HACETTEPE JOURNAL OF BIOLOGY AND CHEMISTRY Research Article
Hacettepe J. Biol. & Chem., 2008, 36 (3), 197-206

Factors Affecting Histamine and Tyramine Formation in Turkish White Cheese

H. Nilgün Filiz Budak[1], Aynur Gül Karahan[1], M. Lütfü Çakmakçı[2]

[1]Suleyman Demirel University, Faculty of Engineering and Architecture, Department of Food Engineering, Isparta, Turkey.

[2]Ankara University, Faculty of Engineering, Department of Food Engineering, Ankara, Turkey.

Abstract

In this study, White cheese was produced to determine concentrations of biogenic amines of cheese samples depending on microorganism level, storage temperature and ripening periods. Trials were planned as 3 replicates. The dry matter, the pH and the salt values were correlated with the results of the amino acids and of the biogenic amines. *E. coli* 43895 caused the highest concentration of histamine (265.5 ppm) in cheese at 10°C after 90 days of ripening. Decreasing of the lactococci caused increased tyramine concentration. According to the results of this experiments showed that the determination of the level of the biogenic amines of cheese would be necessary as a routine analysis in parallel to microbiological tests.

Key Words*:* Biogenic amine, White cheese, HPLC, Ripening periods and *Escherichia coli* 43895.

INTRODUCTION

Biogenic amines are aliphatic, alicyclic and heterocyclic organic bases which increase with metabolic activity in animals, plants and microorganisms. Biogenic amines are naturally present at low concentrations in foods. However they can also occur at higher concentrations in fermented food products. Biogenic amines are formed as a result of microbial decarboxylation of certain amino acids in foods. Therefore, biogenic amines are associated with food deterioration and food safety [1-3]. Cadaverine, putresine, tyramine and histamine have been accepted as spoilage indicators in foods [4]. Since the content of biogenic amines foods are influenced by hygienic conditions of food processing and storage, the determination of biogenic amines can provide useful information about food quality.

Cheese is an ideal environment for biogenic amine formation [5-7]. The major factors determining the amounts and varieties of biogenic amines are amino acids, suitable for biogenic amine formation, and amino acid decarboxylating bacteria [8]. There are many factors which effect the formation of biogenic amines [1,6,9]. These are pH value, low salt concentration, water availability, temperature, maturation and storage period, bacterial counts, presence of cofactors and amine metabolism.

* Correspondence to: Aynur Gül Karahan,

Suleyman Demirel University, Faculty of Engineering and Architecture, Department of Food Engineering, Isparta, Turkey.

Tel: +90246 211 15 39 Fax: +90246 237 08 59

E-mail: aynur@sdu.edu.tr

In the maturation period, each cheese variety gains a specific structure, contents and, most importantly, its particular sensory properties. During ripening period of cheese mainly proteolysis, lipolysis and glycolysis occur which are demanded by the consumers, but at the same time biogenic amines are also formed via amino acid decarboxylation [10,11]. Cheese is the cause of histamine poisoning and comes immediately after fish in this respect. Moreover, in addition to histamin, presence of tyramine was also found to be associated with food poisonings [12,13]. Bacteria forming biogenic amines are derived from raw milk, from contamination of cheese during production or storage and also from starter cultures [14]. Biogenic amines have been reported to cause physiological effects such as, hypertensive, fever, urticaria, ulcers of stomach and of colon. All these effects are related to sensitivity of the individual consumer, his/her alcohol consumption, some pharmaceuticals which may have been previously taken and the presence of other biogenic amines [7].

