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Effect of Xanthan Gum and Carboxymethyl Cellulose on Physical Properties of Cream Cheese

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Abstract

Many problems originated from consuming the high fat products, so reducing the fat in foods is very attractive field. In this study, the effect of xanthan gum at levels 0.05%, 0.17%, 0.3% and carboxymethyl cellulose at 0.02%, 0.11%, 0.2% on physical properties of cream cheese was studied. Results showed that samples contain xanthan and CMC had significant differences ($p<0.05$) in terms of textural properties in comparison to control. We found that increase the level of gum in samples were decreased the adhesiveness (due to decrease of fat), as control sample had the highest adhesiveness (0) and treatment No. 5 had the lowest (-1.672). Elasticity of low fat cheese were lower than high fat, as the lowest elasticity recorded for sample No. 4 and the highest for No. 1. Treatment No. 2 (xanthan 0.05 + CMC 0.2%,) had the highest hardness (0.527) (due to the lowest level of gum and the highest level of fat) and control (sample No. 6) had the lowest hardness (0). The highest and lowest solidarity values recorded for sample 3 and control respectively. Gumminess have increased with increase the fat content as the highest values observed for sample No. 4 (0.25) and the lowest for control (0). Also the highest chewiness recorded in sample 1 which the lowest level of gums used (xanthan 0.05 + CMC 0.02%) and the lowest in sample 2 which had the lowest level of xanthan (0.05%) and the highest level of CMC (0.2%).

Keywords: Cream cheese; Carboxymethyl cellulose; Xanthan; Hardness; Gumminess

Introduction

The increasing need for foods, particularly low fat and carbohydrate products to face a common health problems such as obesity, diabetes, coronary heart disease and hypertension, has paved the way for the formulation of a food product that is sweet in taste and of a high nutritive value; at the same time low in fat and carbohydrate [1]. An excessive consumption of saturated fatty acids has been associated with an increased risk of cardiovascular diseases. As a consequence, limiting the saturated fat consumption is a central theme in national and international dietary guidelines, aiming to help the public to reduce cardiovascular disease risks [2].

Fresh cream cheese is a cheese obtained from the homogenization of a fresh cheese base with further ingredients, including gums and hydrocolloids, salt and other spices. This cheese is a versatile food that permits addition of other ingredients, including fibres like inulin. It has a spreadable structure, and is used as a spread on bread, in sandwiches and as a salad dressing. It is an unripened cheese, stored at refrigeration temperatures, and the shelf life is rather limited [3]. Cheese fat not only has a nutritive role, but also it acts positively to improve its texture and appearance. Low-fat cheeses have defects such as firm and rubbery texture, unfavorable color and taste, and weak meltability. By decreasing the fat amount, cheese protein network becomes more tight and compact and cheese texture turns chewy [4]. Thus, new strategies were developed to produce low-fat cheese with the same characteristics of high-fat cheese.

Hydrocolloids are complex combinations that are used for texture modification, crystallization control, prevent of product leakage or syneresis, covering the aromas and tastes, increased physical stability, film formation, gel formation and increase consistency in food products liquid and semi-liquid. Many of them are not metabolized in the human body and energy (calories speciation) is low. Hydrocolloids affected on the gel formation, maintenance of water, emulsion formation and maintenance of aromas and tastes [5,6]. In formulation of low-fat products, it has been used substances that partially or entirely substitute for fat and developed similar characteristics [7].

Hydrocolloids in dairy industry are mainly used to improve texture of the product by interacting with casein network. For the use of hydrocolloids in dairy products, there are two important aspects needed to be concerned. Firstly, the hydrocolloids should not affect the natural flavor of the product. Moreover they should be effective at the low pH of the product 4.0-4.6. Williams and Phillips also reported that the hydrocolloids that suitable for the use in dairy beverage include carboxy-methylcellulose (CMC), pectin, alginate and xanthan gum (XG).

