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Effect of Xanthan Gum and Carboxymethyl Cellulose on Chemical and Sensory Properties of Cream Cheese

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Abstract

Cream cheese produced from pasteurized milk and cream which has soft texture and mild flavor and is one of the most delicious cheese and has high fat and humidity. Nowadays, problems such as obesity, cardiovascular disease, atherosclerosis and cancer are due to consumpting the high fat products, so reducing the fat in foods is very attractive field. In this study, the effect of xanthan gum at level 0.05, 0.17, 0.3 and carboxymethyl cellulose at 0.02, 0.11, 0.2 on chemical and sensory properties of cream cheese was studied. Chemical results showed that there was no significant difference in pH value between treatments. Protein and dry matter content of the samples ranged from 6.005% to 7.31% and 30.02% to 30.975% respectively. Increasing the level of xanthan and CMC in cream cheese resulted in decrease the dry matter content. There was significant difference ($p<0.05$) in protein and NaCl content between treatments with increase the used gums, but about fat had not effect. The results of sensory properties including texture, flavor, odor, color and overall acceptability showed that replacing xanthan and CMC had not adverse impact on the organoleptical characteristics of cream cheese and general acceptance of the product was good. The lower levels of xanthan in combination with each of the three levels; 0.02, 0.11, 0.2 CMC gum were more acceptable than other samples.

Keywords: Cream cheese; Carboxymethyl cellulose; Xanthan; Protein; Taste

Introduction

Cream cheese is a soft unripened cheese that is well known for its smooth texture and sweet acidic taste. It is available in many forms from plain to flavoured and is very similar to many French types of soft cheeses such as Petit Suisse, Genrais or Fromase Frais. Cream cheese is used to make cheesecakes, salads, spreads and dips [1]. In traditional cheese making, rennet and/or lactic acid bacteria coagulate milk. The concentration takes place after whey drainage. Ultrafiltration substitutes the whey drainage for soft cheese varieties [2]. Membrane Ultrafiltration has been successfully applied in the manufacture of soft cheeses such as Camembert, feta and cream cheese. Covacevich and Kosikowski [3] first proposed the manufacture of cream cheese using ultrafiltration.

Scientific evidences and findings reveal the correlation between extensive use of fatty foods and increasing risk of some diseases such as excessive obesity, atherosclerosis, cardiovascular diseases, hypertension, histological traumas and some types of cancer. Consequently, and by raising the people's awareness of fat consumption, a considerable increase in demanding of low-fat foods including low-fat cheeses has been developed. Cheese fat not only has a nutritive role, but also it acts positively to improve its texture and appearance. Low-fat cheeses have defects such as firm and rubbery texture, unfavorable color and taste, and weak melting ability. By decreasing the fat amount, cheese protein network becomes more tight and compact and cheese texture turns chewy [4]. Thus, new strategies were developed to produce low-fat cheese with the same characteristics of high-fat cheese, some of which are: modifying ordinary methods in production process, selecting starter and adjunct cultures and using fat substitutes. Using of fat substitutes has been proposed as the main strategy to improve functional and textural attributes of low-fat cheese in different studies. Because of their ability to mechanically entrap water and their stronger hydrophilicity, water-soluble and polar fat substitutes have been widely recommended. Following the use of fat substitutes, a sense of lubricity and creaminess is created in cheese [5]. Therefore, in formulation of low-fat products, it has been recommended to use substances that partially or entirely substitute for fat and developed similar characteristics [6].

Xanthan can be used in foods and other segments as a thickening, stabilizing and emulsifying agent and, in synergism with other gums, can act as a gelling agent [7]. Cellulose derivatives such as carboxymethyl cellulose are one of the most edible gums [8,9]. Carboxymethyl cellulose is from the Hydrocolloids which have been used in the food industry and other industries as stabilizer, thickener, suspension, and maintenance of water extensively [10-12].

In this study, we examined the effect of various concentrations of Xanthan gum and Carboxymethyl cellulose as fat replacer on Chemical and sensory attributes of cream cheese.

