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Determination of the Pollution Parameters in Strained Yogurt Industry Wastewater

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ABSTRACT

The main principle in the production of strained yogurt is to reduce the water content by removing the serum phase of the strained yogurt to increase product resistance to deterioration. In the production of strained yogurt, approximately 33% of the yogurt is retained in the bag while 67% is excreted as serum. Yogurt whey has nutritional value, as does whey and buttermilk; however, the yogurt whey produced from strained yogurt production is sent directly to the sewer system and cannot be commercially assessed. This whey causes both environmental pollution and nutrient losses because of the organic and inorganic matter it contains. In this study, pollution parameters such as chemical oxygen demand (COD), suspended solids (SS), fat, oil, and grease (FOG), total phosphorus (P_{total}), and pH were determined in strained yogurt whey that was obtained from two different wheyoff times (12 and 24 h) in two different dairy plants in Turkey. The strained yogurt whey were determined 41 019-42 943 mg/L COD, 1 016-1 293 mg/L SS, 10 551-9 414 mg/L FOG, 22.30-29.70 mg/L P_{total}, and a pH of 3.99-4.23. The result suggests that the nutrients in strained yogurt whey should be recovered and evaluated industrially, as with cheese whey.

Key words: Industrial waste; Dairy waste; Pollution parameters; Strained yogurt whey

INTRODUCTION

Dairy plants are among those industries identified as sources of critical industrial pollutants. The dairy industry is one of the most water-consuming industries and highest producer of effluent per unit production in Worldwide [1]. Each dairy plant in Turkey has at least one production line, and those producing pasteurized milk, cheese, butter, yogurt, strained yogurt, condensed milk, flavored milk, milk powder, and ice cream in Turkey have more than one [2].

According to the Regulation on Water Pollution Control in Turkey, it is mandatory to control the biological oxygen demand (BOD_5); chemical oxygen demand (COD); fat, oil and grease (FOG); and pH using four parameters for the direct discharge of wastewater into the Dairy wastewater (DW) contains milk solids, detergents, sanitizers, milk wastes, and cleaning water and is characterized by high COD and BOD [3] and by high concentrations of soluble and trace organics, fats, nutrients, lactose, and chlorides as well as detergents and sanitizing agents [2, 4-6] and pathogensalong with considerable variations in pH from 4.2 to 9.4, a relatively large load of suspended solids (SS) (0.4–2 g/L), and large variations in wastewater supply [7-9].

The highly variable nature of DW in terms of volumes and flow rates and high organic material contents, such as 921–9004 mg/L COD, 483–6080 mg/L BOD, 8–230 mg/L total nitrogen (TN), and 134–804 mg/L SS, makes the choice of an effective wastewater treatment regime difficult[10].

The main principle in the production of strained yogurt is to reduce the water content by removing the serum phase of the strained yogurt to increase product resistance to deterioration [2, 11]. Based on the conventional method, the whey's obtained in strained yogurt production are rich in protein, lactose, vitamins, and minerals In the production of strained yogurt, approximately 33% of the yogurt is retained in the bag while 67% is excreted as serum [2].

Yogurt whey has nutritional value, as does whey and buttermilk; however, the yogurt whey produced from strained yogurt production is sent directly to the sewer system and cannot be commercially assessed. This whey causes both environmental pollution and nutrient losses because of the organic and inorganic matter it contains. The industries that manufacture strained products are responsible for the two main types of effluents-yogurt whey (resulting from strained yogurt production) and the washing water from the pipelines, storage, and tanks, which generates yogurt whey wastewater. The yogurt whey is a byproduct of strained yogurt manufacturing. This effluent is a greenish-yellow liquid and is considered the most important pollutant in dairy wastewaters because of both its high organic load and the volume generated. Whey separated after the production of strained yogurt is discharged directly into the sewer without being assessed. When this whey is delivered to the receiving environment without any assessment and/or purification, it results in high pollution conditions and economic losses to the receiving environment. Strained (condensed) yogurt has a thick consistency resulting from filtering its liquid. The production of yogurt generates large amounts of wastewater that is characterized by high BOD and COD concentrations, reflecting their high organic content and high levels of dissolved or SS, including FOG; therefore, this wastewater requires proper attention before disposal [2,12].

