Lipolysis <sup>a</sup> (ADV)	WSN/TN <sup>a</sup> (%)	TCA-SN/TN <sup>b</sup> (%)	PTA-SN/TN <sup>a</sup> (%)
11	1.68	9.73 <sup>a</sup>	4.61	3.93
14	1.36	9.16 <sup>ab</sup>	4.37	3.45
17	1.11	8.04 <sup>b</sup>	4.03	3.17
<b>Storage time (day)</b>				
1	0.538 <sup>c</sup>	6.26c	2.46 <sup>c</sup>	2.39 <sup>c</sup>
15	0.876 <sup>c</sup>	8.62b	3.18 <sup>c</sup>	2.59 <sup>c</sup>
30	1.184 <sup>bc</sup>	9.69ab	4.78 <sup>b</sup>	3.69 <sup>b</sup>
60	1.805 <sup>ab</sup>	10.11a	5.45 <sup>ab</sup>	4.17 <sup>ab</sup>
90	2.500 <sup>a</sup>	10.21a	5.81 <sup>a</sup>	4.76 <sup>a</sup>

<sup>a</sup>, P<0.0; <sup>b</sup>, P<0.01; \*, Significant differences were obtained between mean values marked with different letter in the same column and line.

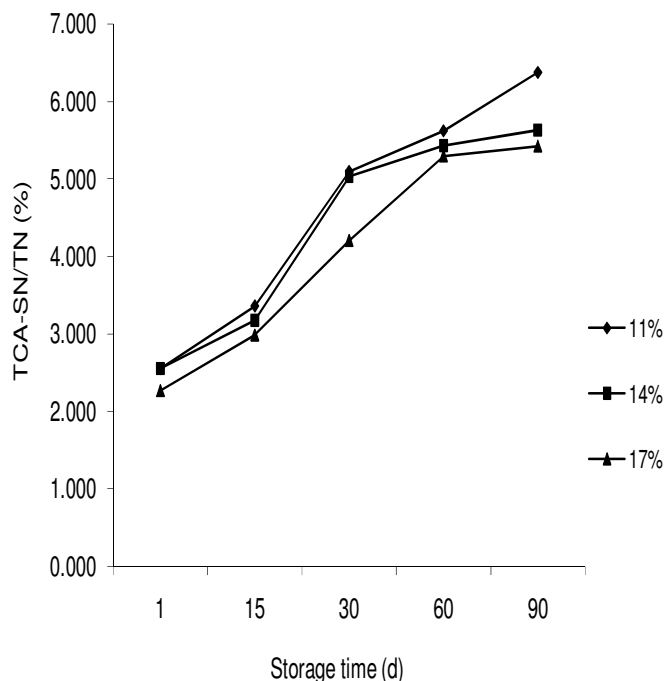
**Figure 7.** Effect of different brine concentrations on Lipolysis of the experimental cheeses during storage.**Figure 8.** Effect of different brine concentrations on WSN, % of TN of the experimental cheeses during storage.

some authors (Sousa and Malcata, 1997; During et al., 2000; Katsiari et al., 2000; Tarakci et al., 2004; Alizadeh et al., 2006) for some types of white-brined cheeses. Furthermore, a slightly variation was observed among the samples (Figure 7), but no significant ( $P > 0.05$ ) differences in ADVs were found between cheeses brined in different ratios (11, 14 and 17% NaCl) (Table 2).

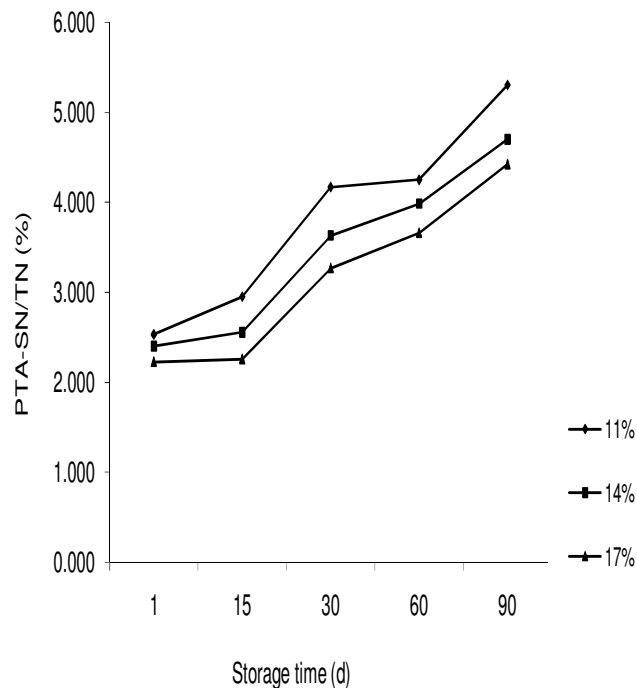
The contents of water soluble nitrogen (WSN) as a percentage of total N (TN) in the experimental cheeses increased significantly ( $P < 0.05$ ) up to day 30 of ripening, then remained almost constant during the rest of the storage period (Figure 8). On the other hand, the different salt concentrations had significant ( $P < 0.05$ ) effect on the level of WSN/TN in the cheeses, probably due to the inhibitory effect of salt on bacterial growth and enzyme activity (Guinee and Fox, 1987; Banks, 1992). Similar

results were reported by Pavia et al. (2000) for Manchego-type cheese, Guven and Karaca (2001) for white cheeses salted and ripened in brines, and Hayaloglu et al. (2005) for Turkish white-brined cheese.

The level of TCA-SN increased significantly ( $P < 0.01$ ) during storage period and this was inversely proportional to the brine concentrations of the cheeses examined (Figure 9), but the differences were not statistically significant ( $P > 0.05$ ) (Table 2). These results are in agreement with the results obtained by some authors for several brined cheeses (Pavia et al., 2000; Katsiari et al., 2000; Guven and Karaca 2001; Hayaloglu et al., 2005; Cinbas and Kilic, 2006; Guven et al., 2006; Al-Otaibi and Wilbey, 2006).



**Figure 9.** Effect of different brine concentrations on TCA-SN, % of TN of the experimental cheeses during storage.



**Figure 10.** Effect of brine concentrations on PTA-SN, % of TN of the experimental cheeses during storage.

The changes of PTA-SN contents of the experimental cheeses during ripening are given in Figure 10. As could be seen from the figure, the values of PTA-SN increased during storage period. This increase was also statistically significant ( $P < 0.05$ ) (Table 2). On the other hand, the highest PTA-SN values were obtained from the experimental cheese containing 11% of salt, but no statistically significant ( $P > 0.05$ ) differences were found among the mean PTA-SN values of the cheeses stored in different brine concentrations. Similar results were reported by Guven and Karaca (2001).

## Conclusions

According to the results, salt brine concentrations and storage time affected some physicochemical and biochemical properties of the experimental cheeses. It appeared that the different salt brine concentrations significantly affected the total solids, ash, salt, pH and WSN contents of cheese samples. No significant differences were found in fat, lipolysis, TCA-SN and PTA-SN values of the cheeses ripened in the three different salt brine concentrations. These results indicated that the storage time affected the protein, ash, salt, pH, lipolysis, WSN, TCA-SN and PTA-SN values of the cheese samples, but total solids and fat were not influenced by storage period.

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