Materials and Method

Preparation of cream cheese

The bovine milk was first standardized to the fat content of about 6%. Milk was heated at 60ºC, bactufugate and homogenized at 100 bar. Then pasteurized at 80ºC for 1 min and cooling to 23ºC. The pasteurized milk was inoculated with a mesophilic starter culture and also 0.005% rennet and incubated at this temperature until the pH reached a value of 4.95.

The curd was heated, after coagulation and concentrate in UF system. After concentrating by UF, salt (1% w/w), Xanthan gum (0.005, 0.17, 0.3%) and Carboxymethyl cellulose (0.02, 0.11 and 0.2%) added as fat replacer. Finally, samples pasteurized at 78ºC, homogenized at 170 bar and cooling to 4-6ºC. Treatment code number were following as, No 1: xanthan 0.05 + CMC 0.02%, No 2: xanthan 0.05 + CMC 0.2%, No 3: xanthan 0.17 + CMC 0.11%, No 4: xanthan 0.3 + CMC 0.2%, No 5: xanthan 0.3 + CMC 0.02%, No 6: control without hydrocolloids.

Chemical analysis

The fat content of cream cheeses was determined by Gerber method [13]. The pH of cheese samples was measured with a digital pH meter (Mettler Toledo PH meter, model seven easy, Switzerland). Cheese was analyzed for moisture content by vacuum-oven method [14]. Salt content was determined according to Bradley et al. [15]. The Kjeldahl method was used to determine total protein content of samples [14].

Sensory evaluation

The sensory evaluation was carried out for samples. Cream cheeses evaluated for their odor, flavor, texture, color and overall acceptability. The panel consisted of 6 members from students and university staff and scores were obtained as described by Nikjooy et al. [16] by rating the above quality characteristics using the following rating scale: 5=Excellent, 4=Good, 3=fair, 2=Poor and 1=Very poor.

Statistical analysis

The results were modeling and analysed using the central composite design and response surface methodology (RSM). Significant differences between treatments were determined using Spss software and the means were compared using ANOVA analysis followed Duncan's test at 5% level (p<0.05) [17].

Results and Discussion

Chemical properties

The main purpose of this study was to prepare functional low fat cream cheese; this could be achieved by replacing cream (control) the basic resource of milk fat by xanthan gum and CMC. Results of chemical properties of cream cheese samples contain different levels of Xanthan gum and CMC shown in Table 1.

Results showed that with decrease the fat level, moisture and protein values of samples increased, but pH values were not changed. Differences between moisture content of samples probably due to differences in theirs protein. Fat in dry matter (F.D.M) and NaCl percentage of samples were significant in some treatments (p<0.05) (Table 1). Protein, fat, F.D.M and dry matter of cream cheeses in this study were lower than those reported by Yasin et al. [18] (in their study reported 8.69, 26.58 and 66.77, 39.81% respectively).

Also NaCl, F.D.M and pH of control sample (No 6) were lower than other treatments contains xanthan and CMC.

There was no significant difference in pH value between low-fat cream cheeses and control (p>0.05). This result agrees with that reported by Katsiari et al. [19] and Fadaei et al. [20].

The lowest pH recorded for control sample. The cause of it was that acidity reduction leads to weakness of protein bands by repulsion of charges existed on protein surface, so as the negative charges on the surface of casein molecule were declined by pH increase. Also in a study, the pH of the cream cheeses was 4.7 and reaches 4.8 after the 20 weeks of storage [21].

Treatment No	NaCl	F.D.M	Dry matter	Protein	Fat	pH
1	0.84 ^{ab}	60.52 ^{b}	30.975 ^{a}	6.005 ^{c}	18.75 ^{ab}	4.94 ^{a}
2	0.895 ^{a}	63.265^{a}	30.02 ^{b}	6.67 ^{b}	19 ^{a}	4.91 ^{a}
3	0.845 ^{ab}	60.105^{b}	30.36 ^{ab}	7.31 ^{a}	18.25 ^{b}	4.94 ^{a}
4	0.9 ^{a}	62.475^{a}	30.36 ^{ab}	7.005 ^{ab}	18.75 ^{ab}	4.915 ^{a}
5	0.885 ^{ab}	59.94 ^{b}	30.02 ^{b}	7.015 ^{ab}	18 ^{c}	4.9 ^{a}
6	0.82 ^{b}	50.005^{b}	30.82 ^{a}	7.2 ^{ab}	18.5 ^{ab}	4.885 ^{a}

Table 1: Chemical properties of cream cheese samples.