Effective microorganisms used in a fermentation process produce much more biogenic amines than that of native flora of raw material. However, some microorganisms such as *Enterobacteriaceae*, lactobacilli, pediococci and enterococci have been determined as the biogenic amine producers [3,15]. White cheese is a soft or semi-soft cheese variety which is produced from cow's, goat's or ewe's milk or a mixture of these and then ripened in brine. In small-scale production facilities, pasteurized milk and starter cultures may not be used for the production of White cheese [16] For this reason, cheese flora comes from the indigenous milk flora and the contaminants. Although biogenic amine levels of White cheese were reported by some researchers [17], contaminants effecting biogenic amine formation were not investigated during ripening of White cheese matured in brine. The subject of this study was determination of the effects of *E. coli* 43895 on histamine and tyramine formation of White cheese at the different storage temperature and a 90-day ripening period.

MATERIALS AND METHODS

Cultures

In this study, *E. coli* 43895 provided from Department of Food Engineering (Microbiology), Faculty of Engineering, Ankara University, Ankara-Turkey were used as the test microorganisms together with the mesophilic starter culture, G3 Mix 6 (Wisby).

Manufacturing of Cheese

The steps that were taken in the manufacturing of White cheeses containing starter culture and *E. coli* are as follows. At the beginning of the production, all equipment has been disinfected thoroughly to prevent contaminations. Raw cow's milk was clarified, standardized and pasteurized at 85°C for 3-4 min. After cooling to 32°C, the pasteurized milk was divided to two vats. Rennet and $CaCl_2$ (0.024%) were added to the vats and these were inoculated with starter cultures at the rate of 0.7%. One of the vats was separated as control and the other vat was inoculated with *E. coli* 43895 at the rate of 0.7%. The remainder of the procedure closely followed the cheese making steps that were described by Hayaloglu, Guven, and Fox [18]. Both groups were ripened for 90 days at 4°C, 10°C and 20°C. The cheese samples were taken after 1, 15, 30, 60 and 90 days of ripening. The sample designations are as shown in Table 1. The trials were carried out in three replicates.

Chemical Analyses

Dry matter, salt and fat contents of the samples were

Table 1. Treatments of white cheese.

Example	Temperature (°C)	Code
Control	4	K
E. coli 43895	4	C
Control	10	K1
E. coli 43895	10	C1
Control	20	K2
E. coli 43895	20	C2

determined according to TSI (Turkish Standards Institute) standard methods [19]. The pH was measured with a pH meter (WTW 537). All analyses were carried out in duplicate.

Microbiological Analyses

The White Cheese samples (10 g) were weighed aseptically and homogenized in sterile 2% sodium citrate solution by using a sterile blender (Waring, USA). In the same solution decimal dilutions were prepared. By using a drop culture method, *E. coli* counts were determined in Eosin Methylene Blue Agar (EMB) and lactococci in M17 Agar (Difco, USA). All plates were incubated for 24-48 h at 37°C. In the control cheeses coliforms and *E. coli* were counted using Most Probable Number methods to determine whether or not any contamination occurred during cheese making process [20-23].

Determination of Biogenic Amines and Their Precursors

A blended cheese sample (10 g) was added to 25 mL trichloroacetic acid solution (5%, w/v), mixed and cooled to 3°C. Samples (8-9 mL) were centrifuged at 10 000 *g* for 10 min at the same temperature. After the fat was collected from the bottom of the centrifuge tube, the supernatant was filtered through a rough filter paper and then a 0.45 mm sterile filter (Schleicher&Schuell) for HPLC determination [8]. The HPLC runs were carried out using a Shimadzu model liquid chromatograph at 215 nm. It contained a stem control unite (SCL-10A vp), a pump (LC-10 AD vp), a diode array detector, an auto injector (SIL–10AD vp), a column oven (CTO 10 A vp) and a degasser (DGU- 14A). The column was YMC-ODS (YMC-Pack ODS-AM). The mobile phase was acetonitrile/water mixture (28 / 72; pH 2.50). Hexanesulfonic acid sodium salt was used as ion pair reagent. The flow rate was set at 0.8 mL/min and column temperature was 30°C [24]

Statistical Analyses

The effect of ripening time and temperature on all parameters of cheeses was assessed by analysis of variance (ANOVA) using SPSS for Windows version 10 (SPSS Inc., Chicago IL, USA).

