Acta Alimentaria, Vol. 31 (4), pp. 319–326 (2002)

CHANGES IN THE SENSORY, MICROBIOLOGICAL AND COMPOSITIONAL PROPERTIES OF TURKISH WHITE CHEESE DURING RIPENING

M. ATASEVER[a]*, Z. G. CEYLAN[a] and M. ALISARLI[b]

[a] Department of Food Science and Technology, Faculty of Veterinary Science, Ataturk University, 25040, Erzurum. Turkey
[b] Department of Food Science and Technology, Faculty of Veterinary Science, Yuzuncu Yil University, 65020 Van. Turkey

(Received: 12 July 2001; accepted: 3 February 2002)

Results of the chemical, microbiological and sensorial properties of Turkish white cheese samples are presented during ripening period.

It was observed that dry matter, fat, sodium chloride, ash and acidity increased during ripening, whereas pH value decreased. Dry matter, fat in dry matter, salt in dry matter, ash in dry matter and acidity (lactic acid) contents of cheese samples were found between 35.41–39.48%, 42.54–46.10%, 10.80–11.46%, 12.33–13.49%, and 0.61–1.11%, respectively. The pH values were found between 4.98–5.68.

Also, high counts of total mesophilic bacteria and Lactobacilli were recorded throughout the ripening of the cheese. Low pH levels and high NaCl content after 30 days affected the growth of most microbial groups resulting in considerably lower counts at 3 months. Lactobacilli constituted the dominant microflora of the cheese. According to sensory evaluations, the cheese samples were more preferred with aging.

This study reported here describes chemical, microbiological and organoleptical changes, which occured during ripening of Turkish white cheese.

Keywords: Turkish white cheese, quality, microorganisms, properties

Turkish white cheese is a type of cheese produced mainly in Turkey. Similar products under different names (Akawi, Brinza, Domiati, Feta, Tellamme etc.) are made in some other countries (DAVIS, 1976; TEKINSEN et al., 1997). Turkish white cheese is a semihard, brine-ripened cheese. It is the most popular cheese consumed in Turkey and its consumption is rapidly increasing and it is produced in volumes of over 130 000 tons per year. It can be eaten while fresh, but it is mostly consumed after ripening in a brine solution for at least two months. It is made from cow's milk, sheep's milk, goat's milk or mixed milks. It is produced from pasteurized or nonpasteurized milk. In spite of its high consumption and increased production, there does not exist a well defined, standardized commercial manufacturing procedure. Some investigators had recorded

* To whom correspondence should be addressed.
Fax: +90 0442 212 11 13;
E-mail: atasever@atauni.edu.tr

0139-3006/2002/$ 5.00

(OZALP et al., 1979; ÇELIK, 1981; KARAKUS & ALPERDEN, 1992; TAYAR, 1995, ATASEVER et al., 1999) that moisture, protein, salt and ash contents were between 39.00–74.60, 12.50–25.40, 2.80–6.40, 3.30–9.30%, respectively. The same authors reported that the pH values were between 4.00–6.81. The composition of Turkish white cheese is variable, depending on the source of milk, method of production and season of production (DAVIS, 1976; TAYAR, 1995; TEKINSEN et al., 1997; ATASEVER et al., 1999).

The microbiology of Turkish white cheese is of interest, since it is processed under primary condition and consequently various types of microorganisms gain entry during manufacture and subsequent handling.

This study describes chemical, microbiological and organoleptical changes that occured during the ripening of Turkish white cheese made from pasteurized cow's milk.

1. Materials and methods

1.1. Cheesemaking

The samples of Turkish white cheese were manufactured in Afyon city of Turkey (Ikbal Dairy Products Inc., Afyon-Turkey). They were manufactured on different days and nine times. The manufacturing procedure for Turkish white cheese has been described by TEKINSEN and co-workers (1997). Turkish white cheese was manufactured in nine replicate trials using a standard protocol (TEKINSEN et al., 1997).

