

Influence of Some Hydrocolloids on Textural Properties of UF Cheese

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ABSTRACT: In this study the rheological and textural properties of Iranian white cheese produced by ultrafiltration technique containing gum tragacanth and xanthan gum each in the range of 0-0.1%, and basil seed and linseed mucilages each in the range of 0-0.2% were evaluated. According to the results obtained, values of Elastic (G') and viscous (G'') moduli increased with increasing frequency sweep in all the cheese samples. G' was always greater than G'' . The values of G' and G'' in the samples containing 0.05% of gum tragacanth, 0.05% of xanthan gum and 0.1% of basil seed mucilage and containing 0.05% of xanthan gum, 0.1% basil seed and 0.1% linseed mucilage were maximum and in samples containing 0.1% of xanthan gum and 0.2% of linseed mucilage and containing 0.1% of gum tragacanth were minimum. By increasing basil seeds mucilage in the samples, hardness, cohesiveness, gumminess and chewiness increased in comparison with the control sample ($p < 0.01$). According to the results obtained, for preparation of white cheese produced by ultrafiltration technique, using 0.05 % of gum tragacanth, 0.05 % of xanthan gum and 0.1 % of linseed mucilage, is recommended.

Keywords: *Basil Seed Mucilage, Linseed Mucilage, Tragacanth, UF Cheese, Xanthan.*

Introduction

The white cheese produced by ultrafiltration technique is one of the widely consumed white brined cheese in all over middle east. Iranian UF-Feta cheese made from bovine milk is manufactured in modern dairy plants from pasteurized concentrated milk with mesophilic starter cultures and commercial microbial rennet which does not have ripening period and is consumable 72 hrs after production (Karami *et al.*, 2009).

High contents of whey proteins in UF cheeses result in some problems for both sensory and textural characteristics of these types of cheeses, Erdem (2000). One of the methods to improve the sensory and textural

properties of this type of cheese is using hydrocolloids. Hydrocolloids are compounds that improve the organoleptic and functional characteristics of cheese (Drake and Swanson, 1995; Mistry, 2001). The most important hydrocolloids used in the food industry are whey proteins (WP), gum tragacanth, gellan gum, xanthan gum, carboxymethylcellulose (CMC), etc (Drake and Swanson 1995; Romeih *et al.*, 2002).

Tragacanth or Katira, is a dried gummy exudate which is prepared by slashing the stems of Asiatic species of Astragalus (*Leguminosae*) which grows wildly in South West Asia, particularly Iran and Turkey. Gum tragacanth is a mixture of two polysaccharides, a non-water-soluble (60–70%) fractions, but swellable part called

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bassorin and a water-soluble (30–40% of TG) part which is called tragacanthin. Gum tragacanth has been used as a stabilizer, viscosity enhancer, emulsifier, thickener and suspending agent in emulsion systems in various foods (Yokoyama *et al.*, 1988).

Xanthan gum is a natural, high-molecular-weight exopolysaccharide and known as an important industrial biopolymer. Xanthan gum synthesizes by *Xanthomonas campestris* under unfavorable conditions. This gum possesses a major cellulosic chain with a primary structure. The biopolymer has been used in different foods for a variety of reasons, including stabilizing, viscosifying, emulsifying and thickening agent (Garcia-Ochoa *et al.*, 2000).

The basil or *Ocimum bacilicum* L. (locally known as Reyhan) is a member of genus *Ocimum*. Basil is one of the endemic plants in Iran that is produced and used as a herb in large amounts. Its hull consists of four layers; the outer layer contains soluble fiber. This soluble fiber, also known as mucilage. The outer pericarp (or outer epidermis) of basil seeds, when soaked in water, soon swells into a gelatinous mass. The high mucilage content of basil seeds can make it a novel source of edible gum. The mucilage extracted from basil seed have two major fractions, an acid-stable core glucomannan (43%) having a ratio of glucose to mannose 10:2, and a (1-4)-linked xylan (24.29%) having acidic side chains at C-2 and C-3 of the xylosyl residues in acid-soluble portion (Hosseini-Parvar *et al.*, 2010). The basil seed gum has lots of advantageous properties such as low cost, easy extraction and hydrophilic properties, relative abundance and biocompatibility as compared to their synthetic ones. This is used as gelling agent, binding agent, bulking agent, lubricating agent, sweetening agent, flavoring agent, and suspending agent. The mucilage is not digested in the human digestive system. Moreover, it is used as

dietary fiber, especially in southeast Asia (Azoma and Sakamoto, 2003).

