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Evaluation of Additional Carboxy Methyl Cellulose and k-Carrageenan Gums on the Qualitative Properties of Gluten- Free Toast Breads

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ABSTRACT: In this research, after carrying out chemical tests measuring the moisture, protein and ash contents on rice flour according to standard methods, gluten- free breads were prepared from rice flour combined with 0.5% Carboxy Methyl Cellulose (CMC) and 1% *k*-Carrageenan gum. A sample lacking gum was also produced as control. Rice breads (with gum and without gum) were then produced by semi-industrial method. Dough and bread yield assays as well as voltmeter were carried on the obtained breads. The results showed that the addition of two gums led to the improvements of dough and bread yield properties as well as specific volume as compared to the control sample with 1% CMC that resulted in a more specific volume and 1% k-carrageen that gave a better dough and bread yields. Chemical tests measuring the moisture, ash and protein contents were performed on all bread samples followed by the determination of staling rate through instrumental method (Instron machine) according to the standard methods. The results of chemical tests carried on wheat flour and rice flour showed that consumed flour was suitable for toast bread making. The results of chemical tests carried on produced bread sample showed that K_2 treatment had the highest moisture content; KC treatment had the most ash content; control treatment 1(W) showed the highest protein followed by KC treatment and rice control treatment (C) had the lowest amount of moisture, ash protein. The results obtained from staling rate test instrumentally at time intervals of 24, 48 and 72 hours after baking showed that at three time intervals C treatment had the highest staling rate, and W, K_2 and C_2 treatments had the lowest staling rate respectively. The obtained rice breads were presented to a group of panelists to assess the sensory properties including porosity and granular appearance of the bread crumb, aroma, color of crumb, chewiness and texture as well as staling property. The results obtained from the sensory analysis indicated that the addition of two gums led to improvement of sensory properties of gum containing samples as compared to the control- of among gum-containing samples, bread with 1% CMC had the best sensory properties.

Keywords: *Carboxy Methyl cellulose, Celiac, k-Carrageenan, Qualitative, Stailing.*

Introduction

Celiac syndrome is a chronic nutritional disorder observed usually at sucking period and childhood due to disorder of digestion and absorption of fat and sugar (Holmes, 2000; Hervonen, 2002). Permanent elimination of gluten from diet is the sole efficient way of curing this disease. However gluten elimination from bread formulation leads to formation of a liquid dough at pre-baking stages and a bread with ruptured crumb, undesirable color and other quality problems (Gallagher, 2004). In addition commercial gluten- free products have unpleasant quality, weak mouth sensation and bad taste (Arendt, 2002). Gluten- free breads become stale in a short time due to substantial amount of starch present at their formulation. Absence of gluten makes more water available to starch leading to tenderness of both crumb and crust (Gallagher, 2004). The mentioned problems cause important technological

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challenges for technologists and bakers which have resulted in many researches on gluten replacement with useful additives such as gums (Lazaridou, 2007; Moore, 2006).

Gums or hydrocolloids are used as thickeners, emulsifiers, syneresis inhibitors and gel makers. They also used for improving water retention capacity as well as texture properties, controlling water migration and keeping quality of food products. They increase the shelf life of bakery products through retention of moisture content and consequently retardation of staling rate. These ingredients confer stability to food products during freezing and thawing circles, and lessen negative effects of freezing process on starch-based products. Kappa- Carrageenan , a common gum applied at food industry is derived from a sea weed(Ward, 2002).This gum doesn't contain nutritional value since it can't be absorbed by the body; however it has many useful functions and can act as water binder, texturizer and adhesive.

Carboxy Methyl Cellulose or CMC is a linear, ionic and synthetic molecule. This gum is an unfermentative substance which can suspend in water and its color varies from white to creamy depending on the degree of purity. CMC is obtained from the reaction of alkali and mono chloro acetic (Movahed , 2011).