The milk was normally clarified and pasteurized (72 °C/1 min) before cheesemaking. The milk was adjusted to 30 °C, inoculated with starter and primed (ripened) for the required time. Lyophilized homofermentative lactic acid bacteria manufactured from CHR Hansen's Lab. A/S. Horshol (Denmark R-703) was used as a starter. Calf rennet was added (rate: 15 ml rennet for 100 l milk). After 60 min the curd was cut into cubes of approximately (1 cm×1 cm×1 cm) 1 cm^3. After draining off the whey, the curd was pressed for about 90 min. The pressed curd was then cut into pieces (8 cm×8 cm×8 cm). The cheese was salted in brine (14% sodium chloride) for about 8 h. It was then placed as layers in a tin and salt was added between each layer; any surplus whey was removed and replaced by fresh brine. It was finally stored in tin at 5± 1 °C for up to three months.

The cheese samples were analyzed on the first day of the production and after 15, 30, 60 and 90 days of the ripening period.

1.2. Analyses of cheese

Analyses for sodium chloride and total solids were carried out as outlined by INTERNATIONAL DAIRY FEDERATION (1970; 1988). Determinations of fat and lactic acid in cheese were made using procedures outlined by TURKISH STANDARD (1974). Ash was analyzed by heating an appropriate sample in a muffle furnace at 200 °C for 2 h and 550 °C for 18 h (ECONOMIDES et al., 1987). pH values were determined by INTERNATIONAL DAIRY FEDERATION method's (1989) using a NEL 821 model pH

meter. When analysed for microbiological properties, 10 g of cheese samples were blended in a mechanical blender for 2 min. Blending and subsequent dilutions were carried out with 0.1% pepton water. Plating and sample treatment were carried out as described in Standard Methods for INTERNATIONAL DAIRY FEDERATION (1984). Total mesophilic bacteria (Plate Count Agar, Difco Laboratories, Detroit, USA) and *Staphylococci*+micrococci (Baird Parker Agar, Difco) at 30 °C for 48 h, coliforms (Violet Red Bile Agar, Difco) at 37 °C for 18 h (HARRIGAN & Mc CANCE, 1976), lactobacilli under anaerobiosis at 30 °C for 48 h (MRS Agar, Difco) (MARSHALL, 1992), faecal streptococci (Barnes' Thallium Acetat Tetrasolium Glucose Agar) at 45 °C for 48 h were enumerated during ripening. Yeast and mould counts were determined in yeast exctract glucose chloramphenicol agar (Oxoid). Plates were incubeted at 22 °C for five days (MARSHALL, 1992).

Cheese samples were organoleptically examined according to the method described by BODYFELT and co-workers (1988) with maximum scores of 10, 5, and 5 for flavour, body and texture, and apperance and colour, respectively. The vocabulary used to characterise the samples was genareted by five residents of Afyon, Turkey, who were familiar with Turkish white cheese. The individuals were given samples, and were asked to taste them and describe any aspects of flavour, body and texture, and apperance and colour that are distinctive. Once the individual tasters had provided a list of descriptors, a round table discussion produced a final vocabulary comprising 12 terms: six covering flavour (salty, bitter, acidic, creamy, milky and minty), four for body and textural characteristics (crumbly, springy, moist, chewy), and two for apperance and color (white/yellow).

The chemical, microbiological, and sensorial data were subjected to analysis of variance according to DUZGUNES and co-workers (1987) using SPSS 10.0 for windows. The result of the chemical and microbiological evaluations were analysed with ANOVA in SPSS. Duncan's test was used in all data where appropriate. In addition, Pearsons' correlation test was used.

2. Results and discussion

The results of the chemical analysis of the cheese samples during the ripening are shown in Table 1. Counts of the total mesophilic aerobic bacteria, Lactobacilli, Coliforms group, Staphylococci+micrococci, faecal streptococcus and yeasts and moulds for the experimental cheese through the ripening period are shown in Table 2. Organoleptical properties of the cheese samples are shown in Table 3.

According to the results of the chemical analysis, dry matter (%) of the samples increased continuously and at the end of the ripening period it was close to 40%. This increase was found to be statistically significant. It is similar to some investigators' results (ATASEVER, 1995; TAYAR, 1995).

