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Research Article
Impact of Xanthan Gum as Fat Replacer on Characteristics of Low Fat Kariesh Cheese

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Abstract
For improving the quality of the popular low fat Kariesh cheese it was manufactured from skimmed buffalo's milk supplemented with different concentrations ranged from 0.01-0.05% of xanthan gum as a fat replacer. The resultant cheese was microbiologically analyzed for *Lactobacillus dlebreuckii* ssp., *L. bulgaricus*, *Streptococcus thermophilus* on MRS agar and M17 agar, respectively at 37°C for 24 h. The total bacterial count was also determined at 37°C for 24 h. Chemical analysis was achieved for determination of fat, total nitrogen, ash and total solids as recommended by AOAC methods. The texture of the product was evaluated using the double compression test with addition of xanthan gum no alteration of microbial population was detected. The increase of cheese yield upon addition of 0.4 and 0.5% was not significant compared with the control. Textural characteristics including, hardness, cohesiveness, springiness, gumminess and chewiness were increased for both the product and the control cheese up to 15 days storage period after that the hardness and cohesiveness were significantly decreased with increasing xanthan gum concentration. Kariesh cheese made with using 0.04 and 0.05% xanthan gum exhibited high acceptability compared with the control after 7 days of storage period. The addition of xanthan gum as a fat replacer upon manufacturing of Kariesh cheese enriched its flavor and improved its quality.

Key words: Kariesh cheese, xanthan gum, fat replacer, textural parameters, cheese characteristics

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Xanthan gum is an extracellular hetero polysaccharide produced by *Xanthomonas campestris*. Due to its excellent rheological behavior, xanthan gum is widely used as a microbial polysaccharide in many industrial applications. It is used as, stabilizing, suspending emulsifying and thickening agent, for food and non-food industrial applications (Sutherland, 1996; Sadek *et al*., 2006).

The applications and impact of stabilizers in food products is not new; they have been employed for more than fifty years ago. However, in the recent years a wide range of novel dairy products that rely, to a large extent, on the rheological functions of stabilizers has been produced (Murad *et al*., 1998). One of the most priorities of dairy industry is to produce desirable products that have good qualities reflected in their appearance, texture and flavor over a more shelf life. In order to reach this objective, dairy industry has been oriented to utilize ingredients such as stabilizers to improve the kinetical stability of food emulsvying agents (Dickinson, 1988, 1992). Mixtures of xanthan gum, galactomannans carrageenan, guar and locust bean gum are excellent stabilizer for many dairy products including ice cream, milk shakes sherbet, ice milk and water ices. Xanthan, guar and LBG blend are very important for improving sliceability, firm body and flavor release of cream cheese. Also, xanthan serve as a thinker for cottage cheese dressings by improving drainage control (Palaniraj and Jayaraman, 2011).

Kariesh cheese is the most popular, cheaper, rich in nutrients and oldest cheese in Egypt. It is a soft acid cheese and low-fat because it is made from skimmed milk. Low fat content of Kariesh cheese led to textural, functional and sensory defects such as rubbery texture, flat flavor, bitter taste, poor meltability and undesirable flavor and colour (Romeih *et al*., 2002) as well as high susceptibility to fragmentation and rough texture. Several visions have been proposed to improve Kariesh cheese include addition of curcumen (Hosny *et al*., 2011), using therapeutic or probiotic cultures containing *Bifidobacterium* spp., which are beneficial for both man and animal (Murad *et al*., 1998; Abd-Elhamid, 2012; Azzaz *et al*., 2016), or using of EPS-producing *S. thermophilus* to enhance Kariesh cheese texture (Hassan *et al*., 2004). The present study aims at production of Kariesh cheese with more acceptable properties especially from sensory properties point of view by using Xanthan gum as a fat replacer.

MATERIALS AND METHODS

Yoghurt starters: *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus salivarius* subsp. *thermophilus* were obtained from Chr. Hansen Laboratories, Copenhagen, Denmark. These organisms are yoghurt starters and were used as starters for Kariesh cheese.

Xanthan gum: Xanthan gum was obtained from Kelco, Division of Merck and Co. Inc., New Jersey, USA.

Milk: Fresh buffalo's milk was obtained from herd of Faculty of Agriculture Cairo University, Egypt. It was skimmed before using in Kariesh cheese preparation.