In 2003, FAO evaluated the effect of adding seven kinds of dairy powders at various concentrations on the sensory and quality properties of wheat- based gluten-free breads. Protein content of these powders were 6.5-9.0%. It was reported that powders containing more protein content gave bulky breads with less elasticity than wheat bread. The obtained breads had appropriate shape and volume (Gallagher, 2003).

Moore *et al*. (2006) investigated the effect of different concentrations of enzyme tranceylutaminase (T.G) on protein network of gluten-free breads. Based on their studies, breads obtained from 10 u/g protein of the said enzyme had less baking loss as well as better quality (Moore, 2006).

Evaluating the effect of combined functions of such gums as pectin, guar and xanthan at concentrations of 1, 3 and 7% on quality properties of gluten free breads, Gambus *et al*. (2007) reported that all bread samples containing Xanthan had more volume than other breads. Also application of more concentration of this gum decreased toughness of prepared breads some days after baking. These researchers found that combined usage of gums and their interaction had an effect on gelatinization of starch as well as on free amilose content (Gambus, 2007).

In order to enrich protein content and create useful mechanical properties in gluten-free breads, Curic *et al*. (2007) added soy flour to bread formulation and reported that breads obtained from a mixture of defatted soy flour and corn flour (75/25 w/w) with rice flour (with a ratio of 1:1) and 3% guar gum had better elasticity, tenderness, volume and porosity than control sample. Gum addition led to enhancement of protein content and sensory properties of the obtained breads (Curic, 2007).

Lee *et al*. (2006) evaluated the effect of xanthan gum on rice bread and found that addition of 1% xanthan led to decreased bread's toughness and increased shelf life.

Moore *et al*. (2006) studied the effect of xanthan gum on gluten- free breads prepared from rice flour, corn starch and potato starch and reported that xanthan gum at 2% increased shelf life of gluten-free breads.

Schober *et al*. (2007) evaluated microstructure and rheology of gluten free breads prepared on the basis of corn and starch flour with addition of hydroxyl propyl methyl cellulose (HPMC). They reported that the addition of 2% HPMC had a good influence on the quality properties and crumb texture of the obtained bread.

Evaluating the effect of guar, HPMC and CMC gums on gluten – free breads prepared from a mixture of rice flour and potato starch, Cato *et al*. (2004) found that incorporation of 0.8% CMC gave breads with more tender texture.

Materials and Methods

Rice flour was obtained from khazar khusheh Co. (Amolo, Iran).CMC and k-Carrageenan were purchased from Dowchemical Co. Bread toast ingredients were prepared from sahar bread Co and dry bakery yeast was obtained from yeast making Co. (Fariman, Iran). In all experiments, control treatments of 1 and 2 were signified with C and W codes respectively; treatment containing 0.5% k-Carrageenan was marked with K1 code; treatment containing 1% k-Carrageenan was signified with K_2 code; treatment containing 0.5% CMC was marked with C1 code; C_2 code denoted treatment containing 1% CMC and treatment containing CMC and k-Carrageenan each at concentration of 0/5% was signified with KC code.

- Chemical test of Flour and Bread Samples

Chemical tests carried on rice flour at three replications included moisture, ash and protein content (AACC., 2003).

- Baking assay

When preparing gum – containing and control toast breads, dough yield as well as bread yield were measured according to relations 1 and 2.

1) $$Bread\ yield = \frac{bread\ weight\ (additives+flour)}{flour\ weight} \times 100$$

2) $$Dough\ yield = \frac{dough\ weight\ call\ additives+flour}{flour\ weight} \times 100$$

- Preparation methods & baking procedure of toast bread

In order to bake toast bread, ingredients such as rice flour, the yeast saccharomysis cerivisiae, sugar and liquid oil were prepared and weighted. k-Carrageenan gum at concentrations of 0.5 and 1% was then added to rice flour followed by mixing in dough-making tank for 10 min. Other dried and powdery materials were added to the mixture. In this stage water was added and after thorough mixing of water with flour, dough was formed. Initial rest of samples was done for 10 min. The dough was then scaled into about 600g portions, rounded and rested for 10 min to undergo medial fermentation. In this stage dough divisions were fed into fermentation chamber to undergo final fermentation at 30˚C and 80% relative humidity for 40min followed by transferring to a rotary oven and baking for 45 min at 180˚C. The obtained breads were then removed from respected molds, cooled at room temperature for 30 min and packed in polypropylene bags (Lazaridou, 2007).

