EFFECTS OF HYDROCOLLOID COMBINATIONS ON PHYSICAL, TEXTURAL AND SENSORY PROPERTIES OF KAZANDİBİ

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***Abstract* -- This study investigated the effect of the utilization of different hydrocolloid combinations (guar gum-xanthan gum, carrageenan-guar gum and carrageenan-xanthan gum combinations) on kazandibi. Kazandibi containing a guar gum and carrageenan combination received the lowest syneresis value and the highest a and b values at the end of the storage period. Hardness and gumminess values were found as 0.46-2.41 Newton (N) and 0.453-1.806 N, respectively. Based on the sensory analysis, guar gum containing formulations had the highest general appreciation during the storage period. The addition of hydrocolloids in kazandibi production resulted in positive effects on textural and sensory properties.**

***Keywords* -- Carrageenan; Dairy dessert; Guar gum; Kazandibi; Xanthan gum**

I. INTRODUCTION

Dairy desserts are widely consumed in Turkey. There are different types of dairy desserts such as sutlaç (rice pudding), kazandibi (pudding with a caramel base), keşkül (milk and almond pudding, muhallebi (custard) in Turkish cuisine (Sertel, 2012). Kazandibi is a milk pudding with a bottom stuck to the pan that is manufactured with milk, sucrose, rice flour or rice milk, starch, flour, different hydrocolloids and other ingredients (Akpinar-Bayizit *et al.*, 2009; Demirag *et al.*, 1999). Formulation of semi-solid dairy desserts consist of milk, thickeners (starch and other hydrocolloids), sugar and other ingredients such as aroma and colorants. The physical and sensory properties of the commercial products are influenced by milk fat content, starch type and concentration, hydrocolloid type and concentration, aroma and colorant, and the interactions between these ingredients (Bayarri *et al*., 2011). Hydrocolloids, known as high molecular weight polysaccharides, play a major role in textural properties of food because of their enhancing viscosity, gelling properties and as a factor that increases physical stability (Şahin and Özdemir, 2007). Dairy desserts are gelled using hydrocolloids such as starch and carrageenan. Carrageenan, which is obtained from red seaweeds, is a sulfated polysaccharide. Carrageenan as an anionic hydrocolloid interacts with positive charges on casein. Starch assists the gelation of other hydrocolloid agents (Tasneem *et al*., 2014). The starch, which is obtained from different sources, is used as a thickening and gelling agent in the food industry (Buriti and Saad, 2014). Guar gum is extracted from the seeds of the guar plant (*Cyamopsis tetragonoloba* (L.) . It is composed of 1,4-β-D-mannose backbone and 1, 6-α-D-galactose side chain. The ratio of galactose : mannose is approximately 1:2 (Tasneem *et al*., 2014). Guar gum used in food products demonstrates thickening and stabilizing properties. It is recommended to be used less than 1% of the food weight (Rezaei *et al.*, 2011). It can be dispersed and enlarged in an aqueous medium with high viscous property (Koksoy and Kilic, 2004). Xanthan gum is a polysaccharide obtained from the micro-organism *Xanthomonas campestris*. Xanthan gum can be dissolved in cold water and its solutions show a highly pseudo-plastic flow (El-Sayed *et al*., 2002; Sworn, 2009). Using two or more gums together in the production of food constitutes a synergistic effect (Morais *et al*., 2014). The combined use of gum can improve the quality of products and ensure economic benefits since it reduces the need to utilize gum (Toker *et al.*, 2013). There are studies on the use of gum mixed into different milk products (Doğan *et al.*, 2014; Morais *et al*., 2014; Toker *et al.*, 2013). Morais *et al.* (2014) prepared a chocolate dairy dessert by adding a guar and xanthan gum combination. Toker *et al.* (2013) examined the rheological properties of puddings prepared with various gum combinations. Dietetic kazandibi was produced with different gums and artificial sweeteners by Demirag *et al.* (1999) and the influences of different additives on energy value, textural, sensory and chemical properties were studied. Nevertheless, there is no comprehensive study concerning the effect of various gum combinations and storage periods on different properties of kazandibi. In this study, kazandibi was manufactured using different hydrocolloid combinations. The changes in chemical, textural, and sensory properties of the kazandibi were monitored on the 1st, 5th and 10th days of storage.