Linseed (*Linum usitatissimum* L.) also contains mucilage in the seed coat, which is readily extracted with hot water. The Linseed mucilage includes two polysaccharide components, neutral and acidic (1:2). The neutral part consists of L-Arabinose, D-Xylose, and D-Galactose and the acidic part consists of L-Rhamnose, L-fucose, L-Galactose and D-galacturonic acid. The mucilage is used as emulsions, suspension of particulates and thickening agent. Linseed mucilage functionality is similar to the arabic gum (Fedeniuk and Biliaderis, 1994).

Korish & Abd Elhamid (2012) showed that the rheological properties (hardness, adhesion, cohesion, gumminess, chewiness and resilience) were significantly lower in the Egyptian Kariesh cheese made with hydrocolloids including commercial pectin, citrus pectin and carboxymethylcellulose (CMC). The samples made with 0.4% commercial pectin and 0.6% CMC recorded the highest scores for sensory attributes. The results of investigation conducted by Wium *et al.* (1997) showed that the rheological, textural and sensory properties of UF cheese can be evaluated using G' modulus. Hosseini-Parvar *et al.* (2015) investigated the effect of basil seed mucilage on the textural and rheological properties of a model processed cheese. The frequency sweep test showed the loss modulus and storage modulus values increased with increasing basil seed mucilage concentration in all formulations with the same protein/solid content. Increasing levels of basil seed mucilage also led to more elastic behavior in the structure of processed cheeses.

As the combination of hydrocolloids is commonly used to get a new rheological property or improve this property in food products and reduce production costs, therefore in this study combination of

hydrocolloids were used. The aim of this work was to evaluate the effect of different concentrations of linseed and basil seed mucilages, gum tragacanth and xanthan gum on the rheological and textural properties of Iranian white cheese produced by ultrafiltration technique.

Materials and Methods

- Raw Materials

Xanthan gum (XG) (Sigma Chemistry, Germany), gum tragacanth (TG) was purchased from Barnard company, a food grade ingredients supplier, Urmia, Iran. Linseed (*Linum usitatissimum*) and Basil seed (*Ocimum basilicum*) were purchased from a local market in Urmia, Iran. The Linseed mucilage (LSM) and Basil seed mucilage (BSM) extraction and purification were carried out according to the methods described by Tabibloghmany *et al.* (2013) and Anroop *et al.* (2006) respectively. All used ingredients were food grade.

- Cheese making

The experimental cheese samples were made according to the method used in the Alpila factory Urmia, Iran for industrial scale. After clarification and bactofugation, raw milk was pasteurised at 72°C for 15 s and then ultrafiltered at 50°C to total solids of about 40%. The membrane cartridges were of the spiral wound type (no UFPH20 Invensys APV, Silkeborg, Denmark) and the

membrane had a nominal molecular weight cut-off of approximately 20 kg/mol with a surface area of 16.9 m². The ultrafiltration unit was operated at an inlet pressure of 5.3 and an outlet pressure of 1.7 bars. In this stage, depending on the type of treatments (Table 1), the gums were added to the retentate and dissolved completely. The retentate was then re-pasteurised at 78°C for 1 min and then cooled to 37°C, at which point, a mixed strain inoculum (1.0%, v/v) of the cheese starters (*Lactococcus lactis* subsp. *lactis* biovar *diacetylatis* and *Lactococcus lactis* subsp. *cremoris*, Danisco, Sassenage, France) and rennet (300 mg/Kg, DSM Food Specialties, Australia Pty Ltd., Moore Bank, NSW, Australia) were added to the concentrate, immediately before filling it in 300 g portions into plastic containers.

The containers were then passed through the coagulation process tube during which the complete coagulation of concentrated milk was achieved at 30°C in about 30 min. The end of coagulation tunnel, a piece of Parchment paper was laid at the top of coagulum, and salt was added at the rate of 3% to the Parchment to achieve even distribution of salt in cheese before the containers were sealed. The containers were then kept at 25–30°C room for 24 h and then 48 h in a cold room at 4° C (Zomorodi *et al.*, 2011). The experimental samples were then transferred to 8–10°C cold room.