RESULTS AND DISCUSSION

Physicochemical Properties of Cheeses

As shown in Table 2, the results were obtained from the physicochemical analyses of the three batches throughout the ripening period.

The solid material levels of fresh cheeses were higher than 40%, but changed after a 90 day ripening period. In all experiments, except for K2, the solid material decreased proportionately. These results agreed with the values obtained from similar cheeses [25, 26]. The exchange of salt and water during ripening period caused changes in the contents of dry matter as well as fat in White cheeses. Although fat contents increased in relation to the storage period, decomposition of cheeses caused a reduction of dry matter and an increase of fat content to a higher level than normal conditions. However, analyses of variance showed that differences among the batches were not significant ($p>0.01$). Fat contents of control group showed a slight fluctuation at 4°C and 10°C, however increased at 20°C which was similar to *E. coli* groups. The storage temperature was increased in

Table 2. Changes of physicochemical properties of cheeses.

Parameter	StorageTime (days)	4°C		10°C		20°C	
		K	C	K1	C1	K2	C2
Dry matter	0	41.695 ± 2.66	42.478 ± 0.77	41.695 ± 2.66	42.478 ± 0.77	41.695 ± 2.66	42.478 ± 0.77
	15	40.550 ± 3.35	37.646 ± 3.19	39.897 ± 2.51	40.673 ± 4.06	41.641 ± 3.31	40.290 ± 3.29
	30	35.802 ± 2.83	35.613 ± 0.65	37.048 ± 1.80	36.512 ± 1.34	39.517 ± 2.97	40.436 ± 2.49
	60	37.025 ± 1.38	36.230 ± 2.12	36.408 ± 2.11	37.870 ± 1.87	41.777 ± 1.29	39.524 ± 2.05
	90	36.831 ± 0.36	38.428 ± 2.06	37.258 ± 2.69	39.032 ± 0.31	42.693 ± 1.74	38.166 ± 2.55
pH	0	5.07 ± 0.073	4.83 ± 0.069	5.07 ± 0.073	4.83 ± 0.069	5.07 ± 0.073	4.83 ± 0.069
	15	4.81 ± 0.04	4.83 ± 0.036	4.84 ± 0.104	4.69 ± 0.099	4.77± 0.076	4.78 ± 0.181
	30	5.09 ± 0.158	4.71 ± 0.080	5.07 ± 0.237	5.07 ± 0.245	5.34 ± 0.255	5.22 ± 0.248
	60	4.93 ± 0.246	4.78 ± 0.117	5.23 ± 0.039	5.41 ± 0.217	5.66 ± 0.320	5.99 ± 0.217
	90	5.08 ± 0.205	4.86 ± 0.085	5.67 ± 0.431	5.92 ± 0.636	5.54 ± 0.312	5.34 ± 0.270
Fat (%)	0	19.66 ± 1.202	22.33 ± 1.453	19.66 ± 1.202	22.33 ± 1.453	19.66 ± 1.202	22.33 ± 1.453
	15	20.00 ± 2.646	19.33 ± 3.180	19.66 ± 2.333	20.00 ± 2.309	21.33 ± 2.028	22.00 ± 2.517
	30	18.00 ± 1.732	19.00 ± 2.309	18.66 ± 1.856	20.00 ± 2.309	21.00 ± 2.517	21.66 ± 3.182
	60	19.00 ± 1.528	19.33 ± 1.764	18.66 ± 0.882	20.33 ± 1.914	22.33 ± 2.667	24.00 ± 1.528
	90	19.00 ± 1.528	18.66 ± 1.667	18.66 ± 1.202	22.33 ± 0.882	24.00 ± 2.082	26.66 ± 1.453
Salt (%)	0	0.766 ± 0.088	3.233 ± 2.384	0.766 ± 0.088	3.233 ± 1.229	0.766 ± 0.088	3.233 ± 1.229
	15	8.333 ± 0.633	7.566 ± 0.775	7.566 ± 0.240	7.966 ± 0.913	8.033 ± 0.437	7.800 ± 0.896
	30	7.666 ± 0.551	7.200 ± 0.436	8.000 ± 0.361	7.300 ± 0.731	8.533 ± 1.436	8.066 ± 0.814
	60	7.556 ± 0.115	7.100 ± 0.656	7.600 ± 0.656	7.366 ± 0.289	8.700 ± 1.386	8.600 ± 0.964
	90	7.500 ± 0.200	7.433 ± 0.503	7.733 ± 0.569	7.700 ± 0.200	7.500 ± 1.039	7.533 ± 0.351