II. METHODS

A. Materials

Pasteurized milk was procured from Sümer Dairy Company (Denizli, Turkey). Sugar, powdered sugar, rice flour, wheat flour, salt and starch used in kazandibi production were purchased from a local market in Denizli, Turkey. Guar gum, carrageenan, xanthan gum were obtained from Smart Chemistry and Consulting Limited Company (Izmir, Turkey).

B. Kazandibi production

In the present study, four different formulations were used to produce kazandibi: (1) control, without any hydrocolloid (control, Ka), (2) kazandibi with guar gum-xanthan gum combination (Ka1), (3) kazandibi with car rageenan-guar gum combination (Ka2), (4) kazandibi

Table 1 Kazandibi sample formulations

	Kazandibi Code			
Ingredients	**Ka**	**Ka1**	**Ka2**	**Ka3**
Milk	1 L	1 L	1 L	1 L
Powdered sugar	65 g	65 g	65 g	65 g
Sugar	180 g	180 g	180 g	180 g
Rice flour	25 g	25 g	25 g	25 g
Salt	1.5 g	1.5 g	1.5 g	1.5 g
Wheat flour	25 g	25 g	25 g	25 g
Maize starch	25 g	25 g	25 g	25 g
Carrageenan	-	-	0.3 g	0.3 g
Guar gum	-	0.3 g	0.3 g	-
Xanthan gum	-	0.3 g	-	0.3 g

Ka, control kazandibi; Ka1, kazandibi containing a guar gum and xanthan gum combination; Ka2, kazandibi containing a guar gum and carrageenan combination; Ka3, kazandibi containing a carrageenan and xanthan gum combination.

with carrageenan-xanthan gum combination (Table 1) The ingredients used in kazandibi production and their amounts are presented in Table 1.

Milk, salt and sugar were mixed in a stainless boiler and heated to 40 ºC. Wheat flour, rice flour, starch and hydrocolloids were dissolved in pre-heated milk in another container. The mixture of sugar, salt and milk was heated to 80º C. Previously dissolved mixture (wheat flour, starch and hydrocolloids) were slowly added to the heated mixture. The mixture was continuously stirred and maintained at 80 ºC for 10 min. Then it was transferred into aluminum containers. Before the transfer, the bottom of the container was lightly wetted and sprinkled with a thin layer of powdered sugar. The container was heated in an oven at 180 ºC for 4 min to get the bottom of the dessert to stick and burn. After bottom part was turned upside down, kazandibi was let to cool.

C. Physical and textural analysis

For whey separation, samples (10 g) were placed in a centrifuge tube. Then, samples were centrifuged with centrifuge equipment (Nüve NF 1200R, Ankara, Turkey) at 6300 g for 30 min at 4 ºC. Results were expressed as percentages (Verbeken *et al*., 2006).

Water holding capacity analysis was performed according to Granato *et al.* (2010). An approximately 10 g sample was placed in a centrifuge tube. The prepared sample was centrifuged for 40 minutes at 5.000 rpm at room temperature. After centrifugation, the supernatant (liquid) fraction was separated and the remaining part was weighed. Water holding capacity (WHC) was calculated using the formula below:

$$\text{Water holding capacity} = \frac{\text{Pellet weight}}{\text{Initial sample weight}} 100$$

Sample Hunter L (brightness, 100 = white, 0 = black), a (+, red; -, green) and b (+, yellow; -, blue)) values were evaluated with Hunter Lab Mini Scan XE model (Hunter Associates Laboratory Reston, USA) colorimeter. Textural parameters were assessed with Texture Analyzer (Brookfield CT3, Brookfield Engineering Laboratory Corp., Middleboro, MA 02346 USA). This analysis was performed with a 4.5 kg load cell and 12.7 mm diameter cylinder prob. Test speed was assessed as 2 mm sec^{-1}. Samples were compressed in two consecutive cycles (Arltoft *et al*., 2008).