Figure 1 showed that with increase the level of used gum, pH of samples increased. These were against to the results of the research by Ghanbari Shendi et al., but agree with results of Soukoulis and Tzia [22] and Hematyar et al. [23] about effect of hydrocolloids on frozen yoghurt. pH of samples in this study almost closed to the results published by Fadaei et al. [20], as they recorded the pH of cream cheese between 4.74-4.8.

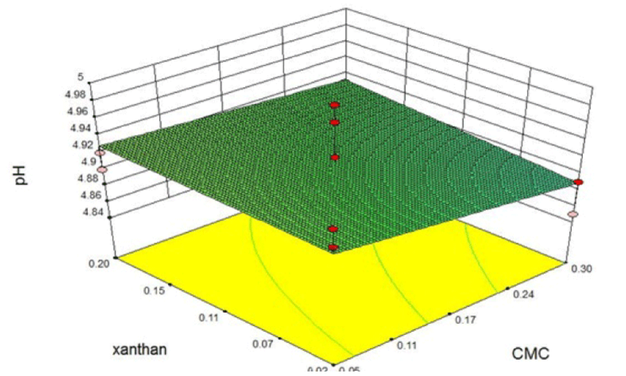

Figure 1: Three dimensional diagram of effect of xanthan and CMC (W/W %) on pH percentage.

Protein and dry matter content of the cream cheese samples ranged from 6.005% to 7.31% and 30.02% to 30.975% respectively. Results of protein, cream cheese samples contain different levels of Xanthan and CMC shown in Table 1. Table showed that there was significant difference (p<0.05) in protein content between different treatments. The highest protein content (7.31) showed in treatment No3 (xanthan 0.17 + CMC 0.11%) and the lowest (6.005) in treatment No1 that had the lowest xanthan and CMC levels (xanthan 0.05 + CMC 0.02%).

Results of ANOVA analysis and Regression model index for protein shown in Tables 2 and 3.

References	Sum of square	Freedom degree	Mean square	F	P
Model	1.55	3	0.52	9.86	0.0046
A-xanthan	3.83E-04	1	3.83E-04	7.306 E- 003	0.934
B- CMC	1.49	1	1.49	28.5	0.0007
CMC × xanthan	1.475 E-003	1	1.475 E-003	0.028	0.871
Residual	0.42	8	0.052		
Lack of fit	0.19	2	0.094	2.46	0.166
Pure error	0.23	6	0.038		
Cor total	1.97	11			

Table 2: Variance analysis for protein of different cream cheese treatments (%).

Indexes	Variable of model
6.68267	Constant
+ 1.8294	Xanthan
-0.48368	CMC
-0.74362	CMC × Xanthan

Table 3: Regression model index for predict independent variables equation model for evaluate the cream cheese protein. = significance at 5% level.

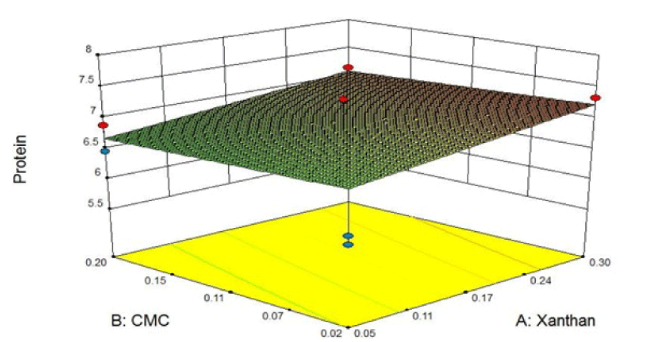

Figure 2: Three dimensional diagram of effect of xanthan and CMC (w/w %) on protein percentage.