- Measurement of volume and specific volume of toast breads

In order to determine volume of bread samples, a method presented by Henry Simon Co. (England) was used. This machine is composed of three parts: lower part (a chamber in which canola seeds are placed for measuring), medial or bottleneck part (a calibrated tower with each degree equals to 25 cm2) and an upper part (a capped square – shaped chamber for introducing canola seeds).

In order to determine volume of bread samples, canola seeds are introduced from the upper part in to a closed vent followed by opening the vent and transferring canola seeds from medial to lower part of the machine in order to exceed zero. Excess canola seeds are then exited followed by closing the upper vent. By reversing the machine, all canola seeds are transferred from the lower part to the upper part, passing vent is closed and machine returns to normal condition. The lower vent is then opened and the sample inside the machine is placed at wooden piece and the volume of bread can be determined. Specific volume is measured through the obtained volume divided by the sample weight.

- Determination of bread's staling rate through instrumental method using Instron

In order to determine staling rate of bread samples, Instron machine was used according to AACC, No. 74-09. This test was performed at time intervals of 24, 48 and 72 hours after baking. Samples were stored at plastic bags at ambient temperature followed by cutting crumb slices with dimensions of 2cm×2cm for measurement of staling by Instron machine. Compression exerted equals to 40% of samples' diameter (Anon1, 2003).

- Sensory analysis of bread

In order to analyse sensory properties of the bread, five senses were used. The criteria was personal opinion of learned assessors on the product. In this assessment samples were cooled, cutted, coded and evaluated by some sensory assessors from Bread and Grain Research Center of Tehran. They scored each sample regarding sensory properties such as porosity and granular appearance of crumb, color of crumb, aroma, taste, chewiness and texture (Curic, 2007).

- Evaluation of staling rate of toast bread by sensory methods

For determining the staling rate, international standard of AACC, NO. 74-30 was used. This test was done at time intervals of 24, 48 and 72 hours of bake. In doing so, bread samples were separately packed in plastic bags and stored at room temperature (AACC., 2003).

- Statistical analysis

In order to analyze the quantitative properties, descriptive statistics was used with the aid of analysis of variance (ANOVA). Data analysis was performed using SPSS software (version 16) followed by Duncan's multiple range test for mean comparison.

Results and Discussion

Table 1 indicates the results obtained from the chemical assays. Tables 2, 3 and 4 present mean comparison of dough and bread yield assays as well as volumetric assays.

Table 1. Chemical properties of rice flour and Nole wheat flour using toast bread preparation

Flour	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	pH
Rice flour	8.7	0.48	9.56	0.88	5.3
Nole wheat flour	10.26	0.68	10.61	1.66	5.7

Table 2. Mean comparison of dough yield assays

Treatment / Property	W	C	KC	C2	C1	K2	K1
dough yield	163.9 ^{b}	145.6 ^{e}	150.6 ^{cd}	153.9 ^{c}	147.6 ^{d}	168.8 ^{a}	163.9 ^{b}

in each row means which have a common letter are not significantly different based on Duncan's test in probability of 1%

Table 3. Mean comparison of bread yield assays

Treatment / Property	K1	K2	C1	C2	KC	C	W
bread yield	129.1 ^{b}	137.9 ^{c}	132.1^{b}	138.1^{cd}	130.9^{e}	128.2 ^{a}	141.2 ^{d}

In each row means which have a common letter are not significantly different based on Duncan's test in probability of 1%

Table 5 shows the results obtained from mean comparison of chemical tests on toast bread samples regarding moisture, ash and protein content.