D. Sensory Analysis

Sensory analysis was carried out by 30 panelists from Pamukkale University Food Engineering Department. The samples were marked with a three digit number. Panelist scored the samples based on a 9 point hedonic scale (Altuğ and Elmaci, 2005; Er-Gürmeriç, 2008).

E. Statistical Analysis

Statistical analysis was conducted with SPSS software. The statistical data was expressed as average ± standard deviation (SD). Statistical significant differences were established using Duncan Test at $p < 0.05$ level. The experimental production was conducted in 2 repetitions. The effects of storage period and the use of different hydrocolloid combinations on the analysis were determined using the statistical software.

III. RESULTS AND DISCUSSION

A. Physical properties

The physical properties of kazandibi samples are presented in Table 2. WHC demonstrates the ability of binding water. The total of the bound water, hydrodynamic water and physically trapped water amounts gives the water holding capacity values (Gurmeric *et al*., 2013). The control kazandibi sample had a higher water holding capacity values than the other samples on the 1st and 10th days of storage. However, control kazandibi demonstrated statistically similar values with other kazandibi samples (except Ka3) at the beginning of storage.

Syneresis, which is an undesirable parameter, adversely affects consumers. The contraction of the gel causes the syneresis. Syneresis affects the degree of thermal treatment, type and concentration of solids, pH and salt additions (Nunes *et al*., 2006). Nunes *et al.* (2006) found that syneresis increased with storage time and at higher starch concentrations. Hydrocolloids have a function to improve viscosity and avoid syneresis (Şahin and Özdemir, 2007). The lowest syneresis value was obtained with Ka2 (carrageenan and guar gum) coded sample at the end of the storage period. Verbeken *et al.* (2006) determined that an increase in carrageenan and starch concentrations caused a decrease in degree of syneresis in dairy desserts. Ramírez-Sucre and Vélez-Ruiz (2014) determined that the increasing starch concentration was more effective in decreasing the syneresis degree of the custard custard than that of increasing whey powder and caramel jam. Carrageenan interacts with the positive charges on the surface of casein micelles due to anionic hydrocolloid properties. Therefore, it causes a decrease in syneresis (Tasneem *et al*., 2014). Nezhad *et al.* (2018) found that syneresis value of the low-calorie Iranian dessert declined as the amount of carrageenan increased.

Color is one of the most important food features, since it could affect consumer acceptance (de Jesús *et al*., 2013). The Hunter L was between 51.82 ± 0.70 and 59.74

± 0.54 in kazandibi samples. The Hunter L values demonstrated irregular fluctuations during the storage time. Kazandibi samples (except control) had positive a values. This situation was reflected in the red color in kazandibi samples. The b values (yellowness) of samples were higher than their a values. Probably, this might be related to the dominant yellow color of used hydrocolloid and other ingredients. The sample Ka3 (carrageenan and xanthan gum) had higher b values than other kazandibi samples on the 1st and 5th days of storage. González-Tomás and Costell (2006) reported that L*, a* and b* values of different brands of vanilla dairy desserts with different characteristics varied between 75.58-85.93, -2.46- (+) 4.87 and 25.91-46.86. Research stated that the color values were influenced by the use of different hydrocolloids and colorants (González-Tomás and Costell, 2006).

B. Textural properties

Complexation between milk proteins and polysaccharides is impacted by pH, ionic strength, polysaccharide charge density, polysaccharide concentration and biopolymer ratio (Ye, 2008). Certain dairy dessert ingredients such as starch and/or several hydrocolloids interact with milk proteins and provide stability and thickness for dairy desserts (Buriti and Saad, 2014). Agoda-Tandjawa *et al.* (2017) determined that carrageenan had a supportive effect on the gel structure formed by carrageenan-milk protein-starch and the gel matrix was strengthened by swollen starch . In addition, the swollen starch granules limited the increase in carrageenan concentration.

It was determined that when carrageenan was used together with starch, this combination resulted in improvement of viscoelastic properties of the gel compared to pure carrageenan..