What is important for improving texture of low-fat cheese is increasing the moisture level or moisture ratio to protein ratio in comparison with high-fat sample. So, the high moisture level in fat-free cheeses and in cheeses containing fat substitute compared to high-fat ones, is of crucial importance [24]. The discrepancy of moisture level in high-fat and low-fat cheeses is probably due to their different protein levels, so as the high amount of protein in cheeses containing less fat can be accompanied with increase in water absorbance within protein network and consequently the raise of moisture amount. Total protein and total solid of cream cheese in the study of Kalab and Wayne Modler [25] higher than current study (8.22 and 45.85% respectively). Also dry matter in this study lower than those reported by Fadaei et al. [20] about wheyless cream cheese contains some hydrocolloids (locust bean gum, carrageenan and inulin), but for control sample in their study was higher than our study (37.88%). These variations are due to milk type, milk component itself.

Three dimensional Figure 2 showed effect of different levels of xanthan and CMC on protein content in cream cheese. The highest protein content of cream cheese recorded for sample contains xanthan 0.17 and CMC 0.11% (treatment No 3). It is revealed that with increase the level of xanthan and CMC used in cream cheese, protein content did not increased.

Dry matter in cream cheese samples contains Xanthan and CMC shown in Table 1.

Results showed that there was significant difference ($p<0.05$) in dry matter content between different treatments. The highest content of dry matter (30.975) showed in treatment No1 which contains the lowest level of xanthan and CMC, and the lowest protein content showed in treatment No 3 (30.3) that contains the highest xanthan gum and the lowest level of CMC (xanthan 0.3 + CMC 0.02%) (Table 4).

Indexes	Variable of model
30.86309	Constant
+ 0.17086	Xanthan
- 4.36843	CMC
- 1.08343	CMC × Xanthan

Table 4: Regression model index for predict independent variables equation model for evaluate the cream cheese dry matter. = significance at 5% level.

Figure 3 showed that increasing the level of xanthan and CMC in cream cheese resulted in decrease the dry matter content. The highest dry matter recorded for sample contains 0.05-0.1% xanthan and 0.02-0.1% CMC.

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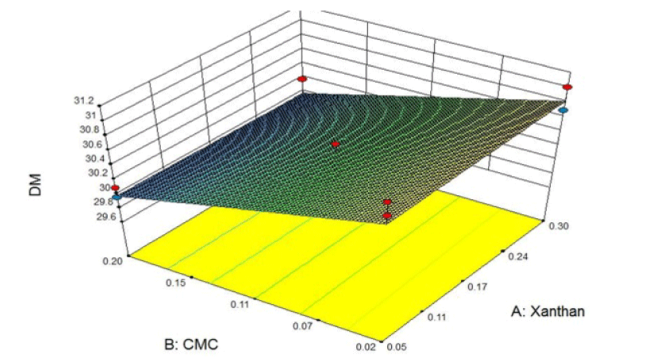

Figure 3: Three dimensional diagram of effect of xanthan and CMC (w/w %) on dry matter perecentage.

The moisture to protein ratio was lower with fat substitute, and the high level of moisture in the samples was possibly due to synergistic activity of the formed curd. This is due to the fact that water binds directly to substitute agents which results in crease of protein matrix [26]. Among samples containing xanthan gum and CMC, the highest degree of moisture absorbance belonged to treatment No 2 and 5. As carbohydrate-based fat substitutes have more ability to absorb water because of an open electron array in their structure, it would lead to compressing and creasing of carbohydrate-protein matrix, and these reactions in turn, result in increasing of moisture in cheeses containing fat substitute comparing with controls (Table 1). These findings were in agreement with those report [5,6,16,27].

Results of fat samples contains Xanthan and CMC shown in Table 5. As showed, there were not significant differences ($p<0.05$) between treatment No 1, 2, 3 and 4 in comparison to control. High content fat in cream cheese originated from fat milk, and added gum had not effect on fat of cream cheese. The highest fat percentage recorded in treatment No 1.

Indexes	Variable of model
18.56004	Constant
+ 0.67969	Xanthan
+ 2.80168	CMC
- 23.36372	CMC × Xanthan

Table 5: Regression model index for predict independent variables equation model for evaluate the cream cheese fat.*= significance at 5% level.