Several previous studies have examined the essential parameters in the wastewater from various dairy plants in terms of environmental pollution. These studies were predominantly conducted on whey, a waste of milk technology that is released after cheese production [2, 13].

The aim of this study was to determine the pollution parameters of the strained yogurt whey obtained after straining for 12 and 24 h in the production of strained yogurt from two different dairy plants in Turkey.

MATERIALS AND METHODS

Strained yogurt production and yogurt whey samples

Strained yogurt is produced using three replications on different days during the manufacturing process (Fig. 1), and parallel analyses were conducted during each production. A sampling of strained yogurt whey was taken by blending the whey during filtration. The whey samples were then stored in a cold chain (+4°C) and taken to the laboratory. All composite samples were transported on ice, stored at 48°C, and analyzed within 2-4 d.

Physical and Chemical Analyses

pH was measured using a Mettler-Toledo AG 8603 pH meter (Switzerland). COD was analyzed using the LCK 514 (100–2000 mg/L) and LCK 314 (15–150 mg/L) kit using the Hach-DR 5000 spectrophotometer (Manchester) [14]. The analyses of the levels of FOG and SS were conducted based on standard methods [14]. Total phosphate, according to the International Organization for Standardization standard method [15] and spectrophotometric measurements were determined using the Fosformolibden Blue method as mg/L PO_4 [14, 15]. All chemicals used in the study were of analytical grade. All analyses were conducted in duplicate.

Statistical analyses

Statistical analyses were conducted according to the Randomized controlled Trial Plan using Minitab 22.0 (http://www.minitab.com). One-way analysis of variance was used to determine the differences between the samples. Tukey's multiple comparison test and Student's *t*-test were used to determine the difference between groups and recurrences [16].

RESULTS AND DISCUSSION

Mean, minimum and maximum values of chemical oxygen demand (COD), suspended solids (SS), fat, oil, and grease (FOG), total phosphorus (P_{total}), and pH in strained yogurt whey are given in Table 1.

The strained yogurt whey were determined 41 019-42 943 mg/L COD, 1 016-1 293 mg/L SS, 10 551-9 414 mg/L FOG, 22.30-29.70 mg/L P_{total}, and a pH of 3.99-4.23.

The pH of the serum obtained after wheyoff for 12 h was 4.23 and after 24 h was 4.06. The effect of wheyoff time on pH was statistically significant ($p < 0.05$).

A crucial requirement for the biological treatment of dairy wastewater is to maintain a pH between 6 and 9. Milk and butter factories have effluents with active reactions close to a neutral pH (i.e., 6.8–7.4). In plants from which a specific amount of whey is discharged, the pH of the effluent is reduced to <6.2. In cheese manufacturing, sweet whey is slightly acidic, with pH = 5.9–6.6, while mineral acid coagulation gives an acidic whey with pH = 4.3–4.6 [17,18].

