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EFFECT OF FORTIFIED LOW FAT-SOFT CHEESE WITH ARABIC GUM ON PHYSICOCHEMICAL AND RHEOLOGICAL PROPERTIES

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Abstract

Arabic gum can be consider as alternative substance of fat, which can be improve the low fat cheese characteristics. Therefore, the current study aims to add Arabic gum as an alternative of fat in low-fat soft cheese with no effect on the functional properties of cheese. Arabic gum powder at 2, 4 and 6% was added into cheese before the pasteurization was done in 63^{o}C for 30 minutes. The samples of cheese were stored for (1 and 14) days at a temperature (1±5)^{o}C. Then, the proximate analysis were conducted such as moisture, ash, protein, compressibility and elasticity. The results of the sensory evaluation such as consist of, flavor, color, consistency, holes and bitterness showed that the cheese fortified with Arabic gum at 4% had the highest levels in comparison with other samples. Thus, this study was indicated that the added of Arabic gum to low fat soft cheese up to 4% could improve the compressibility as well as the elasticity. The results presented that utilizing of Arabic gum could improve the functional and nutritional properties of low fat soft cheese.

Keywords : Low fat-Soft Cheese, Arabic Gum, moisture, ash, protein, compressibility and elasticity.

Introduction

The cheese is multilateral food product that contains many nutrients necessary for the human body and can be made from various food desired by the consumer. Cheese can be divided depend on the fat content (full fat and skim milk), processing technique and physical properties such as texture or moisture content (Kiiru *et al*., 2018). Besides, some studies have focused on High-pressure processing (HPP) of cheese, benefits of HPP treatment include accelerated ripening, microbial inactivation, and extending shelf-life of Mato cheese (Capellas *et al*., 2001).

Soft cheese is one of the most common cheeses in the Middle Eastern countries. It contains salt around 2% to 15%, despite of sometimes sold fresh. Soft cheese produced either by enzymatic or acidic coagulation of fresh milk (buffalos' or cows' milk) or reconstituted skim milk powder with oils (Abou-Donia, 1986). Soft cheese has high percentage of saturated fatty acids that had an important role of increase the calories levels. Fats play a significant role in food and the major contributor of flavor, texture and consistency. The biggest challenge of food producers is removal fat with maintaining sensory quality and strength (Wu *et al*., 2013). The studies showed that the removal of fat from dairy products negatively affected on the strength and texture (Lukman *et al*., 2016). Recent study have tended to add some substances as alternatives of fat called fatmimetic, which improve the rheological properties of products. It has chemical composition different to that of fats, whereas the physical characteristics similar to that of fats. The Fatmimetic will improve the product quality by provided the soft texture and creamy taste in the mouth and suitability of viscosity (Food Safety Network, 2014). Nowadays, the studies tended to use the fats replacer in dairy products due to it has a well functional and nutritional properties. In addition, it contains high proportion of bioactive compounds and play an active role in low energy, which enhance the immune system and low cholesterol. So, the dairy factories were produced different types of low-fat cheese such as mozzarella, cheddar and edam cheese (Renda *et al*., 2015). The acceptability of low-fat cheeses to the consumer can be improved either by replacing the partial and total fat with different fatty alternatives. The process of removing fat affects all the characteristics of the textures of cheese, such as hardness, elasticity and flexibility (Awad *et al*., 2005). In this state, the cheese demonstrate to be a good matrix to incorporate fat mimetic. Thus, imitation cheese or soft cheese is gaining an increasing acceptance with food processors and consumers because of many prospect advantages (Farahmandfar *et al*., 2010).