Therefore, the aim of this study was to evaluate the physical properties of cream cheese prepared by using xanthan gum and Carboxymethyl cellulose as fat replacers.

Materials and Method

Preparation of cream cheese

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

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

Physical evaluation

The treatments were evaluated for their TPA properties with the Instron machine. Single sample (2 × 2 cm) was placed on the platform of a TA-texture analyzer (TA.XT.PLUS Stable Micro Systems, UK). A probe (P/ 36R) was used to exert force on each sample to test TPA parameters. The equipment was set as follows: pre-test speed: 2.00 mm/s, test speed: 1.00 mm/s, post-test speed: 2.00 mm/s, strain: 50%, time: 30 sec.

TPA assessment parameters included adhesiveness, cohesiveness, hardness, springiness, chewiness, solidarity and gumminess measured using the method of Bourne [8]. A brief explanation of each of the terms and the metrics used to perform statistical analysis is highlighted below: (1) Hardness - the peak force during the first compression cycle. (2) Cohesiveness - the ratio of the positive force area during the second compression to that during the first compression. (3) Adhesiveness - the negative force area for the first compression, representing the work necessary to pull the compressing plunger away from the sample. (4) Springiness or elasticity - the height that the food recovers during the time that elapses between the end of the first compression and the start of the second compression. (5) Gumminess - the product of hardness and cohesiveness. (6) Chewiness - the product of gumminess and springiness.

Statistical Analysis

The results were modeling and analysed using the central composite design and response surface methodology (RSM). Significant differences between treatments were determined using Spss software and the means were compared using ANOVA analysis followed Duncan's test at 5% level ($p<0.05$) [9].

Results and Discussion

Results of Texture profile analysis the cream cheese samples given in Table 1. Results showed that application of different levels of xanthan gum and CMC on texture properties of cream cheese were significant ($p<0.05$) (Table 1).

Sample No	adhesiveness	cohesiveness	hardness	springiness	solidarity	chewiness	gumminess
1	-1.0670^{b}	Viscosity	0.4235^{c}	0.0635^{a}	0.3785^{e}	0.01^{a}	0.1605^{e}
2	-1.6720^{f}	-0.1995^{b}	0.5275^{a}	-0.196^{c}	0.4575^{d}	-0.0475^{c}	0.2415^{c}
3	-1.2540^{d}	-0.2510^{b}	0.419^{c}	-0.6615^{d}	0.588^{a}	-0.163^{e}	0.246^{b}
4	-1.3900^{e}	-0.2290^{b}	0.477^{b}	-1.073^{e}	0.5305^{b}	-0.271^{f}	0.253^{a}
5	-1.0955^{c}	-0.2190^{b}	0.4195^{c}	-0.2485^{c}	0.511^{c}	-0.053^{d}	0.2145^{d}
6	0^{a}	-0.1095^{b}	0^{d}	0^{b}	0^{f}	0^{b}	0^{f}

Table 1: Texture profile analysis of cream cheese contains different levels of xanthan gum and CMC. Means in the same column indicated by similar letters were not significantly different ($P>0.05$).

References	Sum of square	Freedom degree	Mean square	F	P
Model	0.47	3	0.16	69.57	0.0001
A-xanthan	0.026	1	0.026	11.51	0.0146
B- CMC	0.04	1	0.04	17.75	0.0056
CMC × xanthan	0.32	1	0.32	142.17	0.0001
Residual	0.013	6	2.239E -003		
Lack of fit	3.648E -004	1	3.648E -004	0.14	0.724
Pure error	0.013	5	2.613E -003		
Cor total	0.48	9			

Table 2: Variance analysis for texture properties of different cream cheese treatments.