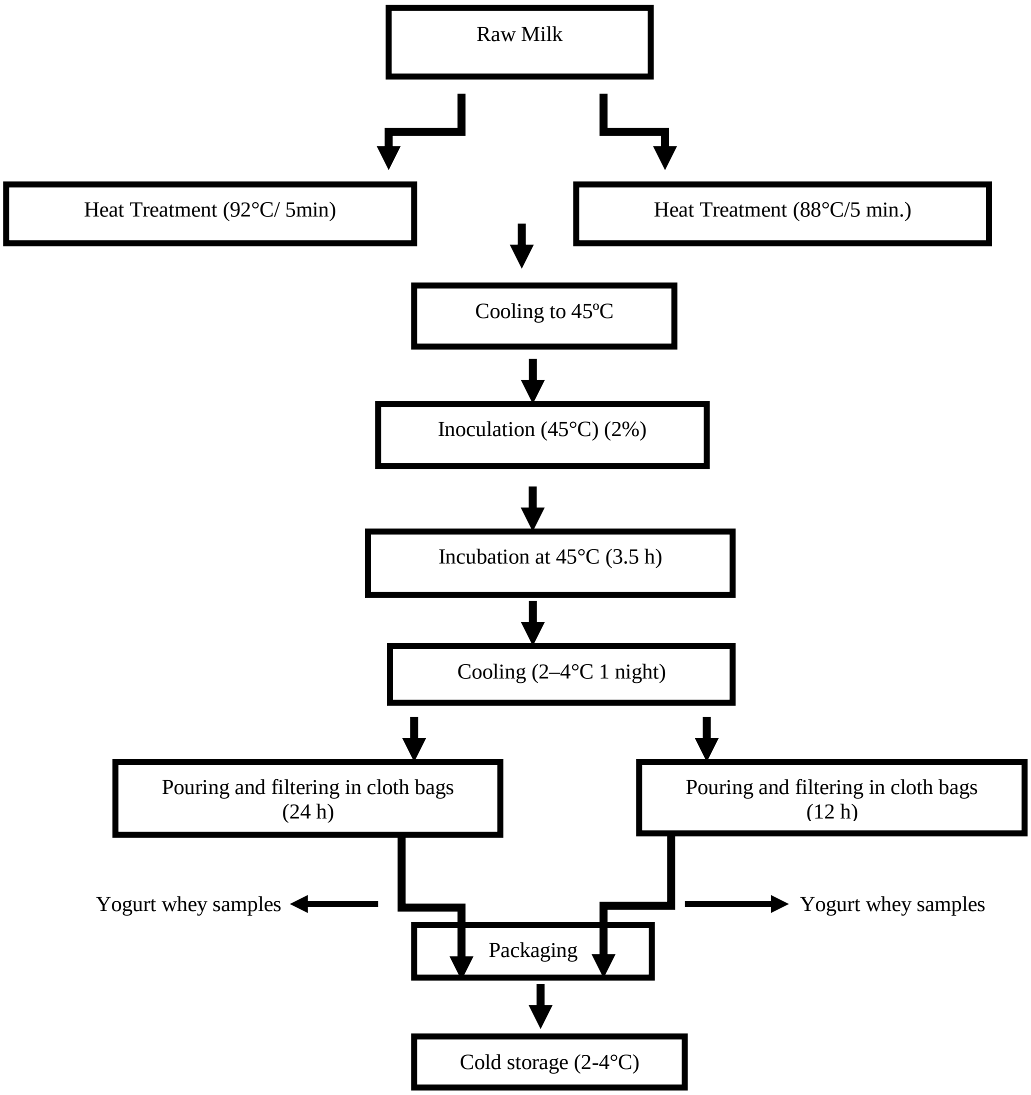

Fig. 1 Flow diagram of the production of strained yogurt produced in two different dairy plants.

Table 1- Pollution parameters of strained yogurt wheys (mg/L)

Parameters	A	B
COD	41019 ± 534 x**	42943 ± 1252 y**
SS	1016 ± 20 x**	1293 ± 45 y**
FOG	10551 ± 41 x**	9414 ± 134 y**
$P_{(total)}$	29.70 ± 5.40 x*	22.30 ± 2.30 y*
pH	4.34 ± 0.05 x**	4.06 ± 0.02 y**

Abbreviations: COD, chemical oxygen demand; SS, suspended solids; FOG, fat, oil & grease; $P_{(total)}$ total phosphorus
Notes:
A: The operation that applies the 12-h filtering time.
B: Operation applying 24-h filtering time.
(x, x) There was no difference between the parameters expressed with the same letters ($p > 0.05$).
(x, y) There is a significant difference between the parameters expressed with different letters:
*$p < 0.05$, statistically significant difference in the range.
**$p < 0.01$, a high significant difference in the range.

pH

Trevor and Schalkwyk [19] have reported that the pH of the yogurt enterprises was 6.92. In other studies, Kirdarand Gun [20] have determined that the pH of the yogurt whey was 3.57–3.78 in winter and 3.56–3.72 in summer, Baladura [21] and Kalender [22] have determined it to be 4.22–4.67 and 4.35-4.40, respectively, in summer months. Altunısık *et al* [23] have reported a pH of 5–9.5 in yogurt whey.