Kariesh cheese preparation: Kariesh cheese was produced following the method of Szczesniak *et al*. (1963). A skimmed buffalo's milk was divided into six equal portions. One batch had no xanthan gum and served as control. Xanthan gum was added to the latter batches at the concentrations of 0.01, 0.02, 0.03, 0.04 or 0.05%, respectively. All milk batches were heated at 75°C and cooled to 42°C, inoculated with starter culture using 2% (v/v) of active mixed cultures (1:1) of *Streptococcus thermophilus* and *Lactobacillus dlebreuckii* ssp. *bulgaricus*. Cheese samples were transferred into 300 mL plastic cups and incubated at 42°C for 4-8 h until coagulation. Cheese preparations were kept at 5±2°C for 15 days storage period.

Microbiological analysis: One cheese cup was taken as a sample from each treatment after complete coagulation at fresh, 5, 10 and 15 days of storage period for microbiological analysis. Karish cheese samples were analyzed for *Lactobacillus dlebreuckii* ssp. *bulgaricus* count on MRS agar (Oxoid) at 37°C for 48 h. While, M17 (Oxoid) was used to determine *Streptococcus thermophilus* at 37°C for 24 h. Total bacterial counts were enumerated on nutrient agar at 37°C for 24 h (APHA., 1978).

Chemical analysis: Total Nitrogen (TN) fat, ash and total solids, of Kariesh cheese samples were analysed according to AOAC (2007), methods, 926.08, 933.05 and 2001.14, respectively. The protein content was estimated by multiplying the percentage of total nitrogen by the factor 6.38. The pH values of the cheese samples were measured using digital pH meter (HANNA, Instrument, Portugal) connected to glass electrode.

Sensory evaluation: Kariesh cheese samples were divided into about 5×5 cm pieces and distributed in white clean plates. Samples were left at room temperature (20±2°C) and then introduced to the panelists for evaluation in a random

order. Mouth wash of the panelists before each sample evaluation was performed. The sensory properties of Kariesh cheese were evaluated by 10 panelists of the experienced members of Dairy Department, National Research Center. Evaluation points were considered for flavor (50 points), body and texture (40 points) and appearance (10 points) according to Keating and White (1990) and Amer *et al*. (1997).

Texture evaluation: Texture Profile Analysis (TPA) was achieved for the whole cheese samples using the double compression test (TA-XT2 Texture Analyzer, Texture Technologies Corp., Scarsdale, NY). Samples were double compressed to 80% of their original height at a compression speed of cm min^{-1}. The following parameters were evaluated by TPA according to the IDF (1991) definitions: Hardness is the force required to reach a given deformation, fracturability is the force at which the material fractures, springiness or elasticity is the rate at which a deformed material goes back to its undeformed condition after removal of the deforming force and cohesiveness is the quantity enhancing the strength of the internal bonds making up the body of the product. The indicated textural properties were estimated using Texture Expert software (version 1.22, Stable Micro Systems Ltd., Haslemere, UK). The value of the peak force of the 1st compression (bite) is the measure of hardness (in Newtons, N). The ratio between areas under peak force of the second bite to that of the first bite is the measure of cohesiveness (no dimension). The measure of the springiness (no dimension) is the ratio of the distance taken to reach the force peak during the second bite to the distance elapsed to reach the peak force during the first bite.

Statistical analysis: Statistical analysis was achieved using the GLM procedure with software (2004). Duncan's multiple comparison procedure was employed to compare the means. A probability of $p \leq 0.05$ was adopted for verification of the statistical analysis significance.