Table 1. Types of treatments

Treatments	Gum tragacanth (%)	Xanthan gum (%)	Linseed mucilage (%)	Basil seed mucilage (%)
C	0	0	0	0
LM _{0.2}	0	0	0.2	0
XG _{0.1}	0	0.1	0	0
XG _{0.1} LM _{0.2}	0	0.1	0.2	0
TG _{0.1}	0.1	0	0	0
TG _{0.1} LM _{0.2}	0.1	0	0.2	0
TG _{0.05} XG _{0.05} LM _{0.1}	0.05	0.05	0.1	0
TG _{0.05} XG _{0.05} BS _{0.1}	0.05	0.05	0	0.1
XG _{0.05} LM _{0.1} BS _{0.1}	0	0.05	0.1	0.1

Notes C: Control, LM: Linseed mucilage, XG: Xanthan gum, TG: Gum tragacanth, BM: Basil seed mucilage

- Rheological properties

Rheological properties of the cheese samples were measured using a Physica Anton Paar Rheometer (MCR 301, Austria) equipped with a cone-plate measurement system with a diameter of 25 mm and a gap size of 1.0 mm. In order to determine the rheometer parameters, cheese samples were cut into pieces with a length and width of 20 mm and a height of 2 mm. The sample was placed between the cones and the plate and was allowed to rest for 10 min at 20 °C in order to allow stress relaxation before the oscillation. Storage modulus (G'), loss modulus (G'') and Complex Viscosity ($*\eta$) were recorded continuously at a shear strain 0.05 % at a frequency 0.1 to 100 Hz. Each sample was analysed in triplicate (Zhu, 2013).

- Texture profile analysis

Texture profile analysis (TPA) of the cheese samples was carried out by using a TA-XT2i Texture Analyzer (England Stable Micro System CO., Ltd) with Texture Expert for Windows (Texture exponent 32 software), equipped with a cylinder probe. For this purpose, samples were made in the form of a cylinder with a height of 20 mm and a diameter of 15 mm, compressed to 50 % of initial height (10 mm) in 2 cycles. Penetration rate was 0.5 mm/s and each test was performed in 3 replicates. The evaluated

properties were hardness, cohesiveness, gumminess and chewiness (Wang and Li, 2012).

- Experimental design and statistical analysis

The data of moisture, textural and rheological properties were analyzed using a completely randomized design in 3 replicates. Statistical analysis was performed using the Minitab 17 program and comparison of means was made using the Tukey test at 1% level. All the charts were drawn using Microsoft Office Excel 2010.

Results and Discussion

- Moisture variations

As the results in Table 2 shows, by increasing basil seed mucilage, the moisture content of samples decreased ($p < 0.01$). Differences in the chemical structure of gums lead to variation in their functional properties, and also affect their efficiency and applications. Basil seed mucilage is a surface active hydrocolloid and has a high water binding capacity. Basil seed gum is a unique thickening and stabilizing agent (Hosseini-Parvar et al., 2010). Johary et al. (2015) also showed that by adding basil seed mucilage in mayonnaise sauce, the moisture content was reduced, which was in agreement with our results.

Table 2. The effect of different treatments on the moisture and textural profile of Uf cheeses

Treatments	Moisture (%)	Hardness (N)	Cohesiveness	Gumminess (N)	Chewiness (N/mm)
1 C	65.27	1.66b ^c	0.44 ^b	0.73 ^b	8.93 ^b
2 LM _{0.2}	66.29	1.40 ^{bc}	0.40 ^b	0.56 ^b	7.36 ^b
3 XG _{0.1}	66.37	1.44 ^{bc}	0.43 ^b	0.62 ^b	8.69 ^b
4 XG _{0.1} LM _{0.2}	67.14	1.28 ^c	0.36 ^b	0.46 ^b	8.75 ^b
5 TG _{0.1}	66.93	1.21 ^c	0.46 ^b	0.56 ^b	6.78 ^b
6 TG _{0.1} LM _{0.2}	66.59	1.37 ^{bc}	0.44 ^b	0.60 ^b	7.56 ^b
7 TG _{0.05} XG _{0.05} LM _{0.1}	66.94	1.57 ^{bc}	0.49 ^b	0.77 ^b	10.81 ^b
8 TG _{0.05} XG _{0.05} BS _{0.1}	62.00	2.01 ^{ab}	0.69 ^a	1.39 ^a	17.90 ^a
9 XG _{0.05} LM _{0.1} BS _{0.1}	62.23	2.35 ^a	0.66 ^a	1.55 ^a	20.21 ^a
SEM	0.97	0.22	0.06	0.21	2.61

Nots C: Control, LM: Linseeds mucilage, XG: Xanthan gum, TG: Tragacanth gum, BM: Basil seeds mucilage. Superscript letters (a–c) beside mean values in columns show the difference in Tukey test ($P < 0.01$). SEM: Standard Error Mean
^{a, b, c, d} In each column, different letters indicate significant differences among the means ($p < 0.05$).