order to shorten the ripening period of White cheese. Depending on the increment of increase of the storage temperature, bacterial metabolism rise rapidly and cheese components are converted to the useful forms for bacteria. This could explain the decomposition of cheeses.

All pH values of cheeses, stored at 4°C, increased, except for control cheeses in spite of the fact that a decrease of the pH value were expected in the ripening period of White cheeses, However, all pH changes in all of the batches were not statistically significant ($p>0.01$).

Throughout the experimental period the salt content of cheeses showed a fluctuation, but these changes were not found to be important ($p>0.01$). Although increases of salt content in White cheese were reported by various researches [27-29], there are some findings similar as our results [30,31]. It is thought that the salt level fluctuated due to variations of the dry matter content of White cheese.

Microbiological Properties of Cheeses

Lactococci and *E. coli* were counted throughout ripening. The results are given in Table 3. The lactococci counts were the highest level at the beginning of the experiment. Their counts showed a slight decrease at 4°C. During ripening at 10°C and 20°C, a sharp drop was determined. The decreases of lactococci counts of all groups, except for K1 and K2, were relatively low. However, no significant differences between the batches were found ($p>0.05$). Tunail, Uraz, Alpar & Halkman [32] reported similar results for White cheese samples, while, in this research, lactococci counts changed rapidly.

Table 3. Changes of microbial counts during storage period (cfu $\log_{10}$/g).

Bacterial Counts	Storage Time (days)	4°C		10°C		20°C	
		K	C	K1	C1	K2	C2
Lactococci	0	9.49 ± 0.14	9.66 ± 0.16	9.49 ± 0.14	9.66 ± 0.16	9.492 ± 0.136	9.66 ± 0.16
	15	8.25 ± 0.33	8.46 ± 0.31	7.98 ± 0.08	8.31 ± 0.73	7.341 ± 0.110	6.87 ± 0.23
	30	7.83 ± 0.70	7.87 ± 0.61	7.36 ± 0.31	6.85 ± 0.15	6.490 ± 0.085	6.96 ± 0.60
	60	7.59 ± 0.43	6.44 ± 0.65	5.83 ± 0.62	6.22 ± 0.61	6.145 ± 0.223	6.48 ± 0.57
	90	7.07 ± 0.34	5.67 ± 0.57	5.21 ± 0.45	6.17 ± 0.67	5.254 ± 1.062	5.91 ± 0.22
E. coli	0	-	8.63 ± 0.52	-	8.63 ± 0.52	-	8.63 ± 0.52
	15	-	7.02 ± 0.20	-	6.06 ± 0.59	-	5.50 ± 0.83
	30	-	4.73 ± 1.03	-	6.03 ± 0.33	-	5.43 ± 0.63
	60	-	5.40 ± 0.29	-	5.35 ± 0.58	-	5.53 ± 0.14
	90	-	4.06 ± 0.43	-	5.28 ± 0.30	-	5.73 ± 0.32