RESULTS

Microbiological analysis: The microbial analysis of Kariesh cheese during storage period is presented in Table 1-3. The viability of *Lactobacillus dlebreuckii* ssp. *bulgaricus* showed significant decrease ($p \leq 0.05$) in both control sample and treatments samples (0.01, 0.02, 0.03, 0.04 and 0.05% xanthan gum) after 5 days of storage period (Table 1). However no significant effect was detected ($p \leq 0.05$) on the viability of *Lactobacillus dlebreuckii* ssp. *bulgaricus* among cheese treatments, except upon using 0.05% xanthan gum which showed significant decrease ($p \leq 0.05$) in the viability of

Table 1: *Lactobacillus dlebreuckii* ssp. *bulgaricus* counts (log CFU g^{-1}) during storage period of Karish cheese

		Xanthan gum concentrations (%)				
Storage periods (days)	Control	0.01	0.02	0.03	0.04	0.05
Fresh	8.45^{Aa}	8.6^{Aa}	8.8^{Aa}	8.5^{Aa}	8.68^{Aa}	7.92^{Ab}
5	8.00^{Bab}	7.89^{Bab}	8.2^{Ba}	7.9^{Bab}	7.92^{Ba}	7.6^{ABb}
10	7.96^{Ba}	7.79^{Bab}	7.97^{Ba}	7.79^{Bab}	7.79^{Bab}	7.5^{Bb}
15	7.20^{Cbc}	7.3^{Cab}	7.46^{Cab}	7.3^{Cab}	7.65^{Ca}	6.85^{Cc}

Means with the same capital letters in the same column and the same small letters in the same row are not significantly difference ($p \leq 0.05$)

Table 2: *Streptococcus thermophilus* counts (log CFU g^{-1}) during storage period

		Xanthan gum concentrations (%)				
Storage periods (days)	Control	0.01	0.02	0.03	0.04	0.05
Fresh	9.67^{Aa}	9.15^{Ab}	9.4^{Aab}	9.5^{Aab}	9.6^{Aa}	9.56^{Aa}
5	9.45^{Aab}	9.11^{Ab}	9.36^{Aab}	9.4^{Aab}	9.5^{Aa}	9.39^{Ab}
10	8.28^{Ba}	8.1^{Ba}	8.15^{Ba}	8.3^{Ba}	8.3^{Ba}	8.11^{Ba}
15	7.47^{Ca}	7.0^{Cb}	7.52^{Ca}	7.3^{Cab}	7.3^{Cab}	7.04^{Cb}

Means with the same capital letters in the same column and the same small letters in the same row are not significantly difference ($p \leq 0.05$)

Table 3: Total bacterial counts (log CFU g^{-1}) during storage period

		Xanthan gum concentrations (%)				
Storage periods (days)	Control	0.01	0.02	0.03	0.04	0.05
Fresh	8.3^{Ab}	8.8^{Aab}	8.9^{Aa}	8.8^{Aab}	8.5^{Aab}	8.2^{Abc}
5	7.9^{Aba}	8.2^{Ba}	8.1^{Ba}	8.3^{Aba}	8.11^{ABa}	8.1^{Aa}
10	7.9^{Aba}	8.1^{Ba}	8.1^{Ba}	8.3^{Aba}	8.1^{ABa}	8.0^{Aa}
15	7.5^{Ba}	7.9^{Ba}	8.0^{Ba}	8^{Ba}	7.9^{Ba}	7.8^{Aa}

Means with the same capital letters in the same column and the same small letters in the same row are not significantly difference ($p \leq 0.05$)

Lactobacillus dlebreuckii ssp. *bulgaricus* (log_{10}7.9) on fresh or after 15 days (log_{10} 6.85) if compared with control and other cheese treatments (Table 1). Data represented in Table 2 and 3 showed the viability of *Streptococcus thermophilus* and total bacterial counts, respectively. The viability of *Streptococcus thermophilus* was significantly decreased ($p \leq 0.05$) after 10 days of storage period in both control and cheese treatments (Table 2). However the viability of both *Streptococcus thermophilus* and total bacterial counts showed no significant effect ($p \leq 0.05$) when using xanthan gum.

Chemical analysis: The changes of pH values of Karish cheese with different xanthan gum concentrations and control are given in Table 4. From data presented in Table 4, the pH values of Karish cheese with different xanthan gum concentrations were higher than those of fresh control cheese and during the storage period (5°C/15 days), except for Karish cheese made by using 0.02% xanthan gum. However, the pH values of all Karish cheese samples gradually decreased during the storage period.

