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Comparison of the effect of linseed and basil seed mucilages with gum tragacanth and xanthan gum on textural and rheological properties of Iranian white cheese produced by ultrafiltration technique effect of some gums on properties of ultrafiltrated cheese

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A B S T R A C T

In this study the rheological and textural properties of Iranian white cheese produced by ultrafiltration technique containing gum tragacanth and xanthan each in the range of 0-0.1%, and basil seed and linseed mucilage 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 sample containing 0.05% of gum tragacanth, 0.05% of xanthan gum and 0.1% of basil seed mucilage and the sample containing 0.05% of xanthan gum, 0.1% basil seed and 0.1% linseed mucilage were maximum. Also, in samples containing 0.1% of xanthan gum and 0.2% of linseed mucilage and containing 0.1% of gum tragacanth were minimum. With 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, application of 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

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1. Introduction

The white cheese produced by ultrafiltration technique is a widely consumed white brined cheese in all over the Middle East. Iranian UF-Feta cheese made from bovine milk is manufactured in modern dairy plants from pasteurized concentrated milk in a conventional method. This type of cheese does not have ripening period and is consumed within 72 hours after production (Karami et al., 2009). High contents of whey proteins in UF cheese results in some problems for both the sensory and textural characteristics of these types of cheeses (Erdem, 2000). One of the methods to improve the sensory and textural properties of cheese is using hydrocolloids (Drake & 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. (Romeih et al., 2002).

Tragacanth 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 in Iran and Turkey. This gum consists of two polysaccharides including a non-water-soluble (60–70%) fraction, called bassorin and a water-soluble (30–40% of TG) part which is called tragacanthin. It is used as a stabilizer, viscosity enhancer, emulsifier, thickener and suspending agent in emulsion systems in different 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 consists of 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 (Garcıa-Ochoa et al., 2000).

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The basil (*Ocimum bacilicum* L.) locally known as Reyhan is a member of genus *Ocimum*. Basil is an endemic plant in Iran which is produced and used as an herb in large scale. Its hull consists of four layers; the outer layer contains soluble fiber, which is 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 contains 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 & 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 & Biliaderis, 1994)

Korish and 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) studied 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 are commonly used to get an improved rheological property in food products, for lowering production costs, therefore in this study combination of hydrocolloids were used.

The purpose 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.

2. Material and Methods

2.1. 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 bacilicum*) 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 Tabibloghmani et al. (2013) and Anroop et al. (2006) respectively. All used ingredients were food grade.

2.2. 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 72ºC for 15 s and then ultrafiltered at 50ºC 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, the gums were added to the retentate and dissolved completely according to Table 1. The retentate was then re-pasteurised at 78ºC for 1 min and then cooled to 37ºC, 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 30ºC in about 30 min. At the end of the coagulation tunnel, a piece of Parchiment paper was laid at the top of coagulum, and salt was added at the rate of 3% to the Parchiment to achieve even distribution of salt in cheese before the containers were sealed. The containers were then kept at 25–30ºC room for 24 h and then 48 h in a cold room at 4º C (Zomorodi et al., 2011). The experimental samples were then kept at 8–10ºC cold room until examined.

Table 1. Type of treatments.

Treatment	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
$G_{0.05}XG_{0.05}LM_{0.1}$	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

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

2.3. 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 thickness 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 (*η) 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).

2.4. 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 & Li, 2012).

2.5. 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.

3. Results and Discussion

3.1. Moisture variations

As the results in Table 2 shows, with 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.

3.2. 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, increasing level of basil seed mucilage increased the hardness, adhesion, gumminess and chewiness significantly ($p < 0.01$). This can be due to low moisture content of the samples. But increasing amount of gum tragacanth, xanthan gum and the linseed mucilage had no significant effect on moisture ($p > 0.05$). 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, with 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 & Thomareis, 2008). Therefore, raising moisture content in cheese leads to production of 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, Hanvakova et al. (2013), also showed that addition of 1% k-carrageenan to the formulation of the processed cheese analogue leaded to the highest firmness as compared to the formulations containing ¡-carrageenan, λ-carrageenan, gum Arabic and locust bean gum 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 & Shah, 2005). However, treatments containing basil seed mucilage had low moisture content, resulting in a higher-force rupture.

The increase in moisture content of the cheese, leading to a weaker protein and hydrocolloid structure and reduce hardness values (Cook et al., 2013). Korish and Abd Elhamid (2012) reported that adding pectin and carboxymethylcellulose to the Egyptian Kariesh cheese reduced the hardness of the samples 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 with 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 affect 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 with 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 & Metin, 2004).

3.3. 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 applying different instruments. 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 (*η) were analyzed.