Figure 4 revealed that simultaneous using of xanthan and CMC had not effect on fat percentage of cream cheese. High levels of CMC led to increase the fat, but xanthan gum have not this effect. The reason is that the gums create compact texture and decrease the fat. Also gums delay the hydration and hinder the issue small fat globules from whey. Result of our findings was agree with those reported by Zalazar [7], Ghanbari Shendi et al. and Kavas et al. [28].

The fat of samples in this study lower than results recorded (Table 6) by Fadaei et al. [20]. They recorded the fat of whey less cream cheese contains some hydrocolloids (locust bean gum, carrageenan and inulin) between 10.35-10.73, but for control sample was 26.5 that higher than our study.

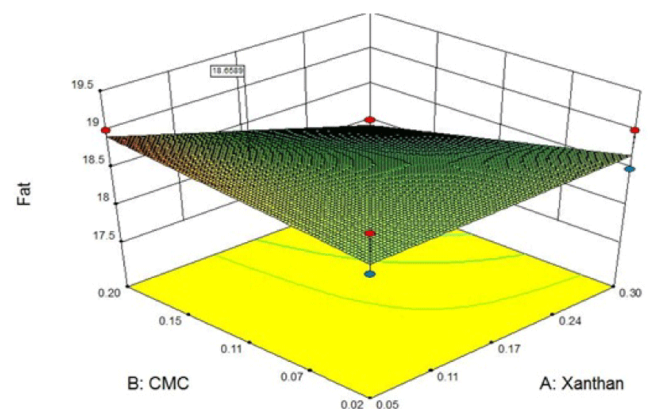

Figure 4: Three dimensional diagram of effect of xanthan and CMC (w/w %) on fat percentage.

Indexes	Variable of model
0.87	Constant
+ 7.809 E- 003	Xanthan
+ 0. 016	CMC
- 0.013	CMC × Xanthan

Table 6: Regression model index for predict independent variables equation model for evaluate the cream cheese NaCl. *= significance at 5% level.

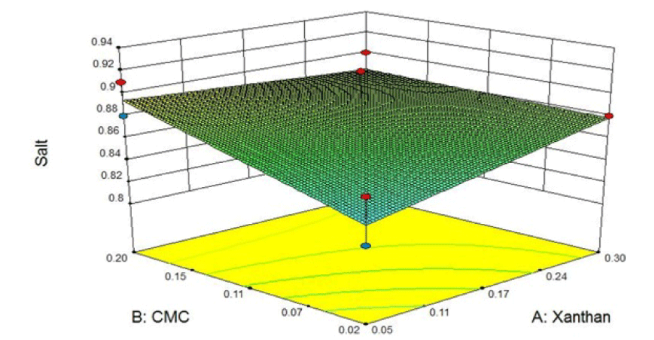

Figure 5: Three dimensional diagram of effect of xanthan and CMC (w/w %) on NaCl percentage.

There were significant differences ($p>0.05$) in term of salt between treatment No 2 and 4 in comparison to control. The highest fat percentage showed in treatment No 4 and the lowest recorded for control sample. The NaCl of different cream cheese samples ranged from 0.82 to 0.9% that agree with results of Fadaei et al. [20] about plain cream cheese, also agree with research carried by Taghvaei et al. [29] about wheyless cream cheese (Figure 5).

With increase the level of used gum, the NaCl of cream cheese increased. Sample contains xanthan 0.3 and CMC 0.2% had the highest NaCl content. Differences in NaCl content probably due to differences in moisture of cream cheese, as with increase the moisture, more salt enter the aqueous matrix phase [28,30].

Sensory properties

Results of organoleptical attributes of cream cheese samples with different levels of Xanthan gum and CMC shown in Table 7.