Table 1. Results of the chemical analysis of the cheese samples during ripening

Age (days)	n	Dry matter (%)		Fat[1]		Salt[1]	
		Mean	Std. Error	Mean	Std. Error	Mean	Std. Error
1	9	35.41^{c}	0.63	43.36	1.90	10.80	0.56
15	9	36.65^{bc}	0.69	44.13	1.61	11.16	0.77
30	9	37.78^{abc}	0.82	42.54	2.21	11.34	0.87
60	9	39.05^{ab}	1.06	46.24	2.09	11.39	0.77
90	9	39.48^{a}	0.95	46.10	2.12	11.46	0.80

Age (days)	n	Ash[1]		Acidity[2]		pH	
		Mean	Std. Error	Mean	Std. Error	Mean	Std. Error
1	9	12.33	0.66	0.61^{b}	0.07	5.68^{a}	0.13
15	9	12.81	0.89	0.69^{b}	0.05	5.47^{a}	0.15
30	9	12.90	1.03	0.72^{b}	0.05	5.40^{ab}	0.18
60	9	13.33	1.05	0.96^{a}	0.08	5.25^{ab}	0.15
90	9	13.49	1.01	1.11^{a}	0.09	4.98^{b}	0.15

[1] in dry matter (%);
[2] titratable acidity of lactic acid (%)
n: number of samples investigated
Different letters within the same column indicate statistically significant difference (P<0.05).

Table 2. Results of the microbiological analysis of the cheese samples during ripening log CFU g^{-1}

Age (days)	n	Total mesophilic aerobic bacteria		Lactobacillus group		Coliform group	
		Mean	Std. Error	Mean	Std. Error	Mean	Std. Error
1	9	8.22^{a}	0.45	5.90	0.58	2.20^{a}	0.63
15	9	7.50^{a}	0.33	6.00	0.58	1.81^{a}	0.64
30	9	6.73^{ab}	0.43	5.25	0.77	1.60^{a}	0.45
60	9	5.73^{b}	0.60	5.37	0.71	0^{b}	0
90	9	5.06^{b}	0.88	4.67	0.70	0^{b}	0

Age (days)	n	*Staphylococcus-Micrococcus*		Faecal streptococcus		Yeast and Moulds	
		Mean	Std. Error	Mean	Std. Error	Mean	Std. Error
1	9	4.81^{a}	0.35	4.46^{a}	0.15	1.02	0.53
15	9	4.68^{a}	0.36	4.61^{a}	0.32	1.12	0.56
30	9	4.25^{a}	0.48	3.33^{b}	0.13	1.03	0.54
60	9	2.85^{b}	0.80	2.71^{b}	0.18	0.50	0.33
90	9	1.69^{b}	0.70	1.33^{c}	0.44	0	0

n: number of samples investigated
Different letters within the same column indicate statistically significant difference (P<0.05).

Table 3. Results of the organoleptical evaluation of the cheese samples during ripening

Age (days)	n	Flavour		Body and texture		Appearance and colour	
		Mean	Std. Error	Mean	Std. Error	Mean	Std. Error
1	45	–	–	–	–	–	–
15	45	5.62^{d}	0.26	2.47^{c}	0.17	2.29^{c}	0.16
30	45	6.47^{c}	0.29	3.49^{b}	0.17	3.38^{b}	0.17
60	45	7.38^{b}	0.29	3.80^{ab}	0.16	4.17^{a}	0.17
90	45	8.91^{a}	0.24	4.22^{a}	0.16	4.47^{a}	0.17

n: number of samples investigated x 5 panelists
Different letters within the same column indicate statistically significant difference ($P<0.05$).
–: Sensory analyses were not performed in those stages

A positive correlation was observed between the dry matter and sodium chloride in dry matter, fat in dry matter, coliform groups bacteria, total mesophilic aerobic bacteria, Lactobacillus and faecal streptococcus bacteria. Fat in dry matter (%) was found between 43.36% and 46.24%.