With MPN methods, the coliform bacteria were not observed in the control group samples. This result indicated that the experiments were carried out under sufficiently hygienic conditions. However, *E. coli* remained alive in C samples throughout the ripening process. The bacteria counts decreased after 15 days. This decrease was related to the increase of storage temperature, but similar interaction was not determined for the other ripening periods (i.e. 30, 60 and 90 days). *E. coli* counts of C and C1 groups reduced by 3-4 log units during the ripening period. Although the bacteria counts of C2 group also decreased, they increased slightly at certain ripening periods. These differences were not statistically significant ($p>0.05$). Inhibition effect of starter cultures was observed to be insufficient in the samples having high *E. coli* counts at the beginning of the process. Tunail, Uraz, Alpar & Halkman [32] reported that coliform counts of White cheese samples decreased by 2-3 log units during ripening. Coliforms at the low rate could be controlled without difficulty. Our findings and other results showed that contaminations during cheese making effected cheese quality significantly. Although starter cultures can inhibit contaminants via producing antimicrobial substances, ripening period should be prolonged with respect to contaminant counts. However, prolongation of ripening period is not an economical procedure and may create health risks via production of metabolites such as biogenic amines. For these reasons, taking precautions for preventing of contaminations have great importance during cheese making process.

Biogenic Amines and Amino Acids

Histamine, phenylethylamine, tyramine and trpytamine were separated in White cheese samples. Phenylethylamine and trpytamine were not detected during the ripening period. Although the main subject of this study was determination whether White cheese can be potential histamine poisoning source or not, tyramine which was reported to be the most abundant biogenic amines in White cheese [9, 33] was also analyzed. The detection limit was less than 2 ppm. The relative standard deviations have been found to be less than 5% and good recoveries (>90%) were obtained. The data on histamine, tyramine and their precursor amino acids contents analyzed during cheese ripening are as shown in Table 4. Initial levels of histidine and tyrosine differed from zero. Bütikofer &

Table 4. Amino acids and biogenic amines during ripening period.

BA and AA (ppm)	Storage Time (days)	4°C		10°C		20°C	
		K	C	K1	C1	K2	C2
Histidine	0	27.8	27.7	27.8	27.8	27.8	27.8
	15	10.4	7.6	4.6	7.3	4.2	2.6
	30	28.9	9.0	9.0	11.2	13.0	22.3
	60	9.4	9.7	15.2	36.1	69.2	189.7
	90	17.6	14.7	361.0	141.3	131.2	135.2
Histamine	0	-	-	-	-	-	-
	15	-	-	-	10.3	8.5	2.0
	30	-	-	0.5	8.7	36.7	0.2
	60	-	0.2	12.0	35.1	84.2	0.4
	90	-	-	59.0	265.5	47.2	1.0
Tyrosine	0	75.2	44.2	75.2	44.2	75.2	44. 2
	15	38.9	25.1	35.0	23.7	28.3	28.6
	30	34.3	26.2	32.2	33.1	28.4	82.5
	60	34.9	25.9	44.0	50.2	222.2	452.2
	90	38.2	19.3	80.1	327.9	228.9	428.8
Tyramine	0	-	-	-	-	-	-
	15	0.9	-	1.2	-	1.4	1.7
	30	-	-	-	-	-	3.9
	60	-	-	-	1.1	-	15.2
	90	-	0.6	-	-	-	19.1

Fuchs [34] suggested this situation to be related with starter culture activities at the day of manufacture. Histidine and tyrosine concentrations increased corresponding to ripening period with the exception of samples stored at 4°C. Amino acid contents of both groups at 4°C declined, while there was a significantly ($p<0.05$) positive correlation between increased storage temperature and histidine contents. Similar effect was observed between ripening period and histidine contents. The results were in agreement with those reported by Pinho, Ferreira, Mendes, Oliveira, and Ferreira [35]. Although histidine contents of samples at 10°C were lower than at 20°C after 60 days, an opposite trend was determined after 90 days. Ripening period and temperature also had a significant effect on the tyrosine contents ($p<0.01$). Fluctuation of amino acid contents was attributed to transport of low molecular weight substances from cheese cubes to the brine.