Treatment	Texture	Odor	Color	Taste	Overall acceptability
1	4.33±0.57 [a]	3.33±0.00 [a]	4.33±0.57 [a]	4.33±0.57 [a]	15.33±0.57 [a]
2	4.33±0.57 [a]	3.33±0.00 [a]	4.33±0.57 [a]	4.33±0.57 [a]	16.33±0.57 [a]
3	3.66±0.57 [b]	3.66±0.00 [a]	5.00±0.57 [a]	3.66±0.57 [b]	15.66±0.57 [a]
4	4.00±0.0 [a]	3.33±0.00 [a]	5.00±0.00 [a]	4.00±0.00 [ab]	16.00±1.15 [a]
5	3.66±0.57 [b]	3.00±0.00 [a]	4.66±0.57 [a]	3.66±0.57 [b]	15.66±0.57 [a]
6	4.33±0.57 [a]	3.66±0.00 [a]	4.33±0.57 [a]	4.33±0.57 [a]	16.33±0.57 [a]

Table 7: Sensory evaluation of cream cheese sample contains different concentration of Xanthan and CMC.

According to Table 7, texture of treatments No 1, 2 and 4 have not significant differences ($p > 0.05$) in comparison to control. The lowest level of used xanthan gums led to suitable texture and have not difference with control. High levels of gums caused the undesirable texture, but about CMC in low and high level had desirable texture (Table 7). In term of taste, increase the level of xanthan gum led to decrease the taste scores. Low level of xanthan gum had more desirable effect and was not differ from control sample. CMC at low and high levels have not bad effect on taste. Milk fat has a strong impact on the taste of milk products including cheese. Low-fat cheeses have weaker taste, which is due to the high level of moisture and lowering fat share in determination of cheese total taste [31,32].

In current study, Odor, color and overal acceptibility of samples had not significant difference ($p > 0.05$) in comparison to control.

Samples No 3 and 4 had the highest scores for color, these samples had more CMC and xanthan. Therewith cheeses contains high level of fat had yellow color, finally, sample No 2 gained the highest overall acceptability scores by panelists and was similar to control.

Conclusion

Results of this investigation signifies that the use of xanthan gum and CMC can be a suitable way to obtain a cream cheese with proper quality and with decrement of received energy. This finding is important for cream cheese-making industry, because of an increasing consumer trend for low-fat dairy products.

References

1. Kosikowski FV (1978) Bakers'. Neufchatel and Cream cheese in Cheese and Fermented Milk Foods (2nd edn.) Kosikowski and Assoc, New York.
2. Maubois JL, Mocquot G (1975) Application of membrane ultrafiltration to preparation of various types of cheese. J Dairy Sci 58: 1001-1007.
3. Covaevich HR, Kosikowski FV (1977) Cream cheese by ultrafiltration. J Food Sci 42: 1362-1364.
4. Oberg CJ (1991) Factor affecting stretch, melt, and cook color in mozzarella cheese. Marschall Italian and Specialty Cheese seminars.
5. Madadlou A, Mosavi ME, Khosrowshahi A, Emamjome Z, Zargaran M (2007) Effect of cream homogenization on textural characteristics of low-fat Iranian white cheese. Int Dairy J 17: 547-554.
6. Drake MA, Truong VD, Daubert CR (1999) Rheological and sensory properties of reduced-fat processed cheeses containing lecithin. J Food Sci 64: 744-747.
7. Lopez MJ, Moreno J, Ramos-Cormenzana A (2001) Xanthomonas campestris strain selection for xanthan production from olive mill waste waters. Water Research 35: 1828-1830.
8. Haghshenas M, Hosseini H, Nayebzadeh K, Rashedi HR, Rahmatzadeh B (2013) Effect of ß-glucan and carboxymethyl cellulose on sensory and physical properties of processed shrimp nuggets. Iran J Nutr Sci Food Technol 8: 65-72.
9. Goppa W (2000) Book of hydrocolloids. USA: Woodhead publishing limited and CRC press LLC. pp: 137-139.
10. Mesbahi G, Niakoosari M, Savadkoohi S, Farahnaky A (2010) A comparative study on the functional properties of carboxymethyl cellulose produced from sugar-beet pulp and other thickeners in tomato ketchup. Scientific Information Database 7: 62-73.
11. Toğrul H, Arslan N (2003) Flow properties of sugar beet pulp cellulose and intrinsic viscosity-molecular weight relationship. Carbohydrate Polymers 54: 63-71.
12. Cancela MA, Alvarez E, Maceiras R (2005) Effects of tempreture and concentration on carboxymethylcellulose with sucrose rheology. J Food Eng 71: 419-424.
13. Rashid M, Miyamoto T (2005) Quality evaluation of traditional milk "Sahi" in Bangladesh. J Milk Sci 54: 29-36.
14. AOAC (1990) Official methods of analysis (15th edn.) Arlington: AOAC.
15. Bradley Jr RL, Arnold Jr E, Barbano DM, Semerad RG, Smith DE, et al. (1993) Chernical and physical methods (standard methods for the examination of dai- products). Amencan Public Health Association.
16. Nikjooy S, Joo MG, Jahanshahi S (2015) The effect of various concentrations of salep gum on physicochemical characteristics of low-fat white. Int J Agric Crop Sci 8: 136-141.
17. Lisazoian L, Joarusti L (1995) SPSS for windows, version 6.0 an introduction to the statistical package, RRZN.
18. Yasin NMN, Shalaby SM (2013) Physiochemical and sensory properties of functional low fat cheesecake manufactured using cottage cheese. Annals of Agricultural Science 58: 61-67.
19. Katsiari MC, Voutsinas LP, Kondyli E (2002) Improvement of sensory quality of low-fat Kefalograviera-type cheese with commercial adjunct culture. Int Dairy J 12: 757-764.
20. Fadaei V, Poursharif KH, Daneshi M, Honarvar M (2012) Chemical characteristics of low-fat wheyless cream cheese containing inulin as fat replacer. Eur J Exp Bio 2: 690-694.