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Results of Table 1 and Figure 1 showed that in term of adhesiveness, there were significant differences between treatments ($p<0.05$). Control sample had the highest adhesiveness (0) and treatment No. 5 (contains xanthan 0.3 + CMC 0.02%) had the lowest adhesiveness (-1.672). We found that increase the level of gum in samples led to decrease the adhesiveness (due to decrease of fat). Results of adhesiveness in our study was agree with Koca and Metin [10], as they reported that decrease the fat led to decreasing adhesiveness. Also Saint-eve [11] expressed that adhesiveness were higher in high fat samples that was agree with our results. According to Dimitreli and Thomareis [12] increase the fat in cheese led to more open matrix structure and consequently the adhesiveness increased, but decrease the fat led to compact the matrix and adhesiveness decreased.

One of the most important strategies for using fat replacers was because of the increase of water binding capacity of the cheese matrix. It has been suggested that water can bind directly to fat replacers and the fat replacers can interfere with the shrinkage of the casein matrix. Therefore, this lowers the driving force involved in expelling water from curd particles [13]; so that, increasing the moisture content is the most common proposition to overcome of the usual textural defects of low fat cheese (Tables 2 and 3) [14].

Indexes	Variable of model
1.3	Constant
-0.063*	Xanthan
0.078*	CMC
-0.22	CMC × Xanthan

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

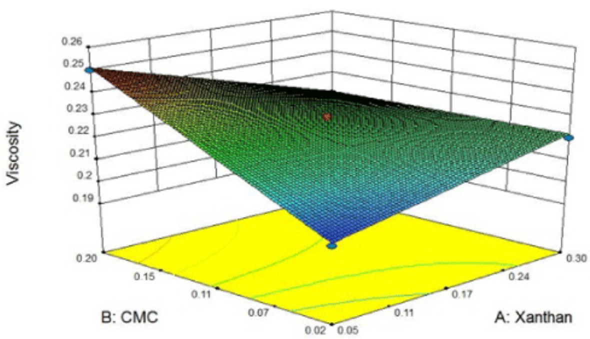

Figure 1: Adhesiveness diagram for different cream cheese samples.

Elasticity or springiness of samples shown in Table 1 ranged from 0.06-1.07. Table 1 revealed that treatment No. 1 (contains xanthan 0.05 + CMC 0.02%) had the highest elasticity, and was different in comparison to others ($p<0.05$) and the lowest elasticity recorded for sample No. 4. $CaCl_2$ and fat effect on elasticity. Koca and Metin [10] reported that elasticity of low fat cheese lower than high fat. After sample No. 1, control sample (without gum) had the highest elasticity (0.063) (Table 1). Our results about elasticity of cream cheese samples (Table 4) were according to Koca and Metin [10].

Indexes	Variable of model
-0.085188	Constant
+ 4.90158*	Xanthan
+1.90103*	CMC

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

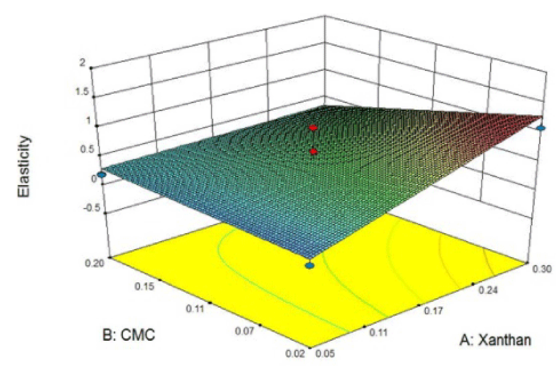

Figure 2: Texture elasticity diagram for different cream cheese samples.

Hardness definite the peak force during the first compression cycle. Results showed in Table 1 and Figure 3 revealed that there were significant difference ($p<0.05$) between different cream cheese samples in comparison to control in term of hardness (Table 1, Figures 2 and 3). Treatment No. 2 (contains xanthan 0.05 + CMC 0.2%,) had the highest hardness (0.527) and control sample (treatment No. 6) had the lowest hardness (0) (Table 1 and Figure 3). Treatment No. 2 had the lowest level of gums and the highest content fat and cream. Fat globules and moisture act as diffusal phase in casein matrix and caused softening the cheese. Results of current study about hardness of cream cheese were agree with those reported by Fox et al. [15].