The results of the current research on pH are in accordance with those of Erbil [24] and Baladura [21] but higher than those obtained by Kirdarand Gun [20] and lower than those reported by Altunısık *et al* [23], Trevor and Schalkwyk [19], and Kalender [22].

Research suggests that high pH values can be caused by differences in the raw material used, the output pH of the incubation used, the characteristics of the bags used for the wheyoff process, and the wheyoff time.

Chemical oxygen demand (COD)

The results showed COD values of 41019–42943 mg/L. The effect of wheyoff time on COD of the samples of strained yogurt whey was statistically significant ($p < 0.05$) (Table 1). Other studies have reported 38223mg/L COD [25] and 40000 mg/L COD [26]. Yogurt whey, one of the primary pollutants in the dairy industry, determined the COD value of yogurt whey samples as 38223 mg/L in their studies which identified the waste material composition and their concentration and pollution parameters due to the organic substances they contained [25]. The results of the study were reported by Toprak *et al* [25] was higher than the results obtained. Zeytinoglu, [26], determined that the need for COD (40000 mg / L) in different sectors operating in Bursa is the highest value of milk and products processing enterprises.

The electrocoagulation of strained yogurt wastewater using a uniquely designed iron reactor, and the sludge produced during electrocoagulation to be used as a raw material in the production of ceramic pigment were investigated. The results showed that this specially designed electrochemical reactor is an effective alternative for the treatment of strained yogurt wastewater. They also showed that the sludge produced during electrocoagulation can be used as a raw material in the ceramic industry and that it can be converted from waste to a value-added product. One study measured COD in strained yogurt wastewater at 6500 mg/L [12].

The COD values were higher than the above values, which suggests that the differences are caused by the raw material, raw milk characteristics, characteristics of the bags used for the wheyoff process, and the production parameters.

Suspended solids (SS)

The total solid is divided into two groups-SS (that remaining on the glass fiber after filtration of the wastewater sample) and dissolved solids. Colloid solids are dissolved solids [27]. Most purification processes are conducted to remove SS that cause deposits in the channels. In the main sewer pipes, in particular, hydrogen sulfide gas is generated, which is harmful to sewage workers [28]. SS in DW originate from coagulated milk, cheese curd fines, or flavoring ingredients [29].

The SS content in DW, raw material quality, applied technological processes, coagulated milk, cheese, cheese particles, ice cream, yogurt, and strained yogurt depend on many factors; therefore, there are significant differences between the amounts of solids in the wastewater. The amount of total inorganic solids is approximately twice that of inorganic volatile SS. The share of inorganic solids in total solids in milk is ~13%; therefore, in DW, most of the SS are from milk and milk products. The waste from dairy factories contains a small amount of SS; however, that amount increases because of the fat globules suspended in the wastes from the cheese factories.

The SS content of the yogurt whey in our study measured 1016–1293 mg/L SS, and the influence of wheyoff time on these values was statically significant ($p < 0.05$) (Table 1).

The SS content of the whey used in the studies by Celik [30] was 1780 mg/L, Gurtekin [31] was 2400 mg/L, Uyum [32] was 500 mg/L, and Altunısık et al [23] was 7 000 mg/L. Trevor and Schalkwyk [19] have reported that the total solids amounted to 2 750 mg/L in their study in which the properties of the yogurt farms were determined and SS could not be detected. The SS values in our study are lower than those obtained by Celik [30], Gurtekin [31], and Altunısık et al [23].

Yazıcı and Dervisoglu [33] have determined that the SS amount after 24 h was 5506 mg/kg at one factory studied that was producing 113398 kg of milk/d. Our results were one-quarter of this value and found to be very low.

According to the characterization of the wastewater, the amount of SS is indicated as 1000 mg/L, which is similar to the results of the previous research.