Between these fat mimetic, Arabic gum is consider as a natural gum made from plants juicer in different types of the acacia tree. Originally, Arabic gum was collected from various types of Acacia trees such as Nilotica, Senegal and Seyal that named as Arabic gum tree. The Arabic gum trees grow in Sudan and Egypt (Al-Assaf *et al*., 2005). The Arabic gum contains many carbohydrates such as rhamnose, galactose and glucuronic acid (Montenegro *et al*., 2012). It effects on the levels of blood cholesterol and also reduces the plasma cholesterol (Ali *et al*., 2009). On the other hand, it uses as a stabilizer and emulsifier in pharmaceutical, cosmetic and food processing (Ali *et al*., 2013). In addition, Arabic gum uses as antioxidant, anti-microbial, anti-coagulant and anti-inflammatory as well as it uses to improve the shelf-life of food products (Patel and Goy, 2015). Moreover, there are a lot of dairy products that should be assessed in order to obtain novel products that can meet market needs, in terms of adequate Arabic gum, nutritional benefits, production costs, higher availability and stability over time. (Brocklehurst and Lund, 1985). In dairy products, Ibrahim and Khalifa (2015) showed that Arabic gum could be use in ice cream, cheese and yogurt. Therefore, the objective of this investigation was to produce and evaluate the physicochemical, rheological and sensory properties of soft cheese fortified with Arabic gum made from skim milk.

Materials and Methods

Materials

Full fat and skim milk were provided by the dairy factory, department of food science, Agricultural college, University of Baghdad. As for the Arabic gum powder was provided by Sigma Company, Germany. Powder animal rennet was obtained from Chr-Hansen's Laboratories, (Copenhagen, Denmark). Rennet was diluted with distilled water to a standard rennet solution before use.

Preparation of Soft Cheese

The samples of soft cheese treatment were prepared by mixing skim milk with Arabic gum powder in 2%, 4% and 6% as A1, A2 and A3 treatment, respectively. Then, the process of filtration and sterilization of full fat milk, skim milk and skim milk fortified with Arabic gum powder was carried out to eliminate almost all pathological microbiology by milk pasteurization at 63 °C for 30 minute. Then, the samples of milk were cooled until 38°C with continuous stirring. The dry rennet was used and added according to the company's recommendations (1g/25kg milk) after dilution with water and stirring for 3 minutes. And then, left the heat rennet for 45 minutes with milks samples until the state of coagulation was formed. The coagulate was caught by knife in size 1 cm longitudinal and wide then left it for 5 minutes. While, the flipping process continues quietly to help the whey out and coagulation cohesion. The coagulation of full fat and skim milk were collected and they were used in the manufacture of soft cheese treated as a positive (C^+) and negative (C^-) control, respectively. Whereas, the coagulation was collected made from skim milk fortified with Arabic gum powder, they were used in the manufacture of A1, A2 and A3 soft cheese treatment. After that, the salt was added to all samples such 5.1% from coagulation weight and then, the coagulation was pressed in container made from stainless-steel to gain the desired shape and texture. Finally, all samples were stored at a temperature of (5 ± 1)°C for the purpose of conducting the required tests.

Chemical Composition of Milk

The chemical composition of milk such as moisture%, fat%, protein%, total solids%, non-fat total solids%, pH, acidity% and qualitative weight were conducted of full fat and skim milk composition using Milko scan (Lactoflash) made from Germany model- 3530-131301 in Food Industries Company-Abu Ghraib Dairy Factory, Ministry of Industry and Minerals.

Physicochemical analysis of soft cheese

(i) Proximate analysis

The soft cheese samples were carried out to determine the proportion of protein, moisture, fat, ash and carbohydrates. Moisture and ash content using AOAC method 926.08 (AOAC, 2000), whereas the proportion of fat and protein was conducted depending on the (Ling, 2008) method. Carbohydrates was determined following the (Ihekoronye, 1985).

(ii) Total Acidity and pH Value

pH value was analyzed according to Ling (2008) by weighed 2.00 g of sample into 200 ml glass bottle, and 100 ml of deionizer water was added. The glass bottle was boiled for 10 min. Then, 50 ml of the filtered extract was used for pH value determination with a pH meter. Measurements were taken in triplicate. The proportion of total acidity was calculated as lactic acid by weighed 3.00 g of sample and mixed with 10 ml of distill water using mortar, and titrate with 0.1 N of NaOH solution (AOAC, 2010).

Rheological measurements of soft cheese

(i) Determination of Compressibility

Compressibility of soft cheese samples were determined using Uniaxial compression according to Shendi *et al.* (2010), the device is equipped with a cylinder in a diameter of 49 mm. The cheese samples were caught in a cylindrical shape with a diameter 2.4cm and height 1.6cm at a temperature 6 C^o. The samples were placed in a sealed container to avoid moisture loss. Then, the samples were placed in the compression device and the pressure was forced to drop the non-axial compressor at 50 mm / min until the sample was destroyed and the reading was recorded.