Sodium chloride and ash in dry matter (%) of the cheeses increased continously during ripening; and they well correlated in the ripening period. This situation has been also reported by other researchers (ATASEVER, 1995; TAYAR, 1995). It has been reported that salt helps some microorganisms to grow, regulates to some extent the taste, and limits the activities of enzymes. There was a negative correlation between salt and dry matter, pH, *Staphylococcus-Micrococcus*, yeast and moulds; and a positive correlation between fat in dry matter, ash in dry matter, total mesophilic aerobic bacteria, and lactobacilli.

From Table 1, it can be concluded that acidity of cheese increased and pH values decreased during the ripening period. These findings were found to be statistically significant. The decrease in pH during the ripening (Table 1) may be considered as a consequence of acid production by the increasing microbial populations. Similar results were found by EL-SODA (1977), TZANETAKIS and TZANETAKIS (1992), TAYAR (1995) and ATASEVER and co-workers (1999). There were negative correlations between pH values and acidity (%). A negative correlation was determined between acidity and pH, total aerobic mesophilic bacteriae and faecal streptococcus. A negative correlation was determined between pH and fat in dry matter, NaCl in dry matter, acidity (%) and lactobacilli. There was a positive correlation between *Staphylococci-Micrococci* and faecal streptococcus.

The $\log_{10}$ values for total mesophilic aerobic bacteria were between 8.22 and 5.06 CFU g^{-1} at the begining and at the end of ripening, respectively. Table 2 shows changes of total mesophilic aerobic bacteria population during the 90-day ripening. Initially the total mesophilic aerobic bacteria were found at about 10^8 CFU g^{-1}. Then they declined slowly. This decline may be due to penetration of the salt, decreasing pH and other changes in the maturing cheese. A decline in the total number of mesophilic aerobic bacteria during the ripening period was found to be significant ($P<0.05$).

A negative correlation was determined between the total number of mesophilic aerobic bacteria and dry matter (%), acidity (%) and a positive correlation was determined between fat in dry matter, NaCl in dry matter, lactobacilli, coliform groups bacteria and faecal streptococcus. Similar results have been reported by many researchers (DEL POZO et al., 1988; TZANETAKIS & TZANETAKIS, 1992; ATASEVER, 1995; TAYAR, 1995).

The levels of coliform bacteria in the cheese samples were 10^2 CFU g^{-1} at the beginning of ripening. The number of the coliform group microorganisms declined during the ripening period and no coliform group microorganisms were found from the 60th day onwards in the cheese. A negative correlation was determined between the number of coliform group microorganism and dry matter (%) and positive correlation was determined between *Staphylococcus-Micrococcus*, total aerobic mesophilic, *Lactobacillus* and faecal streptococcus. These findings support the suggestions on some researchers (OZALP et al., 1979; CELIK, 1981; ATASEVER, 1995), that in the milk processed for cheese, coliform group microorganisms are destroyed. However, they contaminate the cheese during the production period (KARAKUS & ALPERDEN, 1992). This situation shows clearly that during the cheese production period, it is necessary to look out for the hygienic conditions. It has been well established that cheeses, especially soft cheese, are involved in enteropathogenic *E. coli* gastroenteritis (BANWART, 1979) and thus a potential problem is clearly high-lighted.

The moulds and yeasts, like the coliforms, seem to have originated from contamination in dairy plant environment. The moulds and yeasts have been considered a common problem during aging and refrigerated storage of cheese and the significance of these microorganisms in cheese primarily as spoilage organisms is well established. Numbers of moulds and yeasts also increased slightly (0.1 log units) during ripening for 15 days, even though pH decreased to levels favourable for their growth; this suggests the possible presence of salt sensitive species. But their presence appeared to have no adverse effect on quality, in that no off-flavours, visible colonies or any swelling of packets or tins due to CO_2 production (WESTALL & FILTENBORG, 1998) were detected. Similar results were reported by FATICHENTI andt co-workers (1979) and TZANETAKIS & TZANETAKIS (1992). A negative correlation was determined between the number of yeast and moulds in the cheese samples and fat in dry matter, NaCl in dry matter, ash in dry matter; and a positive correlation was determined *Staphylococcus-Micrococcus* and feacal streptococcus. On the 90th day of the aging no yeast and moulds growth were observed.