To improve properties of low-fat Kariesh cheese, xanthan gum of different concentrations (0.01, 0.02, 0.03, 0.04 and 0.05) were used to manufacture of cheese. Data in Table 5 showed the chemical analysis and yield of fresh Kariesh cheese. The yield of Kariesh cheese (actual yield of cheese, expressed as kg of obtained cheese per 100 kg of milk) was affected by increasing xanthan gum concentration. In addition, it could be notice that the highest yield was observed upon using 0.04 or 0.05% xanthan gum (26 or 29% yield, respectively), if compared with control (24.6% yield). However, the Yield based control (22.9% TS), was not significantly different. From the previous, naturally the moisture of cheese increased with increasing xanthan gum concentration and reached 80 and 81.5% in Karish cheese made with 0.04 and 0.05% xanthan gum, respectively against 76.8% for control Table 5. Total solids (T.S) content of fresh cheese samples was 22.90, 22.68, 22.79, 22.49, 20.0 and 18.85% for control, 0.01, 0.02, 0.03, 0.04 and 0.05% xanthan gum, respectively (Table 5). Data showed that total solids decreased with increasing of xanthan gum concentration. The lowest TS value was observed upon using 0.04 or 0.05% xanthan gum concentration. Protein recovery of Karish cheese increased significantly as xanthan gum concentration increased (Table 5). The maximum protein recovery (78.3 and 78.13%) was recorded by using of 0.04 or 0.05% xanthan gum respectively as compared with control. On the contrary the total protein was slightly decreased (11.90 and 10.57%) by increasing of xanthan gum concentration (0.04 or 0.05%, respectively). From the same table, ash content of fresh samples was 1.1, 1.3, 1.7, 1.4, 1.3 and 1.2% for control and Kariesh cheese made with deferent xanthan gum concentrations 0.01, 0.02, 0.03, 0.04 and 0.05%, respectively. Results indicated that ash content was significantly high (1.7%) in Karish cheese made with0.02% xanthan gum. On the other hand ash content showed no significant variations between control and the other treatments. Fat ratio in all samples there was no significant difference antly difference and ranged between 1.7-2.0%.

Texture analysis: Several textural criteria including hardness, cohesiveness, springiness, gumminess and chewiness were

Table 4: Changes in the pH of Karish cheese containing different concentrations of xanthan gum during storage

	pH during storage (days)		
Xanthan gum concentrations (%)	Fresh	7	15
Control (0.00)	4.45^{Da}	4.32^{Cb}	4.19^{Ec}
0.01	4.57^{Ba}	4.51^{Bb}	$4.40C^{Bc}$
0.02	4.35^{Ea}	4.31^{Cab}	4.28^{Db}
0.03	4.51^{Ca}	4.49^{Bab}	4.44^{Bb}
0.04	4.60^{Ba}	4.58^{Aa}	4.50^{Ab}
0.05	4.67^{Aa}	4.54^{ABb}	4.48^{ABc}

Means with the same capital letters in the same column and the same small letters in the same row are not significantly difference ($p \leq 0.05$)

Table 5: Chemical analysis of Kariesh cheese

Xanthan concentration (%)	Yield (%)	Yield based control (22.9% TS)	Total solids (%)	Total protein (%)	Fat (%)	Ash (%)	Moisture (%)	Protein recovery (%)
Control	24.6^{b}	24.6^{a}	22.90^{a}	12.26^{a}	1.8^{bc}	1.1^{bc}	76.8^{b}	76.36^{ab}
0.01	23.8^{b}	23.6^{a}	22.68^{a}	12.46^{a}	1.7^{c}	1.3^{b}	79.2^{a}	75.08^{b}
0.02	22.9^{b}	22.9^{a}	22.79^{a}	13.14^{a}	1.7^{c}	1.7^{a}	77.4^{ab}	76.18^{ab}
0.03	24.2^{b}	23.8^{a}	22.49^{a}	12.48^{a}	1.9^{bc}	1.4^{b}	78.2^{a}	76.30^{ab}
0.04	26.0^{ab}	22.7^{a}	20.0^{ab}	11.90^{ab}	1.7^{c}	1.3^{b}	80.0^{a}	78.32^{a}
0.05	29.2^{a}	24.0^{a}	18.85^{b}	10.57^{b}	2.0^{bc}	1.2^{bc}	81.5^{a}	78.13^{a}