Staling test through mechanical (instrumental) method was performed 24, 48 and 72 and 72 hours after baking. Toast bread samples were placed in plastic bags separately and after codifying, they were stored at room temperature. In order to determine staling by Instron, some portions of crumb were cutted at dimensions of 2cm×2cm. As mentioned earlier compression force exerted was applied to 40% of the sample diameter. Table 6 indicates the results of mean comparison and analysis of variance obtained from staling measurement of toast bread samples by mechanical method.

Table 7 and 8 shows results of mean comparison of sensory tests. Table 9 presents results of mean comparison of staling evaluation by sensory method.

Table 4. Mean comparison of volumetric assays

Treatment / Property	**K1**	**K2**	**C1**	**C2**	**KC**	**C**	**W**
specific Volume	1.11^{d}	1.17 ^{c}	1.272 ^{b}	1.287 ^{b}	1.282 ^{b}	0.885 ^{e}	1.904 ^{a}

In each row means which have a common letter are not significantly different based on Duncan's test in probability of 1%

Table 5. Mean comparison of chemical analysis of toast bread (%)

Treatment	**Moisture**	**Ash**	**Protein**
K_1	32.23^{d}	1.293^{c}	8.34^{c}
K_2	39.20^{a}	1.343^{c}	8.35^{c}
C_1	33.98^{c}	1.403^{b}	8.30^{d}
C_2	35.01^{b}	1.463^{b}	8.35^{c}
KC	33.38^{c}	1.693^{a}	8.99^{b}
C	29.75^{e}	1.153^{e}	8.22^{e}
W	30.68^{e}	1.240^{d}	9.71^{a}

In each column means which have a common letter are not significantly different based on Duncan's test in probability of 1%

Table 6. Mean comparison of staling measurement of toast bread samples by Instron (based on Nioton)

Treatment/ Time	K_1	K_2	C_1	C_2	KC	C	W
24	34.81^{e}	17.69^{c}	18^{c}	9.67^{b}	23.83^{d}	36.43^{f}	6.65^{a}
48	39.14^{e}	19.09^{c}	19.61^{c}	14.48^{b}	25.77^{d}	43.05^{f}	8.18^{a}
72	41.42^{e}	22.40^{c}	21.52^{bc}	18.75^{b}	26.87^{d}	48.33^{f}	8.33^{a}

In each raw means which have a common letter are not significantly different based on Duncan's test in probability of 1%

Table 7. Mean comparison of total external properties score

Property Treatment	**Appearance volume**	**Fracture and tearing**	**Crust trait**	**Backside uniformity**	**Shape fitness**	**Crust color**	**Total external score**
K1	5.66^{c}	2.04^{c}	1.66$^{a\,b}$	1.66^{c}	1.33^{b}	5.66^{d}	17.98^{e}
K2	7.66^{b}	2.33$^{a\,b}$	2.33$^{a\,b}$	2.33$^{a\,b}$	1.66$^{a\,b}$	6.33^{c}	22.64^{bc}
C1	6^{c}	2.07^{b}	1.66$^{a\,b}$	2.03^{b}	1.66$^{a\,b}$	6.30^{c}	19.7^{c}
C2	8.33$^{a\,b}$	2.33$^{a\,b}$	2$^{a\,b}$	2.33$^{a\,b}$	2.33^{ab}	6.66^{b}	23.98$^{a\,b}$
KC	6^{c}	2.04^{c}	1.66$^{a\,b}$	1.66^{c}	1.33^{b}	6.30^{c}	18.98^{d}
C	5.33^{d}	2^{d}	1.33^{b}	1.30^{d}	1.30^{b}	5.33^{e}	16.6^{f}
W	9^{a}	3^{a}	2.66^{a}	3^{a}	2.66^{a}	7.66^{a}	28.64^{a}

In each column means which have a common letter are not significantly different based on Duncan's test in probability of 1%.