(ii) Determination of elasticity

The elasticity of soft cheese samples were estimated using the same previous device in compressibility determination, the soft cheese was placed on the predicate and a circle of fixed dimensions is drawn on a graph sheet placed below the sample. There was a ruler on the right of the device to measure the distance extended by the cheese as a result of compression. As a result of the pressure exerted on the soft cheese samples, the amount of pressure required can be calculated, when extending until 1 cm^2. And then, the pressure was removed and calculated the time required for return the original sample before the pressure.

Sensory evaluation

The sensory evaluation of taste, flavor, texture, consist of, color and bitterness of soft cheese samples were carried out by some trained panelists selected from experienced residents of teaching and staff of the Department of Food Science- Collage of Agricultural engineering science - Baghdad University (Nelson and Trout, 1964).

Statistical analysis

The Statistical Analysis System (SAS, 2012) was used to study the effect of different parameters. Least significant difference (LSD) between the mean values of treatments were determined.

Results and Discussion

Chemical composition of full fat and skim milk

The milk is considered as a nearly complete food since, it is a good source for protein, fat and major minerals. The chemical composition of raw full fat and skim bovine milk used in the manufacture of soft cheese such as %moisture, % fat, %protein, %total solids and %non-fat total solids were presented in table 1. These proportions for the full-fat milk were 87.33, 3.61, 3.38, 12.67 and 9.06%, respectively. And for skim milk were 89.95, 0.5, 3.63, 10.05 and 9.56%, respectively. While, the PH, total acidity (%l actic acid) and qualitative weight of full fat and skim milk were 6.65, 0.16 and 1.032%, and 6.65, 0.16 and 1.035%, respectively (Table 1).

Table 1 : Chemical composition of full fat and low fat bovine milk Used in the manufacture of soft cheese

Skim milk%	Full fat milk%	Ingredients
89.95	87.33	Moisture
0.5	3.61	Fat
3.63	3.38	Protein
10.05	12.67	Total solids
9.56	9.06	Non-fat total solids
6.65	6.65	PH
0.16	0.16	Total acidity (%lactic acid)
1.035	1.032	Qualitative weight

These proportions are within the natural limits of raw milk and approach to what is found by the Shragi (2002), Abadi (2014) and Al Badrani (2017).

Physicochemical analysis of soft cheese samples

(i) Chemical composition of soft cheese

The table 2 showed that the proportion of chemical composition such as ash, carbohydrates, fat, protein and moisture in the sample of positive soft cheese control (C^+), negative soft cheese control (C^-), low fat cheese fortified with 2% Arabic gum (A1), low fat cheese fortified with 4% Arabic gum (A2) and low fat-soft cheese fortified with 6% Arabic gum (A3), respectively. The results showed, the chemical composition increased after the addition of Arabic gum except fat and carbohydrates. The proportion of moisture after one and fourteen days in A1, A2 and A3 sample was (69.20-68.65), (69.35-68.75) and (69.47-68.93). Whereas, the proportion of protein was (19.71-20.10), (18.98-19.23) and (18.93-19.37). And the proportion of ash was (2.20-2.35), (2.54-2.73) and (2.65-2.86), respectively. The Arabic gum incorporation with milk caused the accumulation of solid materials in soft cheese products. The Arabic gum contents 78-88% of solid materials and essential amino acids (Montenegro *et al*., 2012 and Amid *et al*., 2012). The chemical compositions of soft cheese control after one and fourteen days in C^+ sample was (59.50-58.36)%, (17.10-17.35)%, (16.09-16.35)%, (5.51-5.94)% and (1.80-2.00)% and in C^- sample was (63.00-63.28)%, (22.85-23.22)%, (3.85-3.95)%, (8.68-4.77)% and (1.62-1.75)% of moisture, protein, fat, carbohydrates and ash, respectively. Increasing the concentration of Arabic gum added increased solid components in soft cheese products. The results showed, the proportion of moisture was observed in C^- sample as compared to C^+ sample was high, due to decrease the proportion of total solids because of the fat was reduced from milk. These results are agree with Visser (1991), he founded that reduced lipid leads to high moisture in low fat cheddar cheese produced from skim milk.