Ghanbari Shendi et al. [16] studied rheological, physiochemical and sensory properties of Iranian low-fat white cheese, and their findings displayed improvement of low-fat cheese texture by increasing xanthan gum concentration. Besides, in other studies by Volikakis et al. [17] cereal beta glucan has been used as a fat substitute in low-fat white cheese which improved its texture significantly, but cheese taste, color and some other parameters were influenced unfavorably (Table 5).

Indexes	Variable of model
0.046	Constant
- 0.015*	Xanthan
+ 0.013*	CMC
- 0.040*	CMC × Xanthan

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

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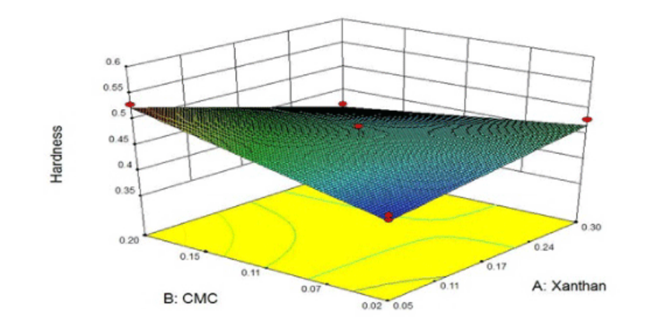

Figure 3: Texture hardness diagram for different cream cheese samples.

Solidarity results showed in Table 1 and Figure 4 were explained the significant differences ($p<0.05$) between control and other samples. The highest and lowest solidarity values recorded for sample No. 3 (contains: xanthan 0.17 + CMC 0.11%) and control respectively. Zisu et al. [18] noted that cheeses with high level of moisture and fat had softer texture due to weakness in bonds. But Koca and Metin [10] have not seen significant differences ($p>0.05$) between solidarity of high fat (24.5 %) and low fat (7.33%) cheese sample (Table 6).

Indexes	Variable of model
0.36094	Constant
+ 0.74770*	Xanthan
+ 0.58346*	CMC
- 2.78036*	CMC × Xanthan

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

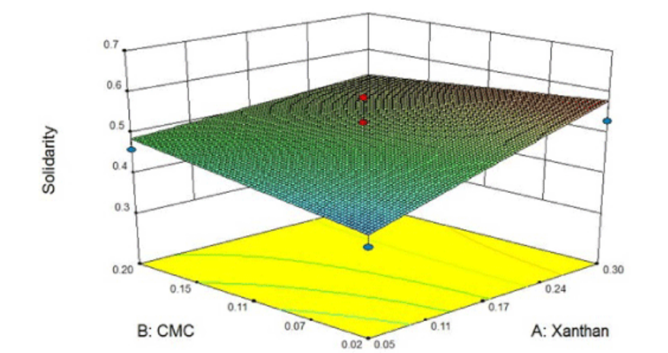

Figure 4: Texture solidarity diagram for different cream cheese samples.

Results of gummines of cream cheese samples showed in Table 7 and Figure 5. There were significant differences ($p<0.05$) between control and other samples in term of gummines. The highest gummines values observed for sample No. 4 (0.25) and the lowest for control (zero). Gummines have increased with increase the fat content. Except fat content, other factors such as moisture, total solids, protein to moisture ratio can effect on mechanical texture parameters of cheese [10]. Zisu et al. [18] about gummines expressed that high moisture content and low total solids led to weakness in bonds of protein structures and these samples breakdown by lower force.

Addition of hydrocolloids initially improved the texture of the product, followed by the subsequent decrease in viscosity as increasing levels of hydrocolloid were added [19]. The initial texture improvement was obtained by the interaction between hydrocolloid (negatively charge) and protein (positively charge). High amount of hydrocolloid increased the charges of the particles, resulting in the low texture improvement. The sedimentation increased, leading to less product acceptability. Nevertheless, if the amount of hydrocolloids used further increased, the texture of the product was also further improved due to the sedimentation was inhibited. This was caused by a decrease in the protein-hydrocolloid interaction, resulting in higher level of hydrocolloids to influence the texture of the product [19].