Total phosphorus (P_{total})

P is a factor for algae growth. The most important feature of the P in wastewater is that chemical methods can remove it without biological treatment [34]. Eutrophication can occur depending on the phosphate concentration in the water. Only 1 g phosphate phosphorus (PO_4-P) accelerates the growth of 100 g algae. When these algae die, decomposition results in an oxygen requirement of ~150 g. Critical concentrations for the initial stage of eutrophication are ~0.1–0.2 mg/L PO_4-P in flowing water and ~0.005–0.01 mg/L PO_4-P in stagnant water. Because of the possible hazards to surface waters, the European Union Directive 91/271/EEC specified limits for the discharge of PO_4 compounds into the receiving environment. Depending on the size of the wastewater treatment plant, these values are 2 mg/L P_{total} (10000–100000 population equivalent [PE]) or 1 mg/L P_{total} (>100000 PE) [15, 35].

The P_{total} values in our study were 22.30–29.70 mg/L. The effect of wheyoff time on total P content in yogurt whey’s was insignificant ($p > 0.05$).

The maximum P_{total} content in the waste water sample is 8 mg/L. In previous studies, the P content of whey was 337 mg/L [36], 110–135 mg/L [23], and 9–280 mg/L of P_{total} [37]. The results of the research on cheese whey were found to be very high. The results obtained in our research were lower than in other studies on the same topic [23,36]. The electrocoagulation of strained yogurt wastewater using a uniquely designed iron reactor and the sludge produced during the electrocoagulation process to be used as a raw material in the production of ceramic pigment were investigated. The results showed that this specially designed electrochemical reactor is an effective alternative for the treatment of strained yogurt wastewater. It also shows that the sludge produced during electrocoagulation can be used as a raw material in the ceramic industry, and that it can be converted from waste to a value-added product [19].

Fat, oil, and grease (FOG)

The dairy industries produce effluents rich in in FOG, which can have negative impacts on wastewater treatment systems, such as foul odors and blocked pipes and sewer lines [32, 38, 39]. FOG concentrations in the wastewater from dairy plants specialized in the production of high-fat products is 0.2–0.4 g/L, although higher values have been reported (e.g., ≤2.88 g/L in a butter factory). In the wastewater from other dairy plants, FOG usually does not exceed 0.1 g/L [40]. The FOG values in our study were 9414–10551 mg/L, and the effect of wheyoff time on FOG of strained yoghurt whey was statistically significant ($p < 0.05$).

According to the Regulation on Water Pollution Control [41], the discharge standards for wastewater from the milk and dairy products industry for FOG were 60 mg/L in a 2-h composite sample, 30 mg/L in a 24-h composite sample, and 200 mg/L in the sewerage discharge. In this study the values of strained yogurt whey's in this swerve significantly higher. In the study conducted on the factories operating within different sectors in Bursa, the FOG values were 7.4 mg/L in the lowest oil enterprises and 100 mg/L in the meat plants. This value was 1793 mg/L in milk and milk products [42]. The results of this study were significantly higher than those of Zeytinoglu (1993) [26].

In two studies, the FOG content of subterranean wastewater was 4095 mg/L [43] and 25620 mg/L [41]. The strained yogurt whey samples used in our study had FOG values higher than those of Senol [42] and lower than those of Konar [44].

CONCLUSION

The results suggest that strained yogurt whey, which has a high pollution load, should be industrially recycled. As in whey, the nutrients are recovered using ultrafiltration and hyperfiltration techniques, and demineralization of mineral substances to prevent nutrition and economic losses.

Based on the results, we suggest the following:

1. An important factor for legumes in agriculture applications is the evaluation of strained yogurt whey.
2. It is believed that the fertilizer needs of farmers can be reduced by using strained yogurt water, which is considered as waste and will be economically beneficial.
3. The harmlessness of the treatment and the use of this chain in the form of fertilizer in agriculture is important to prevent economic losses.
4. With the establishment of the waste exchange, it is believed that one product will be waste, and the other will be the production input and raw material.
5. Strained yogurt water is important for the production of biogas energy, such as a hydrogen and carbon source.
6. Strained yogurt whey can be used as a food additive because it is rich in nutrients.
7. Strained yogurt whey can be used as a nutrient enricher in bakery products.
8. It can be evaluated by using yogurt whey instead of water in Ayran production.
9. It can be used in the formulation of infant formula.
10. It can be used in the formulation of skin care products.