Table 2 : The chemical composition of soft cheese products with Arabic gum in different proportion for 14 days of storage at (1±5)°C

Chemical composition%					Soft cheese age	Treatment	
Moisture	**Protein**	**Fat**	**Carbohydrate**	**Ash**			
59.50	17.10	16.09	5.51	1.80	1	**Full fat soft cheese control (C^+)**	
58.36	17.35	16.35	5.94	2.00	14		
63.00	22.85	3.85	8.68	**1.62**	1	**Low fat soft cheese control (C^-)**	
63.28	**23.**22	3.95	4.77	1.75	14		
69.20	19.71	3.70	5.19	2.20	1	**A1 2%**	**Parameters**
68.65	20.10	3.90	4.97	2.35	14		
69.35	18.98	3.83	5.30	2.54	1	**A2 4%**	
68.75	19.23	3.95	5.34	2.73	14		
69.47	**18.9**3	3.65	5.30	2.65	1	**A3 6%**	
68.93	19.37	3.83	5.01	2.86	14		

*A1=low fat-soft cheese fortified with 2% Arabic gum, A2= low fat-soft cheese fortified with 4% Arabic gum and A3= low fat-soft cheese fortified with 6% Arabic gum

Total Acidity Percentage and pH Value of soft cheese

As shown in table 3, the total acidity calculated as percentage of lactic acid were (0.16-0.36)% and (0.17-0.41)% in C^+ and C^- samples, respectively after one and fourteen days of storage days at (1±5)°C. Whereas , the PH value of C^+ and C^- samples were (6.73-6.00)% and (6.78-5.65)% after one and fourteen days, respectively. Low acidity in control soft cheeses caused by the low development of probiotic bacteria in the milk and lactose hydrolyze (Lourens-Hattingh and Viljoen, 2001). With regards to A1, A2 and A3 sample, no high effect was observed on the addition of Arabic gum to the acidity and pH values of the treatments compared to positive and negative control (C^+ and C^-) samples. These results corresponded to the findings of Guven *et al*. (2005), the addition of inulin to soft cheese as fat substitutes did not change the pH values after manufacturing. As for storage (14 days), there is a decrease in pH values for most treatments samples such as C^+, C^- and A3 sample were 6.00, 5.65 and 6.00, respectively. The low pH due to the lactose consumption by micro-organisms produced by lactic acid, as well as the acid produced by lipid substitutes after partial fracture. This is consistent with Yahyavi and Kalajahi (2014), the pH values of low-fat feta cheese were significantly reduced during the storage period of the control treatment.

Table 3 : Total Acidity Percentage and pH Value of soft cheese products with Arabic gum in different proportion for 14 days of storage at (1±5)°C

Total acidity	pH	Soft cheese age	Treatment	
0.16	6.73	1	**Full fat soft cheese control (C^+)**	
0.36	6.00	14		
0.17	6.78	1	**Low fat soft cheese control (C^-)**	
0.41	5.65	14		
0.16	6.75	1	**A1 2%**	**Parameters**
0.37	5.89	14		
0.16	6.75	1	**A2 4%**	
0.36	5.95	14		
0.17	6.73	1	**A3 6%**	
0.35	6.00	14		

*A1=low fat-soft cheese fortified with 2% Arabic gum, A2= low fat-soft cheese fortified with 4% Arabic gum and A3= low fat-soft cheese fortified with 6% Arabic gum.