The lowest hardness value was obtained in the control sample (Table 3). The use of different hydrocolloid combinations in kazandibi caused in a rise in hardness. The highest hardness value was detected in the Ka3 coded sample at the beginning of storage . Kazandibi containing carrageenan and gum had the second highest hardness value. As shown, samples prepared with different carrageenan combinations (guar gum-carrageenan and carrageenan-xanthan gum) had higher hardness values than that of the other samples at the beginning of storage . κ-carrageenan in dairy dessert is often used as a gelling agent. There is an electrostatic interaction between a positively charged region of κ-casein and the negatively charged sulfate groups of κ-carrageenan (Verbeken *et al.*, 2004). Therefore, this interaction might have caused an increase in hardness value.

At the end of the storage, samples containing hydrocolloid had similar hardness values. The springiness, hardness, gumminess and cohesiveness values usually decreased throughout the storage period ($p < 0.05$). The sample with guar gum and xanthan gum had the highest springiness value. The differences between cohesiveness values were not significant ($p > 0.05$) at the beginning of storage. The highest cohesiveness and gumminess values were observed in sample Ka2 during the storage period. Toker *et al.* (2013) reported that puddings including carrageenan combinations demonstrated high effects on certain rheological parameters such as G′, G″ and G*. Demirag *et al.* (1999) determined that a guar gum-xanthan gum combination in kazandibi production positively affected textural quality. El-Garawany and Abd El Salam (2005) reported that desserts prepared with 4% whey protein concentrates, 3% potato starch and 0.1% ι-carrageenan with 10% sucrose, 3% milk fat and 3% chocolate possessed acceptable rheological features and a good shelf life. Cardarelli *et al*. (2008) determined that symbiotic chocolate mousses supplemented with inulin resulted in a high firmness value (5.24 N) and absolute adhesiveness (-0.956 N) at 28 days of storage. The effects of different concentration of kappa-carrageenan, skimmed milk powder (SMP), maize starch on rheological properties of dairy desserts were investigated by Depypere *et al.* (2009). The springiness and cohesiveness values of dairy desserts were found between 0.79-0.99, and 0.41-0.68 by in this study, respectively. Konar *et al.* (2014) investigated the rheological properties of milk chocolate prepared with inulin. The hardness values of the sample were found between 10.37 and 13.96 N depending on the different process conditions and composition by these researchers.

C. Sensory properties

The effects of different formulations and storage periods on the appearance, odor, taste, visual consistency, and general appreciation scores were significant ($p<0.05$). Table 4 presents sensory properties of the samples. The samples prepared with the combination of carrageenan and xanthan gum (Ka3) received the highest appearance and odor scores at the end of the ripening period. Differences in consistency property in the mouth of kazandibi samples were significant during storage and a sharp decrease was observed after 5 days of storage. In our study, formulations that contained carrageenan had lower taste scores than that of the other formulations (except control). This difference may be related to the chemical composition of the gum. Tarrega and Costell (2006) demonstrated that sweetness perception in dairy desserts decreased by increasing the carrageenan level. The highest visual consistency was determined in the Ka2 sample at the end of storage. In another study related to the color and consistency of vanilla dairy desserts, dairy dessert containing carrageenan and guar gum received a high score in terms of color in sensory analysis (Tárrega and Costell, 2007). General appreciation scores varied between 5.20 and 8.80 during the storage period. Kazandibi containing a guar gum and carrageenan combination had a higher general appreciation score when compared to other samples at the beginning of storage. Krasaekoopt and Cabraal (2011) found that sensory properties of fermented whey beverages were positively affected by addition of hydrocolloids. Tárrega *et al.* (2010) produced low-fat custards using long-chain inulin and short-chain

Table 2. Water holding capacity values, syneresis and color values of kazandibi samples during storage[a]