Means with the same small letters are not significantly difference ($p \leq 0.05$)

determined in Kariesh cheese made with or without different concentrations of xanthan gum (0.01, 0.02, 0.03, 0.04 and 0.05%) in fresh or after 15 days of storage period (Table 6). Generally, all parameters of textural profile for control and Karish cheese manufactured with xanthan gum increased along the storage period. However, results revealed that hardness and cohesiveness values were significantly ($p \leq 0.05$) decreased with increasing of xanthan gum concentration after 15 days of storage period as compared with control. On the contrary, control cheese and Kariesh cheese treatments exhibited no significant differences in springiness values when fresh or after 15 days of storage period except Karish cheese made with 0.05% xanthan gum which exhibit significant increase in springiness value after 15 day if compared with control (Table 6). However, results of gumminess and chewiness showed no significant different values between control and Karish cheese treatments after 15 days of storage period.

Sensory evaluation: Sensory evaluations of Karish cheese when fresh and during storage period were given in Table 7. Results revealed that both xanthan gum concentrations and storage period were affected the sensory evaluation of Karish cheese. There were significant increase and decrease of flavor and body texture values, respectively in Karish cheese made by using xanthan gum as compared with the control. However, results showed that Karish cheese made by using 0.04 and 0.05% xanthan gum had high acceptability score points as compared with the control after 7 days of storage.

DISCUSSION

The activity of lactic acid bacteria in Kariesh cheese samples increased the acidity and consequently decreased the total bacterial count as reported by Nayra *et al.* (2002). All samples of Kariesh cheese either fresh or stored were free of coliform, yeast and molds. This could due to the efficient heat

Table 6: Texture analysis parameters of Karish cheese containing different concentrations of xanthan gum

Xanthan concentration (%)	Storage period (days)	Hardness (Newton)	Cohesiveness (Newton)	Springiness (mm)	Gumminess (kg)	Chewiness (Newton/mm)
Control	Fresh	14.0^{D}	0.568^{D}	0.619^{C}	4.829^{G}	3.365^{E}
	15	28.0^{A}	1.799^{A}	0.691^{B}	16.07^{BC}	9.951^{B}
0.01	Fresh	13.5^{DE}	0.564^{D}	0.666^{BC}	5.889^{FG}	4.198^{D}
	15	26.6^{A}	1.458^{B}	0.676^{B}	9.06^{DE}	6.03^{CD}
0.02	Fresh	11.0^{E}	0.545^{D}	0.667^{BC}	6.426^{EFG}	4.441^{D}
	15	20.2^{B}	1.256^{C}	0.699^{AB}	15.00^{C}	12.00^{B}
0.03	Fresh	10.2^{EF}	0.630^{D}	0.671^{BC}	8.194^{E}	5.335^{D}
	15	19.6^{BC}	0.677^{D}	0.703^{AB}	15.26^{A}	12.36^{B}
0.04	Fresh	8.7^{EF}	0.533^{D}	0.697^{AB}	7.952^{EF}	6.170^{CD}
	15	17.0^{C}	0.610^{D}	0.713^{AB}	16.038^{BC}	10.532^{B}
0.05	Fresh	8.2^{F}	0.589^{D}	0.702^{AB}	11.09^{D}	7.496^{C}
	15	12.8^{DE}	0.607^{D}	0.753^{A}	17.08^{B}	10.69^{B}

Means with the same capital letters are not significantly difference ($p \leq 0.05$)

Table 7: Sensory evaluation of Kariesh cheese during storage period

Xanthan concentration (%)	Storage period (days)	Flavor (50 points)	Body and texture (40 points)	Appearance (10 points)	All acceptability (100 points)
Control	Fresh	46^{a}	38^{a}	8^{a}	92^{a}
	7	43^{b}	35^{b}	7^{ab}	85^{b}
	15	42^{b}	33^{b}	6^{b}	81^{b}
0.01	Fresh	46^{a}	38^{a}	8^{a}	92^{a}
	7	43^{b}	35^{b}	7^{a}	85^{b}
	15	40^{c}	33^{b}	7^{a}	80^{b}
0.02	Fresh	47^{a}	38^{a}	8^{a}	93^{a}
	7	45^{ab}	36^{ab}	7^{a}	88^{ab}
	15	43^{b}	34^{b}	7^{a}	84^{b}
0.03	Fresh	48^{a}	37^{a}	8^{a}	93^{a}
	7	46^{a}	35^{ab}	7^{a}	88^{ab}
	15	43^{b}	34^{b}	7^{a}	84^{b}
0.04	Fresh	48^{a}	37^{a}	9^{a}	94^{a}
	7	47^{ab}	35^{ab}	8^{ab}	90^{ab}
	15	45^{b}	34^{b}	7^{b}	86^{b}
0.05	Fresh	49^{a}	37^{a}	9^{a}	95^{a}
	7	47^{ab}	35^{a}	8^{ab}	90^{ab}
	15	45^{b}	35^{a}	7^{b}	87^{b}