Rheological measurements of soft cheese

(i) Compressibility of soft cheese samples

Hardness can be define as the amount of force required to compress the sample and measured by shedding a certain weight on the sample and also known as the force needed to achieve deformation assorted in the form of cheese sample

(Nategh *et al.*, 2012). The figure (1) shows the results of the hardness test during storage for (1 and 14) days at a temperature (1±5) °C for both cheese control treatment C + and C- sample, and the parameters of A1, A2 and A3 sample. The (figure 1) shows that clear differences in the amount of force applied on cheese samples indicating the difference in hardness depending on chemical composition. It is noted that the hardness of C^- sample was higher than the hardness of the C^+ and other parameters samples due to the high content of casein and also the fat in whole-fat cheeses is lubricated and can penetrate into the protein block to make cheese more tender. In addition, the fatty granules in low-fat cheese are small in size and little amount in comparison to the fatty granules in cheese made from whole-fat milk (Koca and Metin, 2004). The use of fatty replacers reduces the hardness of the cheese that indicates the role of these additives in improving the texture of cheese by linking them to water and thus reduce hardness (Rudan *et al.*, 1998). Therefore, the hardness of the A1, A2 and A3 sample was less than the hardness of the C^- and close to the hardness of C^+ sample. where the value of compressibility was 250, 370, 280, 230 and 200 Newton/m 2 in C^+, C^-, A1, A2 and A3 sample, respectively after one day. Those results were corresponded with Kumar (2012), he referred the hardness of the cheese made from skim milk was higher than the hardness of the cheese produced from the skim milk fortified with the fatty alternatives. On the other hand, it is also noted that reduced the hardness in all samples of cheese in the end of the storage (14 days) was 180, 300, 200, 160 and 170 Newton/m^2 in C^+, C^-, A1, A2 and A3 sample, respectively due to the increase in total acidity and reduction of pH value for all treatments with the aging of the treatments.

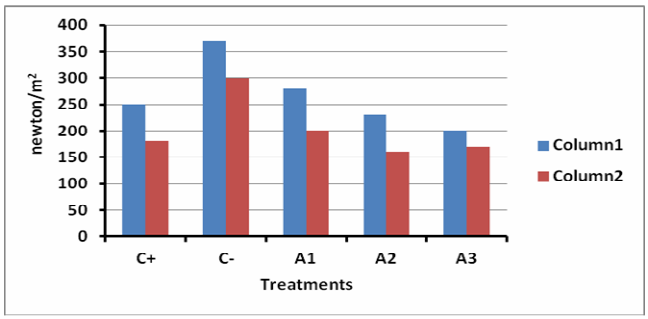

Fig. 1: The strength required to compress cheese samples produced from whole milk (C^+), skim milk (C^-) and low fat cheese fortified with Arabic gum after 1 and 14 days.

*Column 1= one day of storage and column 2= 14 days of storage. A1=low fat cheese fortified with 2% Arabic gum, A2= low fat cheese fortified with 4% Arabic gum and A3= low fat cheese fortified with 6% Arabic gum.

(ii) Elasticity of soft cheese samples

The elasticity is the degree to which the sample returns to its original form after putting pressure on it between the tongue and the upper surface of the mouth. The properties of the cheese texture are determined by overlapping structural properties of both the protein template and the fatty droplets (Lobato-Calleros *et al.*, 2007). The results noted, there is a clear difference in the time to return different cheese samples to its original position after reducing the impact of weight. Therefore, the difference in the degree of elasticity, which is affected by the chemical composition and the quantity of alternative fat. As shown in figure 2, the C^- sample took longer time (9 minutes) compared to C^+ sample (7 minutes) for returning to normal position after one day of storage due to the high protein content of low fat soft cheese, which provides a protein complex and rough as well as the spongy is reduced by the presence of fat in the protein form. In addition, the results showed that A1, A2 and A3 sample was more elasticity as compared to C^- sample by approximate time it takes to return the cheese to its original position with the time required to return the C^+ sample, where was 7.5, 7.8 and 8 minutes at the age of one day storage. These results are corresponded with Korish and Abeer (2012), the high elasticity of korish cheese added to water colloids for treatment of negative control. With regard the end of the age storage (14 days), elasticity increased with the time required for the return of the cheese samples to their original position which were 5, 6, 5.5, 5.3 and 7.1 minutes in C^+, C^-, A1, A2 and A3 sample, respectively.