Parameters		Storage Period (day)	Kazandibi code[b] Ka	Ka1	Ka2	Ka3
Water holding capacity (%)		1	99.43±0.32^{Bb}	99.17±0.78^{Bb}	99.17±0.69^{Bb}	97.40±0.58^{Ba}
		5	98.54±0.34^{Ab}	97.35±0.32^{Aa}	98.99±0.42^{Bb}	97.85±0.57^{Ba}
		10	98.24±0.65^{Ac}	96.74±0.57^{Ab}	97.08±0.81^{Ab}	95.45±0.27^{Aa}
Syneresis (%)		1	3.24±0.29^{Ad}	2.22±0.17^{Ac}	1.50±0.08^{Ab}	0.53±0.22^{Aa}
		5	5.50±0.12^{Bc}	5.35±0.07^{Bc}	4.93±0.49^{Bb}	3.94±0.11^{Ba}
		10	8.68±0.15^{Cb}	11.46±0.46^{Cd}	6.68±0.09^{Ca}	9.34±0.12^{Cc}
Color	L	1	56.41±0.79^{Ac}	53.41±0.78^{Aab}	53.90±0.06^{Ab}	51.82±0.70^{Aa}
	a		1.84±0.16^{a}	2.09±0.17^{a}	3.94±0.08^{b}	2.71±1.19^{ab}
	b		10.99±0.65^{Aa}	11.44±0.59^{Aa}	11.34±0.27^{Aa}	12.91±2.96^{Aa}
	L		56.67 ±0.76^{Ac}	52.45±0.39^{Aa}	57.98±0.52^{Bc}	54.42±0.79^{Bb}
	a	5	-0.43±0.38^{a}	1.20±0.04^{b}	0.83±0.14^{ab}	2.91±1.03^{c}
	b		10.95±1.20^{Aa}	12.43±1.55^{Aab}	12.45±0.21^{ABab}	14.67±0.03^{Ab}
	L		55.64±0.59^{Ab}	53.67±0.28^{Aa}	55.63±0.27^{Ab}	59.74±0.54^{Cc}
	a	10	-1.31±0.96^{a}	0.44±1.04^{ab}	2.90±0.98^{b}	0.43±0.08^{ab}
	b		12.67±0.19^{Ab}	10.71±0.21^{Aa}	13.25±0.62^{Bb}	13.20±0.67^{Ab}

[a] All values are mean ± standard deviation (n = 4). Different uppercase superscripts (A–C) for the same kazandibi types represent the significant differences between storage periods. Different lowercase superscripts (a–d) for the same storage time represent the significant differences between kazandibi types ($p < 0.05$).

Table 3. Textural parameters of kazandibi samples during the storage period[a]

Parameters	**Storage Period (day)**	**Kazandibi code**[b] **Ka**	**Ka1**	**Ka2**	**Ka3**
Hardness value (N)	1	0.86±0.06^{Ca}	2.07±0.05^{Cab}	2.24±0.11^{Cb}	2.41±0.09^{Cb}
	5	0.59±0.02^{Ba}	1.24±0.04^{Bc}	1.15±0.12^{Bb}	1.17±0.05^{Bb}
	10	0.46±0.05^{Aa}	0.85±0.06^{Ab}	0.82±0.04^{Ab}	0.89±0.03^{Ab}
Springiness (mm)	1	9.43±0.24^{Ca}	11.39±0.17^{Bbc}	10.85±0.11^{Bb}	10.22±0.01^{Bb}
	5	8.88±0.15^{Ba}	11.25±0.24^{Bc}	9.87±0.14^{Bb}	9.85±0.13^{Bb}
	10	7.55±0.18^{Aa}	10.08±0.15^{Ac}	8.99±0.26^{Ab}	8.55±0.10^{Ab}
Gumminess (N)	1	0.875±0.24^{Ba}	1.617±0.07^{Cb}	1.806±0.12^{Cb}	1.558±0.20^{Cb}
	5	0.784±0.15^{ABa}	0.946±0.01^{Bb}	1.594±0.02^{Bc}	0.754±0.02^{Ba}
	10	0.486±0.13^{Aa}	0.454±0.08^{Aa}	1.219±0.07^{Ab}	0.453±0.07^{Aa}
Cohesiveness	1	0.51±0.05^{Ca}	0.54±0.02^{Ba}	0.58±0.04^{Ba}	0.53±0.01^{Ca}
	5	0.44±0.01^{Ba}	0.48±0.02^{Aab}	0.53±0.03^{ABc}	0.50±0.01^{Bbc}
	10	0.37±0.01^{Aa}	0.45±0.01^{Ab}	0.51±0.01^{Ac}	0.44±0.05^{Ab}

[a] All values are mean ± standard deviation (n = 4). Different uppercase superscripts (A–C) for the same kazandibi types represent the significant differences between storage periods. Different lowercase superscripts (a–c) for the same storage time represent the significant differences between kazandibi types ($p < 0.05$).