Histamine was the major biogenic amine in cheese samples. While formation of biogenic amines was not detected in control cheese samples at 4°C, *E. coli* 43895 produced very low level biogenic amines at the same storage temperature. However, in the other experimental groups biogenic amines were determined at the different levels. Starter cultures used to manufacture the safe and standard quality products also formed biogenic amines. To verify

these results, further studies should be carried out because there are various parameters effecting histamine formation at the condition of dairy plant. According to our results the amount of biogenic amines formed by *E. coli* 43895 was evidently higher than that of cheese samples with a starter culture. Histamine concentration reached 265.5 ppm after 90 days ripening at 10°C. As clinical illness has been associated with consumption of 100-225 mg/kg histamine in food [14,36], it is likely that this level of histamine could cause foodborne intoxication. In various studies, *Enterobacteriaceae* members were found to be responsible for the formation of putrecine and cadaverine [14] as well as histamine [3]. In this study, toxic levels of histamine were detected in White cheese with *E. coli* 43895.

Although the major biogenic amine was tyramine in brine ripened cheeses such as Feta and White [9,15], in our studies, tyramine concentrations were very low. Tyramine was not detected except for 15th day in a control group. Tyramine concentration slightly increased after 15 day storage when cheeses were stored at a higher temperature. Tyramine contents of C2 group reached from 1.7 ppm after 15 days to 19.1 ppm after 90 days. Our results were significantly lower when compared with the findings of Durlu-Özkaya, Alichanidis, Litopoulou-Tzanetaki and Tunail [17] and Karahan, Öner and Filiz [9]. Although 3 different commercial starter cultures were reported to form *in vitro* high amounts of tyramine [37], tyramine amounts of cheeses produced with the same starter cultures were found at low levels. However, many factors such as pH, dry matter, fat and counts of lactococci were found to have limiting effects on formation of biogenic amines in White cheese in comparison with M17 medium. Especially, development of acidity significantly decreased the production of biogenic amines in White cheese. On the other hand, high concentration of histamine caused a considerable increase of pH ($p<0.01$). However, as previously reported [13, 15], increasing salt and dry matter contents reduced tyramine levels. Usage of amino acids by bacteria caused the decrease in tyrosine contents in White cheese. Tyrosine contents were significantly ($p<0.05$) effected from the increase of the lactoccocci and *E. coli*. In addition to this, increasing of lactoccocci caused a significant reduction ($p<0.05$) in the tyramine contents.

CONCLUSIONS

The experiments confirmed the expected result of decrease of lactococci counts and the increase of tyramine contents in White cheese during ripening. The results showed that determination of biogenic amine levels of the cheese is necessary as a routine analysis in addition to microbiological examinations. It was concluded that for controlling the production of histamine in cheese the following procedures should be observed:

(a) High quality raw milk should be used for the cheese production.
(b) Technological precautions such as pasteurization, cooling etc. should be used to prevent the growth of decarboxylase positive microflora.
(c) Starter cultures should be used for fermentation,
(d) The process line is proper DIN EN ISO 9000 quality management system.

ACKNOWLEDGEMENTS

We thank Prof. Dr. Ender Olcayto for editing of the manuscript. This work has been supported by Suleyman Demirel University in Turkey, Research Project Grants SDU-AF-404.