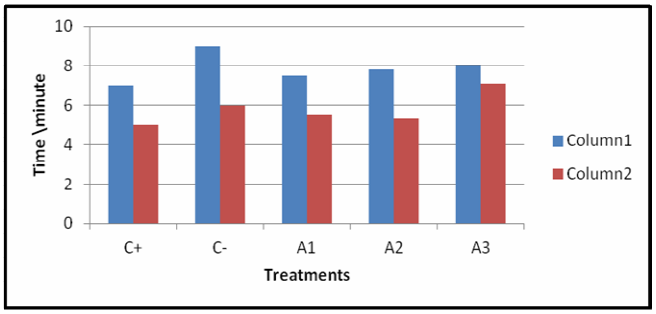

Fig. 2: Time required (min) to measure the elasticity of soft cheese samples

*(C^+)= full fat soft cheese control, (C^-)= low fat soft cheese control, Column 1= one day of storage and column 2= 14 days of storage. A1=low fat-soft cheese fortified with 2% Arabic gum, A2= low fat-soft cheese fortified with 4% Arabic gum and A3= low fat-soft cheese fortified with 6% Arabic gum.

Sensory Evaluation

Sensory evaluation is one of the most important measures to determine the quality of food product by means of acceptability. Stone *et al.* (2012) defined sensory evaluation as a scientific discipline used to interpret and determine the perception of the panelists (consumer) to evaluate the properties of food products**.** Cheese samples were subjected to sensory evaluation by a group of experienced and specialized food science staff. The results obtained from evaluator is given in Table 4. In this study**,** the C^+ sample was the highest in all sensory evaluation characteristics among other cheeses samples because of fat plays an effective role in the color, taste, flavor and texture. The results reported, the low fat soft cheese fortified with 4% Arabic gum (A2) has proven the best result compared with other treatment (A1 and A3), respectively. The texture was the highest in the 4% Arabic gum, according to Lobato Calleros et al. (2006) as fat content is decreased, more non-intermittent protein areas organize the cheese structure. Thus, a high grade of cross-linking between protein molecules happen, resulting in three-dimensional networks displaying high resistance to deformation.

Table 4 : Sensory evaluation of soft cheese samples during storage at (1±5)°C for 14 days

Total score of 60	Bitterness	Color	Flavor	Texture	Consistency	Holes	Soft cheese age	Treatment	
58.7	10.0	10.0	9.7	9.5	9.5	10.0	1	**Full fat soft cheese control (C^+)**	
43.9	8.3	7.5	6.3	7.0	6.3	8.5	14		
46.9	10.0	9.0	8.3	8.2	9.3	8.3	1	**Low fat soft cheese control (C^-)**	
39.5	7.5	7.0	6.0	6.0	6.0	7.0	14		
55.3	10.0	9.0	8.5	.4 8	9.4	10.0	1	**A1 2%**	**Parameters**
50.4	8.7	8.0	7.3	7.5	9.5	9.4	14		
57.2	10.0	9.4	9.6	8.7	9.5	10.0	1	**A2 %4**	
51.7	9.0	8.3	7.7	7.6	9.5	9.6	14		
53.0	10.0	**8**.3	8.4	8.2	8.6	9.5	1	**A3 6%**	
47.8	9.3	6.6	7.6	7.5	7.7	9.1	14		

*A1=low fat-soft cheese fortified with 2% Arabic gum, A2= low fat-soft cheese fortified with 4% Arabic gum and A3= low fat-soft cheese fortified with 6% Arabic gum.

Oberg *et al*. (2015) referred the utilize of xanthan gum at 1% was developed the texture of mozzarella cheese as well as the guar gum also was improve the texture of cheese (Lashkari *et al*., 2008). Flavor was the highest in the samples containing Arabic gum 4% as compared to the C^- sample. Other authors have showed the ability of Arabic gum to encapsulate flavors and odorous compositions in food products (Kennedy *et al*., 2011).

Color assessment was also highest at 4% Arabic gum as compared to C^-, A1 and A3 sample. But, depending to Mistry (2001), low fat soft cheeses do not contain the colors desired by the consumer. Although the low fat content, the level of color was high for Arabic gum sample at 4%. Consequently, Arabic gum can be utilized at this rate (4%) with less effect on the color of low fat soft cheese. That means the Arabic gum has the ability of developing the attraction of low fat soft cheese.

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