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REFERENCES

[1]. AV Leena, C Meiaraj, N Balasundaram, BOD/COD a measure of dairy waste treatment efficiency- a case sudy, *IOSR Journal of Mechanical and Civil Engineering*, 2016, 13, 107-114.

[2]. SS Kirdar, G Toprak, E Guzel, Determination of the mineral content in yoghurt whey. *Euopean International Journal Science and Technology*, 2017, 6, 26-34.

[3]. F Omil, JM Garrido, B Arrojo, R Mendez, Anaerobic filter reactor performance for the treatment of complex dairy wastewater at industrial scale. *Water Research,* 2003, 37, 4099–4108.

[4]. JP Kushwaha, C Srivastana, ID Mall, An overview of various technologies for the treatment of dairy wastewaters. *Critical Reviews in Food Science and Nutrition*, 2011, 51, 442-452.

[5]. A Sengil, M Ozacar, Treatment of dairy wastewaters by electrocoagulation using mild steel electrodes. *Journal of Hazardous Material B*, 2006, 137, 1197-1205.

[6]. UB Deshannavar, RK Basavaraj, NM Naik, High rate digestion of dairy industry effluent by upflow anaerobic fixed-bed reactor. *Journal of Chemical and Pharmaceutical Research*, 2012, 4, 2895-2899.