- *Textural Profile Analysis (TPA)*

Texture is an important characteristic used to differentiate many cheese varieties and is considered by the consumer as a determinant of overall quality and preference (Aminifar *et al.*, 2013). In this study, the textural properties of the cheese samples including hardness, adhesion, cohesion, gumminess and chewiness were evaluated. The effect of different treatments on textural profile of UF cheeses are presented in Table 2. The hardness is used as an index of product strength while cohesiveness indicates the strength of internal bonding of the cheese.

As shown in Table 2, by increasing the level of basil seed mucilage increased the hardness, adhesion, gumminess and chewiness increased significantly ($p < 0.01$). This can be due to low moisture content of the samples. However, increasing the amount of gum tragacanth, xanthan gum and the linseed mucilage did not show significant effects ($p > 0.05$). According to the results of this study, the hardness of treatment 9 was significantly different from the control (no gum) ($P < 0.01$). The results indicated that at the formulations containing basil seed mucilage, by increasing the solid content, the hardness and cohesiveness of the samples increased.

The values of hardness, adhesion, gumminess and chewiness were maximum in treatments 8 and 9 and minimum in treatments 4 and 5 (Table 2). The moisture is a very effective factor on the hardness and compression of the cheese. The moisture acted as a plasticizer contributing to a more liquid-like behavior of the cheese samples (Dimitreli and Thomareis, 2008). therefore, raising moisture content in cheese leads to a softer cheese (Fox *et al.*, 2000). Souza and Saad (2009) claimed that besides other factors, increase in syneresis, concomitant with the decrease in moisture, increase in hardness of the cheese, as also reported by Cerqueira *et al.* (2009) and Weiserová *et al.*

(2011). Recently, Hanakova *et al.* (2013), showed that the addition of 1% k-carrageenan to the formulation of the processed cheese analogue leads to the highest firmness as compared to the formulations containing γ -carrageenan, λ -carrageenan, gum Arabic and locust bean gum.

However, with an increase in the basil mucilage, the moisture content of the samples decreased, and this could be a factor in increasing the hardness and cohesion of the samples (Zisu and Shah, 2005). Similar to the cases of gumminess, high moisture content in cheese, resulted in a weak body and their structural bones links, and they were broken with low force (Zisu and Shah, 2005). However, treatments containing basil seed mucilage that had low moisture content, resulted in a higher-force rupture. The increase in moisture content of the cheese, leading to a weaker protein and hydrocolloid structure and reduced hardness values (Cooke *et al.*, 2013). Korish & Abd Elhamid (2012) reported that the addition of pectin and carboxymethylcellulose to the Egyptian Kariesh cheese reduced the hardness of the samples as compared to the control. Aminifar and Emam-Djome (2016) stated that the addition of tragacanth gum reduced the hardness of the Lighvan cheese in comparison to the no-gum-sample. Romeih *et al.* (2002) revealed that cheeses prepared with hydrocolloids, had higher moisture content and softer texture. Similar results were obtained by Konuklar *et al.* (2004) and Sipahioglu *et al.* (1999). Various studies have shown that the moisture content of cheeses affects texture and functionality and cheeses with increased moisture retention were made softer and their melting properties were improved making the product more pliable (Low *et al.*, 1998; McMahon *et al.*, 1999). Similar results were observed by Bryant *et al.* (1995). They showed that by increasing moisture, the hardness, springiness and cohesiveness

increased and adhesiveness decreased in Cheddar cheese. In addition to the moisture content, dry matter and the ratio of moisture to protein are the other determinant factors of the mechanical parameters of the cheese texture (Koca and Metin, 2004).

- Rheological properties

Cheese rheology is an important tool to study and identify the textural and structural properties. It deals with deformation of the sample by employing different kinds of instruments. The results of the small and large deformation tests are interpreted to understand the effect of composition, process modification and storage variables (McEwan *et al.*, 1989). In this work, the rheological properties of the cheese samples after 10 days of production including the elastic or storage modulus (G'), the viscous or loss modulus (G'') and complex viscosity ($*\eta$) were analyzed.