Table 8. Mean comparison of total internal properties score

Property/ Treatment	Porosity granular	Total internal score	Texture crumb	Chewiness	Flavor and taste	Aroma	Color crumb	Final score
K1	5.66^{c}	45.31^{d}	9.66^{c}	6.33^{c}	11^{c}	7$^{a\,b}$	5.66^{d}	63.29^{d}
K2	6.66^{bc}	54.99^{b}	11.67^{b}	8.33^{a}	12.67$^{a\,b\,c}$	8$^{a\,b}$	7.66$^{a\,b}$	77.63^{b}
C1	6.66^{bc}	48.64^{c}	10.33$^{b\,c}$	6.66^{b}	11^{c}	7.66$^{a\,b}$	6.33^{cd}	68. 34^{c}
C2	7.33$^{a\,b}$	51.66^{c}	11^{b}	7^{b}	11.67$^{b\,c}$	8^{ab}	6.66^{bc}	75.64^{b}
KC	5.66^{c}	49.32^{c}	11.33^{b}	6.33^{c}	13$^{a\,b}$	7$^{a\,b}$	6^{cd}	68.3^{c}
C	5^{d}	41.33^{e}	9.01^{d}	5.33^{d}	10.33^{d}	6.33$^{a\,b}$	5.33^{e}	57.93^{e}
W	8.33^{a}	61.98^{a}	14^{a}	8.66^{a}	13.67^{a}	8.66^{a}	8.66^{a}	90.62^{a}

In each column means which have a common letter are not significantly different based on Duncan's test in probability of 1%.

Table 9. Mean comparison of sensory staling rate

Treatment/ Time(h)	K1	K2	C1	C2	C	KC	W
24	6^{a}	6^{a}	6^{a}	6^{a}	6^{a}	6^{a}	6^{a}
48	5^{a}	5.667^{a}	5.333^{a}	5.667^{a}	4.667^{a}	5.333^{a}	5.667^{a}
72	3.333^{c}	5.333^{a}	4.333^{b}	4.333^{b}	3^{d}	4.667$^{a\,b}$	5.333^{a}

In each row means which have a common letter are not significantly different based on Duncan's test in probability of 1%.

The results obtained from the chemical test indicated that rice flour containing 8.7% moisture and 9.56% protein was suitable for rice bread making according to Iranian National Standard No. 11136.

Regarding the results obtained from mean comparison of dough yield assay (Table 2), it was found that the addition of both gums led to the enhancement of dough yield and k_2 and k_1 treatments showed the most dough yield white the control treatment had the lowest dough yield. On the other hand, were not significant differences between c_2 and kc, k_1 and w and kc and c1 ($p<0.01$).

The increase in dough yield is due to the presence of consumed gum which absorbs water and consequently form a viscous solution by hydrophilic molecules. Results obtained in this study are in line with findings of Curic *et al*. (2007) and Moor *et al*. (2006) who reported that gum addition led to the improvement of water retention capacity, water absorption percent and enhanced dough yield. As it is clear from Table 3, use of both gums enhanced rice bread yields as compared to the control treatment where w treatment had the most bread yield followed by C_2 and K_2.

The lowest bread yield was related to C treatment. On the other hand, there were not significant differences observed between K_2 and C_2, KC and k_1 as well as with C_1. However a significant difference was observed between all gum containing samples and control ($p <0.01$). This is due to the hydrophilic characteristics of the molecules after bake. The higher the moisture content the less will be the weight loss after bake. Since there is a reverse relationship between bread weight loss after bake and bread yield, incorporation of gums into rice bread formulation enhances the yield. These results agree with those of Curic *et al.* (2007) who found that bread yield enhanced with gum addition. Table 4 shows the additions of both gums resulted in an increased specific volume of gum containing samples as compared to the control treatment were w had the highest specific volume followed by C_2, KC and C_1 treatments. The lowest amount of specific volume was related to C treatment. On the other hand there were significant differences between all gum – containing samples and the C sample. This is related to the hydrophilic characteristics of gums leading to enhanced viscosity, dough extension and gas retention capacity. Rosell *et al*. (2001) also found similar results. Furthermore, the reason for increase in specific volume of w sample is related to the presence of the gluten protein and its effect on water retention capacity (Movahed, 2011).