Means with the same small letters are not significantly difference ($p \leq 0.05$)

treatment and good sanitation conditions applied during manufacture and storage of cheese samples. These results agree with those reported by Manzano *et al.* (1992) who mentioned that when homo fermentative thermophilic lactic acid bacteria were found in cheese, the resultant cheese was characterized by the presence of negligible levels of yeast and coliform.

Kariesh cheese made by using different xanthan concentrations showed slight increase of pH value. The increasing in pH value due to xanthan gum supplies may led to some type of buffering effect during acid production (James, 1995). However the gradually decreasing of pH values during the storage period could be due to conversion of the residual lactose in cheese by starter bacteria (Badawi and Kebary, 1998).

Cheese yield depends on several factors, including milk composition, amount and genetic variations of casein, quality of milk coagulant type, milk pasteurization, vat design, curd firmness at cutting, adding of stabilizers and manufacturing criteria (Lawrence, 1993; Lucey and Kelly, 1994; Walsh *et al.*, 1998; Fenelon and Guniee, 1999).

The present study revealed that the yield of Karish cheese was not affected by using of xanthan gum (as the yield not significantly differ compared with the control) (22.9% TS). This indicated that the yield increase might be attributed to an increase in moisture content, similar finding was previously found by other authors (Ahmed *et al.,* 2005) and agree with those reported by Awad *et al.* (2005) and Costa *et al.* (2010).

Polysaccharides such as xanthan gum will increase water absorption, since polysaccharides bind to water and moisture; retention properties are the key strategy for improving the performance of low-fat cheese (Tadayoni *et al.*, 2009). Polysaccharides or EPS-producing cultures are widely used in yogurts to improve texture and reduce spontaneous syneresis (Hassan *et al.*, 1996; Robitaille *et al.*, 2009; Zoon, 2002) due to their ability to bind or trap water. This ability has also been used in reduced-fat cheese manufacture, as by increasing the moisture content, the yield is also increased and the functional characteristics improved (Awad *et al.*, 2005; Costa *et al.*, 2010; Jimenez-Guzman *et al.*, 2009). However, the way of water retaining in the cheese texture is remaining not very clear, as it has been proposed that the EPS capable of bind moisture as well as just trap it within the texture (Hassan, 2008).

The meaning of cheese yield or definition is important in two main applications: 1) Controlling of cheese making economically. 2) An expressive criterion for the results of cheese making experiments (Emmons, 1993).

The total solids and protein content were slightly lower by increasing xanthan gum concentrations. This particular behavior of total solids and protein changes may be attributed to the ability of polysaccharide to increase water absorption. Similar data was obtained by Mashaly *et al.* (1983), Hallal and Al-Omar (1987) and Karakus and Alperden (1995). The differences in ash content of cheeses are related to the differences of moisture content in resultant cheeses. The increase of cheese moisture content due to water adsorption or binding by xanthan gum, were negatively affected the textural parameters of Karish cheese such as hardness and cohesiveness. Because the increase in moisture content weakens the casein micelles-polysaccharide gel network leading to a less firm cheese (Kaya, 2002), the texture of high moisture cheese was smother. Similar observations were registered by Volikakis *et al.* (2004). The softer character of the cheese made by xanthan gum was expected as fat impedes the formation of a solid protein matrix and acts as lubricant, yielding a cheese with a higher smoothness and softness (Romeih *et al.*, 2002). Much study has been conducted to improve the texture of Kariesh cheese; most of them were designed to modify conventional cheese making technologies to increase moisture content, which improves texture (Egyptian Standards, 2013).

CONCLUSION

From such results it could be concluded that adding of xanthan gum slightly improved.

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