At the begining, the number of *Lactobacillus* were determined to be 5.90 CFU g^{-1} ($\log_{10}$ values). On the 90th day it was 4.67 CFU g^{-1} ($\log_{10}$ values). It was observed that the number of *Lactobacillus* was high and it constituted the dominant flora of the cheese. It was determined that there was a negative correlation between *Lactobacillus* and dry matter and pH values; a positive correlation between fat in dry matter, NaCl in dry matter, ash in dry matter, coliform and total mesophil bacteria.

Initially, the number of faecal streptococci was 4.46 CFU g^{-1} ($\log_{10}$ values) and on the 90th day of ripening period, it was 1.33 CFU g^{-1}. This decrease was statistically significant. The high frequency of occurrence of faecal streptococci in dairy products

and Turkish white cheese have also been reported by other researchers (INSALATA et al., 1969; TURANTAS et al., 1989). The high coliform and faecal streptococci levels found in Turkish white cheese reveals the sanitary quality of the cheese. A negative correlation was observed between the number of faecal streptococcus microorganisms and dry matter and acidity and a positive correlation between pH, coliform, *Staphylococci*-micrococci, total aerobic mesophilic and moulds and yeasts.

It was determined that the number of *Staphylococcus-Micrococcus* microorganisms decreased, depending on the proceedings of ripening. The number of microorganisms which was 4.81 CFU g^{-1} ($\log_{10}$ value) initially in the cheese, decreased to 1.69 CFU g^{-1} ($\log_{10}$ value) on the 90th day. Similar findings were determined also by OZALP and co-workers (1979), TZANETAKIS & TZANETAKIS (1992) and TAYAR (1995). A negative correlation was determined between the number of *Staphylococcus-Micrococcus* microorganisms and fat in dry matter, NaCl in dry matter, and ash in dry matter and; positive correlation, between pH values, coliform, yeast-mould and faecal streptococcus.

Ripening time had an important effect on flavour, appearance and colour, and body and texture. Cheese samples were criticized for lack of flavour until the 60th day of the ripening.

3. Conclusions

In conclusion, it was observed that dry matter, fat, sodium chloride, ash and acidity increased during the ripening period, whereas pH value decreased. Also, the number of microorganisms decreased during the ripening period. Lactobacilli constituted the dominant flora of the cheese. It is clear that during the cheese production period, it is necessary to look out for the hygienic conditions.

References

ATASEVER, M. (1995): Civil Peynirinin Uretiminde Farkli Asitlikteki Sutlerin Kullanimi ile Tuzlama Tekniklerinin Kaliteye Etkisi Uzerine Arastirmalar. (Studies on the effects of salting techniques and different acidity values of milk used in civil cheese production.) Thesis, Selçuk Univ. Sağlik Bil. Enst., Konya, 84 pages.

ATASEVER, M., UCAR, G., KELES, A. & KOSE, Z. (1999): *Beyaz peynir uretiminde sivi duman uygulamalari.* (Using of liquid smoke in Turkish white cheese production.) S.U. *Vet. Bil. Derg.*, *15* (1), 63–70.

BANWART, G. J. (1979): *Basic food microbiology*. Avi. Publ. Co., Westport, CN, 781 pages.

BODYFELT, F. W., TOIAS, J. & TROUT, G. M. (1988): *The sensory evaluation of dairy products*. AVI, Westport, pp 300–376.

CELIK, C. (1981): *Cesitli Starter Kulturleri Kullanarak Salamura Beyaz Peynirin Standardizasyonu Uzerine Calismalar.* (Use of some starter cultures in white pickled cheese production.) The scientific and technical research council of Turkey, VHAG No: 488.

DAVIS, J. G. (1976): *Cheese manufacturing methods*. Vol. III., Churchill Livingstone, London, 876 pages.

DEL POZO, B. F., GAYA, P. MEDINA, M., RODRIQUEZ-MARIN, M. A. & NUMEZ, M. (1988): Changes in the microflora of La Serana ewe's milk cheese during ripening. *J. Dairy Res.*, *55*, 449–455.