The effect of different levels of CMC and κ-Carrageenan gums on moisture content of toast bread samples is presented in Table 5. The addition of gums led to increased in moisture content. K2 and C2 treatments had the highest moisture content respectively while control samples had the lowest moisture. There were not significant differences between C1, KC, C and W treatments where as significant differences were observed between the other treatments ($p<0.01$). Increased moisture observed at gum-containing bread samples is due to high water-holding capacity of gums' structure. These results are in line with findings of Rosell *et al*. (2001) who reported that moisture content was increased with gum addition (Rosell, 2001).

Based on the results shown in Table 5 the ash content of the samples was increased by gum addition. KC treatment showed the highest ash content as well as significant differences with the other treatments and the control sample. There was a significant difference between all gum-containing treatments and control ones while no significant differences were observed between C1 and C2 as well as K1 and K2 treatments. These results are in accordance with those of Brites *et al*. (2008), who reported that gum addition caused an increase in the ash content. Gum addition led to an increase in protein content of gum-containing samples as compared to the control.

C treatment had the lowest protein content. There were not significant differences between K1, K2 and C2 treatments where as a significant differences were observed between all gum-containing samples and the control (C&W). The reason for the slight increase in gum- containing sample as compared to C sample is the presence of protein and some amino acids in gums. These finding are in agreement with the results of Brites *et al*. (2008) who reported that protein content of gum-containing samples was increased due to the presence of protein and carbohydrates in gums incorporated. The increase in protein content of wheat toast bread as compared to rice is attributed to higher concentration of protein in wheat flour as compared to rice flour.

As presented in Table 6, gum addition led to a decrease in staling rate at three time intervals of 24, 48 and 72 hours after baking as compared to the C treatment. W treatment showed the lowest staling rate as well as a significant difference with the other treatments followed by K2 and C2 treatments. Rice control sample (C treatment) had the most staling rate. On the other had no significant difference was observed between C1 and K2 treatments during the said time intervals while there were a significant differences between all gum- containing treatments and control treatments (gum-free). Based on the results shown in Ttable 6, addition of CMC and κ-Carrageenan gums to rice bread formulations led to a decrease in staling rate during three days after baking bread. In addition, 72 hours after baking E treatment showed the lowest staling rate followed by C1 and C2 treatments while rice control sample (C) had the most staling rate.

Decrease in the staling rate of gum-containing samples is attributed to incorporated gums which led to enhancement of dough's elasticity and consequent softness of the obtained breads as compared to the control breads. These results are in line with the findings of Mezaize *et al*. (2009) who reported that the addition of gums to gluten-free bread's formulation led to softer crumbs (Movahed, 2013).

Results of mean comparison of data related to sensory evaluation (Table 2) indicated that the addition of both gums led to enhancement of appearant volume of gum-containing breads as compared to the control treatment. W and C2 treatments had the highest amount of appearant value, and C treatment had the lowest of this index. On the other hand there were not significant differences observed between W and C2, K2 and C2, KC and C1 treatments. There was a significant difference between all gum-containing breads and control treatment ($p<0.01$). The reason for enhanced appearant volume (in sensory method) is related to the hydrophilic characteristics of gums leading to high viscosity and consequent enhanced gas retention in dough (Curic *et al*., 2007).