REFERENCES

1. Rice, S., Koehler, P.E., Tyrosine and histidine decarboxylase activities of *Pediococcus cerevisiae* and *Lactobacillus species* and the production of tyramine in fermented sausages. J. Milk Food Technol., 39: 166-169,1976.
2. Izquierdo-Pulido, M., Vidal-Carou, M.C., Marine-Font, A., Determination of biogenic amines in beers and their raw materials by ion-pair liquid chromatography with post-column derivatization. Int. J. Assoc. Off. Anal. Chem. 76: 1027-1032, 1993.
3. Halász, A., Baráth, A., Simon-Sakardi, L., Holzapfel, W., Biogenic amines and their production by microorganisms in food. Trends in Food Sci. and Tech. 5: 42-49, 1994.
4. Bover-Cid, S., Holzapfel, W.H., Improved screening procesure for biogenic amine production by lactic acid bacteria. Int. J. Food Microbiol., 53: 33-41, 1999.
5. Edwars, S.T., Sandine, W.E., Symposium: microbial metabolites of importance in dairy products. J. Dairy Sci., 64: 2431-2438, 1981.
6. Chang, S.F., Ayres, J.W., Sandine, W.E., Analysis of cheese for histamine, tryptamine, histidine, tyrosine and tryptofan. J. Dairy Sci., 68: 2840-2846, 1985.
7. Joosten, H.M.L.J., Stadhouders, J., Conditions allowing the formation of biogenic amines in cheese. 1. Decarboxylative properties of starter bacteria. Neth. Milk Dairy J., 41: 247-258, 1987.
8. Van Boekel, M.A.J.S., Arentsen-Stasse, A.P., Determination of aromatic biogenic amines and their precursors in cheese by high performance liquid chromatography. J. Chromatogr., 389: 267-272, 1987.
9. Karahan, A.G., Öner, Z., Filiz, H.N., Farklı depolama sürelerinde White peynirlerde meydana gelen değişimler. II. Ulusal Kromatografi Kongresi Bildirisi. *Kromatografik Yöntemler* (pp.316-326), 2001.
10. Taylor, S.L., Histamine food poisoning: toxicology and clinical aspects. Crit. Rev. Toxicol., 17: 91-128, 1986.
11. Kebary, K.M.K., El-Sonbaty, A.H., Badawi, R.M., Effect of heating milk and accelerating ripening of low fat Ras cheese on biogenic amines and free amino acids development. Food Chem., 64: 67-75, 1999.
12. Taylor, S.L., Keefe, T.J., Wındham, E.S., Howell, J.F., Outbreak of histamine poisoning associated with consumotion of Swiss cheese. J. Food Protect., 45(5): 455-457, 1982.
13. Joosten, H.M.L.J., Conditions allowing the formation of biogenic amines in cheese, 3. factors influencing the amounts formed. Neth. Milk Dairy J., 41: 329-357, 1987.
14. Marino, M., Maıfrenı, M., Moret, S., Rondinını, G., The capacity of Enterobacteriaceae species to produce biogenic amines in cheese. Lett.. Appl. Microbiol., 31: 169-173, 2000.
15. Valsamaki, K., Michaelidou, A., Polychroniadou, A., Biogenic amine production in Feta cheese. Food Chemistry., 71: 259-266, 2000.
16. Başyiğit Kılıç, G., Gündoğdu, A., Şanlıdere Aloğlu, H., Öner, Z., Karahan, A. G., Aydemir, S., Erkuş, O., Harsa, Ş., Turkish white “Beyaz” cheese production with novel starter cultures. IFT 2007 Annual Meeting & Food Expo, Chicago, USA, 2007.
17. Durlu-Özkaya, F., Alichanidis, E., Litopoulou-Tzanetaki, E., Tunail, N., Determination of biogenic amine content of Beyaz cheese and biogenic amine production ability of some lactic acid bacteria. Milchwissenschaft, 54(12): 680-682, 1999.

18. Hayaloglu, A.A, Guven, M., Fox, P.F., Microbiological, biochemical and technological properties of Turkish White cheese 'Beyaz Peynir', Int Dairy J 12: 635-648, 2002.

19. TS 591 (1995) *Beyaz Peynir Standardı*. Türk Standartları Enstitüsü, Ankara

20. Harrigan, W.F. ve McCance, M.E., Laboratory methods in microbiology. Academic Press, London and Newyork, 362s., 1966.

21. Kırdar, S.S., Süt ve Ürünlerinde Analiz Metodları Uygulama Kılavuzu, S.D.Ü. Yayını: 18, Isparta, Türkiye, 2001.

22. Karahan, A.G., Arıdoğan-Cicioğlu, B., Çakmakçı, M.L. Genel Mikrobiyoloji Uygulama Kılavuzu, SDÜ Yayın No. 24, Isparta, Türkiye, 2002.