The Figures 1a, 1b and 1c have shown changes in G' , G'' and $*\eta$ at different frequencies for cheese samples respectively. As shown in these Figures, the values of G' and G'' increased with increasing frequency in all cheese samples, indicating viscoelastic structure of the samples, and $*\eta$ decreased, indicating viscoelastic structure of the samples. Nolan *et al.* (1989) reported that the protein network structure is responsible for causing cheese viscoelastic. Wium *et al.* (1997) also suggested that the lower pH of feta cheese (4.5–4.7) was probably the main reason for its dominant elastic character. pH has a major role on the viscoelastic properties of cheese (Tunick, 2000). These results are in agreement with the results reported by Yilmaz *et al.* (2011). They showed that the Storage (G') and loss (G'') moduli increased by increase in the frequency, while complex viscosity ($*\eta$) decreased. According to the results of Yilmaz *et al.* (2011), reduction of the $*\eta$ with increasing frequency also show shear-thinning behavior. Such behavior was in

good agreement with the work carried out for processed cheese (Subramanian *et al.*, 2006).

In all cases, the storage modulus (G') values was always higher than loss modulus (G'') values, indicating that weak gel or soft solid-type structures were present (Tunick 2000). When G' was granted than G'' (gel character), the elastic behavior dominates over the viscous behavior (Steffe, 1996). Sharoba *et al.* (2005) also stated when the storage modulus is much larger than the loss modulus, it indicates dominant elastic properties. Messens *et al.* (1999) also showed that the G' value was greater than G'' value in Gouda cheeses. The similar results reported by Gonzalez-Martin *et al.* (2007) in Cheddar cheese. Based on the frequency sweep data of G' and G'' moduli as a function of frequency, exhibited the rheological behavior similar to weak gel-like macromolecular dispersions with G' much greater than G'' with in the whole range of frequency applied.

The values of G' and G'' were maximum in treatments 8 and 9 and minimum in treatments 4 and 5 (As shown in Figure 1a and 1b), which indicated that treatments 8 and 9 were more viscoelastic compared to the treatments 4 and 5. One possible explanation is that by increasing the amount of BSG in treatments 8 and 9, more intensive interactions between BSG chains take place, leading to the formation of a denser network structure.

However, increasing the amounts of BSG led to a more elastic structure in the cheese, which could be attributed to the formation of BSG network throughout the casein matrix (Hosseini-Parvar *et al.*, 2015). Hosseini-Parvar *et al.* (2015) also showed that by increasing the levels of BSG led to more elastic behavior in the structure of processed cheeses. They also stated that solid-type structures were present and both parameters increased with frequency. Hort *et al.* (1997) explained that water in the cheese can