Indexes	Variable of model
0.23	Constant
+ 0.018*	Xanthan
+ 9.132 E-003*	CMC
-0.031	CMC × Xanthan

Table 7: Regression model index for predict independent variables equation model for evaluate the cream cheese gumminess. *= significance at 5% level.

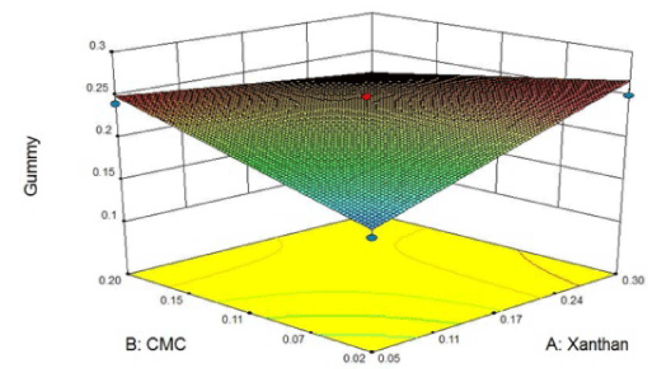

Figure 5: Texture gumminess diagram for different cream cheese samples.

With regard to Table 1, it is obviously that significant differences ($p<0.05$) showed between control and other samples about chewiness (Table 8 and Figure 6). The highest chewiness observed in sample No. 1 (contains xanthan 0.05 + CMC 0.02%) and the lowest in sample No. 2 (contains xanthan 0.05 + CMC 0.2%). In sample No. 1, the lowest level of gums used and in sample No. 2 the lowest level of xanthan and the highest level of CMC used. Similar to gumminess, high moisture content and low total solids led to weakness in bonds of protein structures and these samples breakdown by lower force, also other factors such as moisture, total solids and protein to moisture ratio effect on mechanical texture parameters of cheese [9,17].

Indexes	Variable of model
-0.029686	Constant
+ 1.26111*	Xanthan
+ 0.53964*	CMC
- 6.34832*	CMC × Xanthan

Table 8: Regression model index for predict independent variables equation model for evaluate the cream cheese chewiness. *= significance at 5% level.

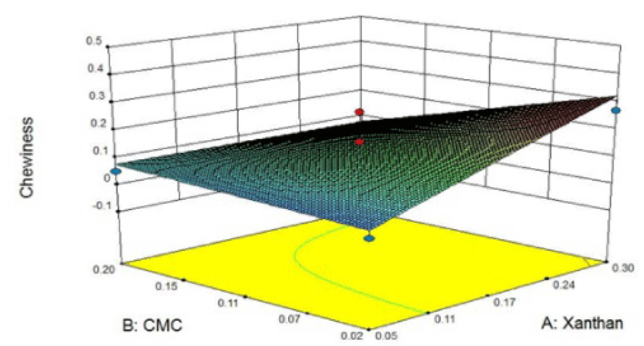

Figure 6: Texture chewiness diagram for different cream cheese samples.

Conclusion

For the use of hydrocolloids in dairy products, there are two important aspects needed to be concerned. Firstly, the hydrocolloids should not affect the natural flavor of the product. Moreover they should be effective at the low pH of the product 4.0-4.6. Williams and Phillips also reported that the hydrocolloids that suitable for the use in dairy beverage include carboxy-methylcellulose (CMC), pectin, alginate and xanthan gum (XG). So, Using carboxymethyl cellulose and xanthan in cream cheese improve the physical and terxtural properties of product. Result of this investigation signifies that the use of xanthan gum and CMC can be a suitable way to obtain a cream cheese with proper quality and with decrement of received energy. This finding is important for cream cheese-making industry, because of an increasing consumer trend for low-fat dairy products.

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