DUZGUNES, O., KESICI, T., KAVUNCU, O. & GURBUZ, F. (1987): *Istatistik metotlari-II.* (Statistical methods-II.) A.U. Zir. Fak. Yay. 2021, Ankara, 381 pages.

ECONOMIDES, S., GEORGHIADES, E. & MAVROGENIS, A. P. (1987): The effect of different milks on the yield and chemical composition of halloumi cheese. *Agr. Res. Inst. Ministry of Agr. And Natural Resources, Technical bulletin 90*, Cyprus.

EL-SODA, M. A. I. (1977): Studies on Provolone cheese. *J. Dairy Sci.*, *29* (2), 88–94.

FATICHENTI, F., DEIANA, P., FARRIS, G. A. & SOGGIA, G. (1979): Etudes microbiologiques sur le lait et le fromage de chevre en Sardigne. Note II: streptocoques, lactobacilles et leuconostoc. *Le Lait*, *587*, 387–400.

INSALATA, N. F., WITZEMAN, J. S. & SUNGA, F. C. A. (1969): Faecal streptococci in industrially processed foods. *Fd Technol.*, *23*, 1316–1318.

INTERNATIONAL DAIRY FEDERATION (1970): *Determination of dry matter in whey cheese*. Standard 58, International Dairy Federation, Brussels.

INTERNATIONAL DAIRY FEDERATION (1984): Milk and milk products. Preparation of test samples and dilutions for microbiological examination. Standard 122, International Dairy Federation, Brussels.

INTERNATIONAL DAIRY FEDERATION (1988): *Determination of the salt content*. Standard 12B, International Dairy Federation, Brussels.

INTERNATIONAL DAIRY FEDERATION (1989): *Determination of pH*. Standard 115A, International Dairy Federation, Brussels.

HARRIGAN, W. F. & MC CANCE, M. E. (1976): *Laboratory methods in food and dairy microbiology*. Revised ed., Academic Press, London, 451 pages.

KARAKUS, M. & ALPERDEN, I. (1992): Beyaz peynirin olgunlasma suresince mikrobiyolojik ve kimyasal ozelliklerindeki degismeler. (Changes in the microbiological and chemical properties of Turkish white cheese production.) *Gida Sanayii*, *6* (2), 34–47.

MARSHALL, R. T. (1992): *Standard methods for the examination of dairy products*. 16th ed., APHA, 1015, Washington, 547 pages.

OZALP, E., KAYMAZ, S., YUCEL, A. & AKGUN, S. (1979): Inek sutu ile yapilan salamura beyaz peynirlerde hijyen indeksi bazi mikroorganizmalar uzerinde arastirma. (Some hygenic microorganisms in white cheese produced from cow's milk.) *A.U. Vet. Fak. Derg.*, *26* (3,4), 277–286.

TAYAR, M. (1995): Beyaz peynirlerin olgunlasmasi suresince kimyasal ve mikrobiyolojik ozelliklerindeki değismeler. (Changes in the microbiological and chemical properties of Turkish white cheese production.) *Gida*, *20* (2), 97–101.

TEKINSEN, O. C., ATASEVER, M. & KELES, A. (1997): *Sut urunleri uretimi ve kontrolu.* (Production and control of dairy production.) Selcuk University Press, Konya, 87 pages.

TURANTAS, F., UNLUTURK, A. & GOKTAN, D. (1989): Microbiological and compositional status of Turkish white cheese *Int. J. Fd Microbiol.*, *8*, 19–24.

TURKISH STANDARD (1974): *Beyaz peynir*. [(Turkish) White cheese]. Ankara, TS No: 591.

TZANETAKIS, E. L. & TZANETAKIS, N. (1992): Microbiological study of white-brined cheese made from raw goat milk. *Fd Microbiol.*, *9*, 13–19.

WESTALL, S. & FILTENBORG, O. (1998): Yeast occurrence in Danish Feta cheese. *Fd Microbiol.*, *15*, 215–222.