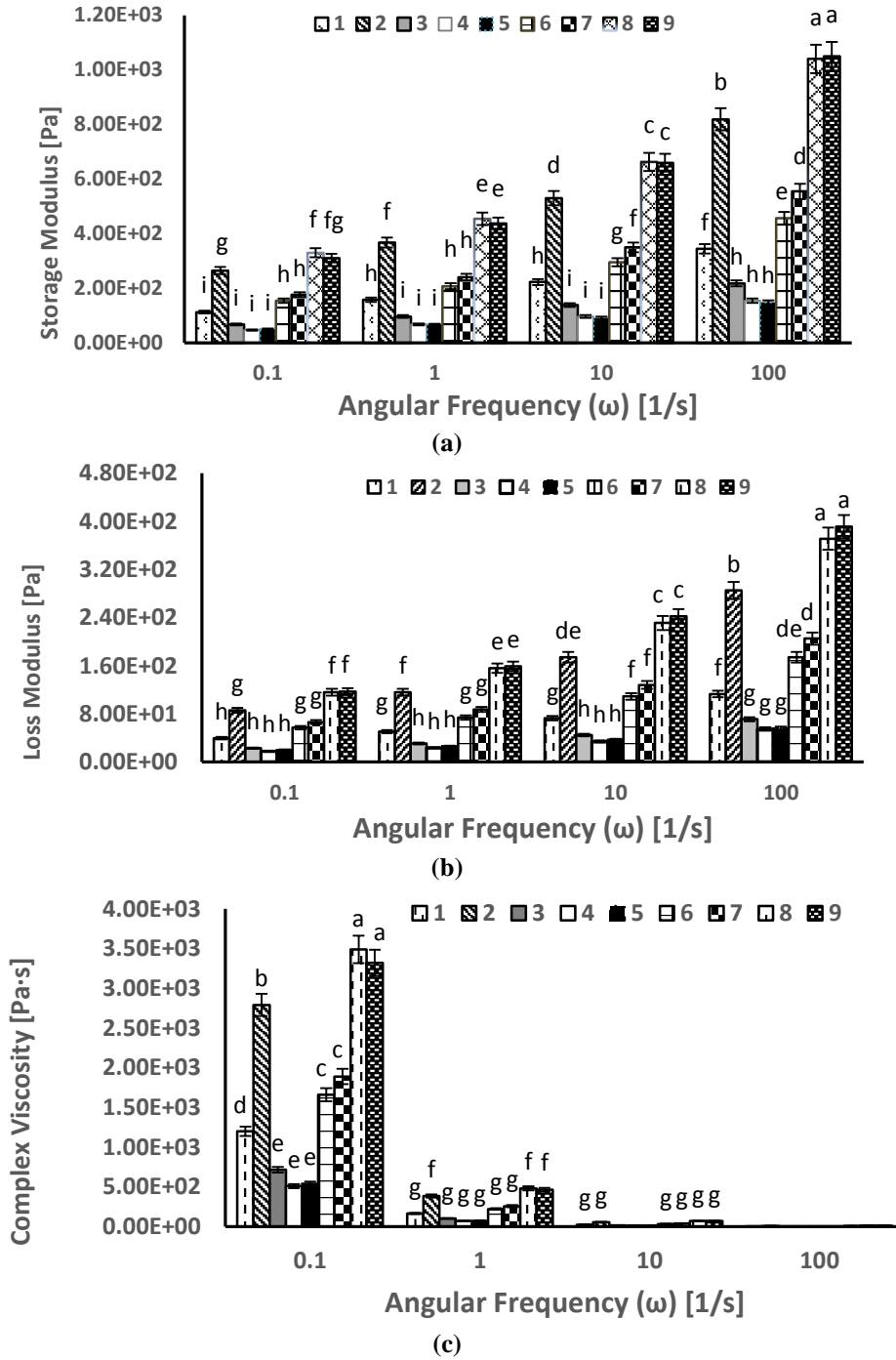


Fig. 1. The variations of G' (a), G'' (b) and $*\eta$ (c) at different frequencies in cheese treatments.

Note: **1:** control, **2:** 0.2 % Linseed mucilage, **3:** 0.1% Xanthan gum, **4:** 0.1% Xanthan gum with 0.2% Linseed mucilage, **5:** 0.1% Xanthan gum, **6:** 0.1% Gum tragacanth with 0.2% Linseed mucilage, **7:** 0.05 % Gum tragacanth with 0.05% Xanthan gum and 0.1% Linseed mucilage, **8:** 0.05% Gum tragacanth with 0.05% Xanthan gum and 0.1% Basil seed mucilage, **9:** 0.05% Xanthan gum with 0.1% Linseed mucilage and 0.1% Basil seed mucilage. Lowercase letters (a-i) above each bar graph shows the difference in Tukey test ($P < 0.05$).

associate with the protein; it exists in both free and bound states. The presence of proper percent of water in cheese is important, since water acts as lubricant or

plasticizer between protein molecules, therefore lower moisture content in cheese leads to harder cheese body (Hennelly *et al.*, 2006). The high G' values can be attributed to the low moisture content of those cheese samples. According to the results obtained by Gonzalez-Martin *et al.* (2007), high value of G' can be attributed to high protein and low moisture content of samples, that confirms the results of this study. Luyten *et al.* (1991) also showed that the value of G' , which indicates the hardness of the cheese, increased with decreasing fat and moisture contents.

Increasing the storage modulus represent the increased hardness of the cheese, which shows an increase in elastic bonds between the main cheese structures (Pandey *et al.*, 2000).

Conclusion

The results showed that by increasing basil seed mucilage, the moisture content decreased and hardness, adhesion, gumminess and chewiness of the cheese increased ($p < 0.01$).

the values of G' and G'' increased with increasing frequency in all cheese samples, indicating viscoelastic structure of the samples, and η^* decreased, that also indicates the viscoelastic structure of the samples. In all cases, the storage modulus (G') values was always higher than loss modulus (G'') values, indicating that weak gel or soft solid-type structures were present. The values of hardness, adhesion, gumminess and chewiness and values of G' and G'' were maximum in treatments 8 and 9 and minimum in treatments 4 and 5, which indicated that 8 and 9 treatments were more visco-elastic compared as to the 4 and 5 treatments.

Therefore, the production of white cheese produced by ultrafiltration technique, using 0.05% of gum tragacanth, 0.05% of xanthan gum and 0.1% of linseed mucilage might be recommended and valuable.

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