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)
C	65.27	$1.66b^{c}$	0.44^{b}	0.73^{b}	8.93^{b}
$LM_{0.2}$	66.29	1.40^{bc}	0.40^{b}	0.56^{b}	7.36^{b}
$XG_{0.1}$	66.37	1.44^{bc}	0.43^{b}	0.62^{b}	8.69^{b}
$XG_{0.1}LM_{0.2}$	67.14	1.28^{c}	0.36^{b}	0.46^{b}	8.75^{b}
$TG_{0.1}$	66.93	1.21^{c}	0.46^{b}	0.56^{b}	6.78^{b}
$TG_{0.1}LM_{0.2}$	66.59	1.37^{bc}	0.44^{b}	0.60^{b}	7.56^{b}
$TG_{0.05}XG_{0.05}LM_{0.1}$	66.94	1.57^{bc}	0.49^{b}	0.77^{b}	10.81^{b}
$TG_{0.05}XG_{0.05}BS_{0.1}$	62.00	2.01^{ab}	0.69^{a}	1.39^{a}	17.90^{a}
$XG_{0.05}LM_{0.1}BS_{0.1}$	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 ($p < 0.01$).

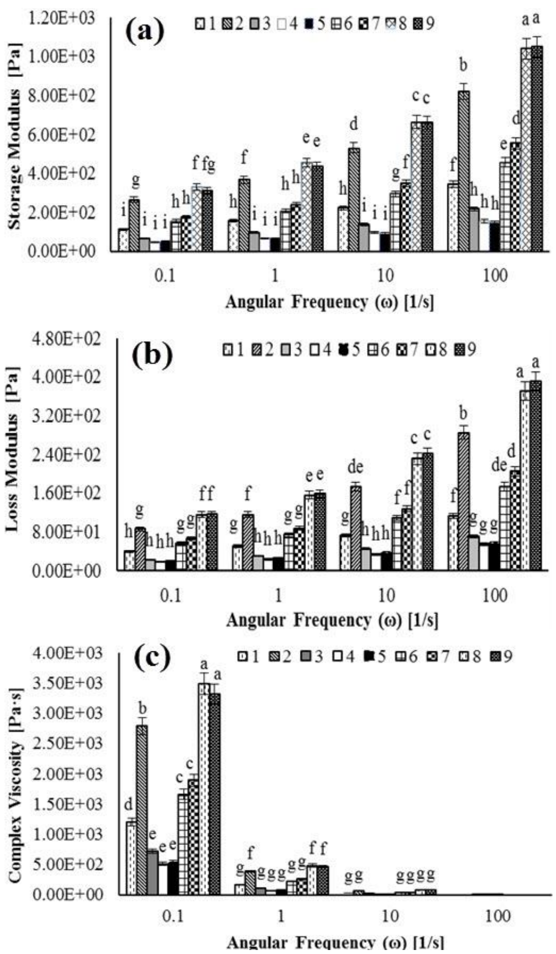

Fig. 1. The variations of G′ (a), G″ (b) and *η (c) at different frequencies in cheese treatments. (Note: 1: control, 2: 0.2 % Linseed mucilage, 3: 0.1% Xanthan gum, 4: 0.1% Xanthan gum with 0.2% Linseed mucilage, 5: 0.1% Xanthan gum, 6: 0.1% Gum tragacanth with 0.2% Linseed mucilage, 7: 0.05 % Gum tragacanth 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)).

The Fig. 1a, b and c show the changes in G′, G″ and *η at different frequencies for cheese samples respectively. As shown in these figures, the values of G′ and G″ increased and *η decreased with increasing frequency in all cheese samples, 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″) modulus increased with increase in frequency, while complex viscosity (*η) decreased. According to the results of Yilmaz et al. (2011), reduction of the *η with increasing frequency also cause shear-thinning behavior. Such behavior was in good agreement which was found in 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′ > G″ (gel character), the elastic behavior dominates over the viscous behavior (Steffe, 1996). Sharoba et al. (2005) also stated that when the storage modulus is much larger than the loss modulus, indicating dominant elastic properties. Messens et al. (1999) also showed that the G′ value was greater than G″ value in Gouda cheeses. 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 Fig. 1a and b), which indicated that treatments 8 and 9 were more viscoelastic compared to the treatments 4 and 5. One possible explanation is that with increasing 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 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 increasing levels of BSG led to a more elastic behavior in the structure of processed cheeses. They also stated that solid types structures were present and both parameters increased with frequency. Hort et al. (1997) explained that water in the cheese can 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., 2005). Then, high G′ values can be attributed to the low moisture content of those cheese samples. Luyten et al. (1991) also showed that the value of G′, which indicates the hardness of the cheese, increased with a decreasing fat and moisture content.

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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).

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 viscoelastic compared to the 4 and 5 treatments. All in all, it can be said for 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 is recommended.

4. Conclusion

The results showed that with 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 and *η decreased with increasing frequency in all cheese samples, indicating viscoelastic structure of the samples. In all cases, the storage modulus (G′) values were always higher than loss modulus (G″) values, indicating that weak gel or soft solid type structures were present.

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