21. Horn FA, Green-Petersen D, Nielsen SN, Andersen U, Hyldig G, et al. (2012) Addition of fish oil to cream cheese affects lipid oxidation, sensory stability and microstructure. Agriculture 2: 359-375.
22. Soukoulis C, Tzia C (2008) Impact of the acidification process, hydrocolloids and protein fortifiers on the physical and sensory properties of frozen yogurt. Int J Dairy Tech 61: 170-177.
23. Hematyar N, Samarin AM, Poorazarang H, Elhamirad AH (2012) Effect of gums on yogurt characteristics. World App Sci J 20: 661-665.
24. Zalazar CA, Zalazar CS, Bernal S, Bertola N, Bevilaequa A, et al. (2002) Effect of moisture level and fat replacer on physicochemical, rheological and sensory properties of low fat soft cheeses. Int Dairy J 12: 45-50.
25. Kalab M, Modler WH (1985) Development of microstructure in a cream cheese based on queso blanco cheese. Food Microstruct 4: 89-98.
26. Zisu B, Shah NP (2005) Textural and functional changes in low-fat Mozzarella cheese in relation to proteolysis and microstructure as influenced by the use of fat replacers, pre-acidification and EPS starter. Int Dairy J 15: 957-972.
27. Rudan M, Barbano D, Yun J, Kindstedt P (1999) Effect of fat reduction on chemical composition, proteolysis, functionality, and yield of Mozzarella cheese. J Dairy Sci 82: 661-672.
28. Kavas G, Oysun G, Kinik O, Vysal H (2004) Effect of some fat replacer on chemical, physical and sensory attributes of low fat white pickled cheese. Food chemistry 88: 381-388.
29. Taghvaie Z, Taslimi A, Mazloumi M (2006) Study of the low cholesterol white cheese production with sunflower oil. IJFST 1: 1-11.
30. Fox PF (1988) Rennets and their action in cheese manufactura and ripening. Biotechnol Appl Bioc 10: 522-535.
31. Rashidi H, Tehrani MM, Razavi SMA, Rohani MG (2011) The effect of lowering fat percent and amount of calcium chloride on sensory and textural attributes of ultra-filtrated feta cheese made from powdery exudates from milk ultrafiltration. J Iran Food Sci Ind Res 7: 218-226.
32. Fox PF, Guinee TP, Cogan MT, McSweeney PLH (2000) Fundamentals of cheese science. Aspen publication.