[7]. US Department of Agriculture-Soil Conservation Service (USDA-SCS), *Agricultural Waste Management Field Handbook.* Washington, DC.1992.
[8]. MR Kosseva, CA Kent, DR Lloyd, Thermophilic bioremediation strategies for a dairy waste. *Journal of Biochemical Engineering*, 2003, 15, 125–130.
[9]. AK Slavov, General characteristics and treatment possibilities of dairy wastewater – a review. *Food Technology Biotechnology*, 2017, 55, 14–28.
[10]. B Farizoglu, S Uzuner, The investigation of dairy industry wastewater treatment in a biological high performance membrane system. *Biochemical Engineering Journal*, 2011, 57:46– 54.
[11]. B Özer, *Yogurt Science and Technology*. Sidas Media, Çankaya- İzmir, 2006 (in Turkish).
[12]. U Tezcan, E Ozel, Electrocoagulation of yogurt industry wastewater and the production of ceramic pigments from the sludge. *Separation and Purification Technology*, 2013, 120, 386–391.
[13]. SS Kirdar, Dairy industry and environmental pollution. *Journal of Dairy Product and Technology*, 2008, 12, 55-56.
[14]. APHA, Standard methods for the examination of water and wastewater, 20th Edition, Washington, DC.2012.
[15]. ISO, Water quality-determination of phosphorus. Part 1: Ammonium molybdate spectrometric method.*Web* https://www.iso.org/ standard/ 13398.html.
[16]. O Duzgunes, T Kesici, OKavuncu, F Gürbüz, *Research and Experimental Methods (Statistical Methods-II)*, Ankara University Faculty of Agriculture, Ankara, Turkey, 1987 (in Turkish).
[17]. T Tsachev, *Dairy industry wastewater treatment*. Sofia, Bulgaria, State Publishing House Technique, 1982 (in Bulgarian).
[18]. N Venetsaneas, G Antonopoulou, K Stamatelatou, M Kornaros, G Lyberatos, Using cheese whey for hydrogen and methane generation in a two-stage continuous process with alternative pH controlling approaches. *Bioresources Technology*, 2009, 100, 3713-3717.
[19]. J B Trevor, CV Schalkwyk, *Treatment of Dairy Processing Wastewaters*, Taylor and Francis Group, 2006.
[20]. S Kirdar, I Gun, Physical, chemical and microbiological properties of strained yogurt consumed in Burdur. *Journal of Food*, 2002, 27, 59-64 (in turkish).
[21]. E Baladura, *Effect of using some dietary fibers on color, texture and sensory properties of strained yogurt.*Celal Bayar University, Turkey, 2011(in turkish).
[22]. M Kalender, *The effect of the addition of different amounts of inulin on fat reduced strained yogurt production.*Çukurova University, Turkey, 2014(in turkish).
[23]. İ Altunısık, R İleri, R Artık, The usability of bentonite and sepiolite in the treatment of small and medium-scale dairy wastewaters. *SAÜ Journal of Institute of Science*, 2002, 6, 65-76 (in turkish).
[24]. F Erbil, *Quality criteria of bag yogurt produced from different milk.*Uludag University, Turkey, 1997 (in turkish).
[25]. G Toprak, SS Kirdar, E Guzel, Determination of pollution parametres of yogurt whey in terms of environmental pollution.*27th. National Chemistry Congress,* Çanakkale, Turkey, 2015, 801p (in turkish).
[26]. E Zeytinoglu, Effects of food industry wastewater on environmental pollution. Uludağ University, Turkey, 1993(in turkish).
[27]. A Samsunlu, *Environmental Engineering Chemistry*, 4th edition. Sam-Environmental Technologies Center Publications, Istanbul, Turkey, 1999 (in turkish)
[28]. D Orhon, N Artan, Control and restriction principels of ındustrial wastewater project-milk and dairy products industry, ITU Environmental and Urban Planning Application and Research Center, 1984 (in turkish)
[29]. HB Brown, RF Pico, Characterization and treatment of dairy wastes in the municipal treatment system. *34th Purdue industrial waste conference*, 1979, 326–334.
[30]. A Celik, *Treatment alternatives of dairy induatry wastewaters.*Namık Kemal University, Tekirdağ, Turkey, 2011 (in Turkish).
[31]. E Gurtekin, Physicochemical treatability of cheese whey by coagulation/ floculation process. *AKU Journal of Science*, 2011, 11, 17-22 (in turkish).
[32]. S Uyum, *Investigation of treatment of whey wastewater in anaerobic hybrid reactor/ aerobic cntinuos mixing tank reactor systems.* Pamukkale University, Turkey, 2011(in Turkish).
[33]. F Yazici, M Dervişoğlu, Waste and wastewater management in dairy industry. *Journal of Food*, 2003, 28, 497-504 (in turkish).
[34]. M Atamer, *Sanitation in the dairy industry*. Ankara University Faculty of Agriculture Publishing House, Ankara, 2005(in Turkish).
[35]. H Asperger, Dairy Science Abstract, 1977, 39(1): 594.
[36]. B Kavacık, B Topaloglu, Biogas production from whey and fertilizer mixture.*7th National Environmental Engineering Congress*, *Life Enviroment Technology*, Turkey, 2007,
[37]. N Gavala, H Kopsinis, IV Skiadas, K Stamatelatou, G Lyberatos, Treatment of dairy wastewater using an upflow anaerobic sludge blanket reactor. *Journal of Agriculture. Engineering Research*, 1999, 73, 59–63.

[38]. D Orhon, N Artan, Control and restriction principels of ındustrial wastewater project-milk and dairy products industry, ITU Environmental and Urban Planning Application and Research Center, 1984 (in turkish)
[39]. P Becker, D Koster, MN Popov, S Markossian, G Antranikian, HMarkl, The biodegradation of olive oil and treatment of lipid-rich wool wastewater under aerobic thermophilic condition. *Water Research,* 1999, 33, 653–660.
[40]. SM Schifrin, GV Ivanov, BG Mishukov, Y Feodanov, *Wastewaters from dairy industry*. Moscow, Russia, 1981 (in Russian).
[41]. Anonimyous, Regulation on water pollution control, No: 19919, Official newspaper, 2004, pp. 13-73.
[42]. Z Yoney, *Technological research on processing and durability of canned yoghurt*. Ankara University, Faculty of Agriculture Publication, 1965 (in turkish).
[43]. E Senol, *Study on the treatability of wastewater from the dairy industry.* Sakarya University, Turkey, 1997 (in turkish).
[44]. A Konar, Heating of milk to be processed in yogurt and determination of temparature and time that canbe applied in high quality yogurt production. *III. National Milk and Dairy Products Symposium,* Ankara, Turkey, 1995, 51-65p.