Table 4. Sensory properties of kazandibi samples during the storage period[a]

Parameters	**Storage Period (day)**	**Kazandibi code**[b] **Ka**	**Ka1**	**Ka2**	**Ka3**
Appearance	1	7.70±0.92^{Ba}	8.40±0.50^{Ca}	8.10±0.55^{Ca}	8.40±0.94^{Ba}
	5	7.20±0.76^{Ba}	7.60±0.51^{Ba}	7.30±0.65^{Ba}	7.80±0.76^{Aa}
	10	6.20±0.76^{Aa}	6.10±0.55^{Aa}	6.10±0.71^{Aa}	7.50±0.88^{Ab}
Odor	1	8.20±0.69^{Cab}	8.50±0.51^{Bb}	8.00±0.64^{Ca}	8.50±0.60^{Bb}
	5	7.70±0.65^{Bab}	8.10±0.71^{Bb}	7.60±0.50^{Ba}	7.85±0.67^{Aab}
	10	6.30±0.65^{Aa}	6.30±0.65^{Aa}	6.30±0.65^{Aa}	7.40±1.35^{Ab}
Taste	1	8.10±0.85^{Ba}	8.60±0.50^{Cb}	8.00±0.64^{Ca}	8.40±0.68^{Bab}
	5	7.60±0.68^{Ba}	8.00±0.79^{Bab}	7.60±0.50^{Ba}	8.15±0.87^{Bb}
	10	5.75±0.85^{Aa}	6.70±0.72^{Ac}	6.30±0.80^{Abc}	6.10±0.64^{Aab}
Visual consistency	1	8.30±0.47^{Ca}	8.40±0.50^{Ba}	8.50±0.69^{Ca}	8.65±0.58^{Ca}
	5	7.80±0.61^{Bb}	8.00±0.64^{Bb}	7.90±0.71^{Bb}	7.15±0.81^{Ba}
	10	6.30±0.80^{Aab}	6.20±0.76^{Aab}	6.60±0.68^{Ab}	6.00±0.85^{Aa}
Consistency property in the mouth	1	8.60±0.50^{C}	8.30±0.65^{C}	8.20±0.62^{C}	8.50±0.51^{C}
	5	7.00±0.65^{B}	7.50±0.83^{B}	7.10±0.85^{B}	6.90±0.85^{B}
	10	5.85±0.81^{A}	5.70±0.66^{A}	5.90±0.55^{A}	6.10±0.97^{A}
General appreciation	1	8.00±0.65^{Ca}	8.50±0.51^{Cbc}	8.80±0.41^{Cc}	8.40±0.50^{Cb}
	5	7.25±0.64^{Ba}	7.80±0.41^{Bb}	7.40±0.50^{Ba}	7.15±0.36^{Ba}
	10	5.20±0.89^{Aa}	6.00±0.65^{Ab}	6.00±0.65^{Ab}	5.65±0.74^{Aab}

[a] All values are mean ± standard deviation (n = 4). Different uppercase superscripts (A–C) for the same kazandibi types represent the significant differences between storage periods. Different lowercase superscripts (a–c) for the same storage time represent the significant differences between kazandibi types ($p < 0.05$).

inulin blend with or without κ-carrageenan. They found that the custard that included carrageenan demonstrated a thicker, creamier, preferred structure than the full-fat sample.

IV.CONCLUSIONS

The color analysis demonstrated that the differences in formulations and storage periods between L and b values were statistically significant ($p < 0.05$). Using a combination of carrageenan and guar gum resulted in a more significant decrease in the syneresis value. Generally, the textural properties of the control sample were lower than those of the samples with hydrocollloids. Interactions between the gums and dairy proteins might lead to increased hardness, springiness, gumminess and cohesiveness values. Sensory properties continuously decreased throughout the storage period. The addition of hydrocolloids in dairy dessert production was attributed to positive effects on sensory properties. The results demonstrated that hydrocolloid combinations could be used successfully in kazandibi production.

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