23. Pintado, A.I.E., Pinho, O., Ferreira, I.M.P.L.V.O., Manuela, M., Pintado, E., Gomes, A.M.P., Malcata, F.X., Microbiological, biochemical and biogenic amine profiles of Terrincho cheese manufactured in several dairy farms. Int. Dairy J 18; 631–640, 2008.

24. Şanlı, N., Şanlı, S., Ozkan, G., Method optimization and separation of aromatic biogenic amines and precursor amino acids by high performance liquid chromatography. Hacettepe J of Biology and Chemistry 35 (2); 129-134, 2007.

25. Gönç, S., Standart beyaz peynir yapımı için öneriler. İstanbul Ticaret Odası Yayını: 1984-4: 94-104., 1984.

26. Güler, Z., Beyaz, Kaşar ve Tulum peynirlerinin serbest yağ asitleri ile duyusal (tat-koku) nitelikleri arasındaki ilişkiler üzerine bir araştırma. Doktora Tezi, Ankara, Türkiye, 2000.

27. Demiryol, İ., İnek, koyun, keçi sütleri ile yapılan ve farklı sıcaklıklarda olgunlaştırılan beyaz peynirlerin özellikleri üzerinde araştırmalar. Doktora Tezi, İzmir, Türkiye, 1983.

28. Aydemir, A.S., Lipaz ve proteaz enzimleri katılarak üretilen beyaz peynirlerin uygun olgunlaşma süresinin saptanması. U. Ü. Fen Bilimleri Enstitüsü Yüksek Lisans Tezi, Bursa, Türkiye, 1988.

29. Gürsoy, A., Beyaz peynire tuz geçişini etkileyen bazı faktörler üzerinde araştırmalar. Doktora Tezi, Ankara, Türkiye, 1996.

30. Ergüllü, E., Beyaz peynir yapımı için öneriler. Beyaz Peynir Sempozyumu. Karınca Matbaacılık, İzmir, Türkiye, 1983.

31. Aydemir, A.S., Lipaz enziminin Beyaz ve Kaşar peynirlerinin olgunlaşması üzerine etkisi. A. Ü. Fen Bilimleri Enstitüsü Doktora Tezi, Ankara, Türkiye, 2000.

32. Tunail, N., Uraz, T., Alpar, O., Halkman, K., İzole suşlar ve ticari laktik asit bakterileri ile yapılan Beyaz peynirlerde mikroorganizma kalite ilişkisinin belirlenmesi üzerinde araştırmalar. Doğa Bilim Dergisi, 9(1):95-107, 1985.

33. Durlu-Özkaya, F., Xanthopoulos, V., Tunail, N., Litopoulou-Tzanetaki, E., Technologically important properties of lactic acid bacteria isolates from Beyaz cheese made from raw ewes' milk. J. Appl. Microbiol., 91: 861-870, 2001.

34. Bütikofer U, Fuchs D. Development of free amino acids in Appenzeller, Emmentaler, Gruyere, Raclette, Sbrinz and Tilsiter cheese. LAIT, 77 (1): 91-100 199735.

35. Pinho, O., Ferreira, M.P.L.V.O.I., Mendes, E., Oliveira, B.M., Ferreira, M., Effect of temperature on evolution of free amino acid and biogenic amine contents during storage of Azeitao cheese. Food Chem., 75: 287-291, 2001.

36. Roig-Saguẻs, A.X, Molina, P.A., Hernández-Herrero, M., Histamine and tyramine-forming microorganisms in Spanish traditional cheeses. Eur. Food Res. Tech., 215: 96-100. 2002.

37. Öner, Z., Karahan, A.G., Şanlıdere, H., Laktik starter kültürlerin tirozinden tiramin oluşturma özellikleri. 3. Ulusal Kromatografi Kongresi, Isparta, Türkiye, 2002.