Mean comparison of data related to the sensory evaluation of the crust color (Table 7) showed that gum addition improved crust color of gum- containing samples as compared to C sample. The highest score of crust color was related to W treatment followed by C2, K2, C1, KC and K1 respectively. On the other hand there were not significant differences between C1, KC and K2 treatments. However a significant difference was observed between all gum-containing treatments and C treatment. In general, addition of gum to bread formulation improved crust color. This improvement is attributed to browning reaction due to the addition of gums (the presence of amino acids in the structure) and their interaction with sugar compounds present at the formulation. Results obtained in this study were in line with the findings of Lazaridou *et al*. (2007) who reported that incorporation of gums at the formulation of rice flour-based gluten free breads led to improvement of crust color.

Regarding the results of mean comparison of data related to the shape fitness of bread samples (Table 7), it was found that this index was increased with gum addition. Furthermore, W treatment had the best shape fitness while the lowest amount of this index was related to C treatment. On the other hand there were not significant differences between W treatment and K2, C2 and C1 treatments as well as between K1 with KC and C treatments. There was not significant difference observed between all gum-containing treatments and C treatment. The slight increase in the shape fitness of gum-containing samples is attributed to thickening property of incorporated gums. Mezaiz *et al*. (2009) also obtained similar results. The reason for improved shape fitness observed at W treatment is related to gluten present at the formulation. This protein has contributed to the formation of a firm gluten network, gas retention and consequent improved shape fitness.

As one can observe from Table 7, the addition of gum to gluten- free bread formulation resulted in an increase of backside uniformity of the obtained samples as compared with the C sample. W treatment gained the highest score of backside uniformity followed by K2 and C2 treatments. The lowest score of backside uniformity was recorded for the C treatment. There were not significant differences between W with K2 and C2, K2 with C2 and C1 as well as K1 with KC; however all gum-containing samples showed a significant difference with C sample ($p<0.01$). Increase in backside uniformity was due to the structure of incorporated gums. These results were in accordance with those of Moore *et al*. (2006) who reported that uniformity is increased with gum addition. The results of mean comparison of both gums led to the improvement of crust trait of gum breads as compared to the control bread. W and K2 treatments gained the highest score of crust trait while C treatment had the lowest score.

In addition, significant differences were not observed between K2 with C2, C1, KC and K1 treatments. Also there were not significant differences between all gum-containing treatments and the control treatment. The slight improvement in the crust trait is caused by the formation of an uniformed crust with an appropriate thickness due to application of gums. Gallagher *et al*. (2003) obtained similar results based on their addition of gum to gluten-free bread formulation improved the crust trait.

Mean comparison of data related to the fracture and tearing properties of toast bread samples has shown that gum addition led to a decrease in the amount of fracture and tearing of gum-containing rice samples as compared to the control therefore these samples showed an increased resistance to tearing- In addition W treatment had the most resistance to tearing followed by K2 treatment while C treatment showed the least resistance to these indexes. Significant differences were not observed between W K2 and C2 as well as K2 and C2 and C1. On the other hand there was a significant difference between gum-containing treatments and control treatment ($p<0.01$). The reason for the increase of score of fracture and tearing in gum- containing breads is related to the viscous nature of incorporated gums leading to increased resistance. These results are in agreement with the findings of Mezaize *et al*. (2009) who reported that gum addition resulted in an increased resistance to fracture and tearing.

Mean comparison of the total external properties scores are presented in Table 7 indicating that the external properties score increased by gum addition therefore Wand C2 treatments had the highest scores respectively while the lowest score was recorded for C treatment. Although no significant differences observed between W with C2, C2 with K2 and K2 and C1 treatments, there was a significant difference between gum-containing treatments and C treatment ($p<0.01$). This effect was once again due to incorporation of gums at gluten-free bread formulation that improved apparent characteristics of the obtained breads. These results confirmed the finding of Mezaize *et al*. (2009). who found that the external properties of gluten-free bread is enhanced with gum addition.

Table 3 presents the addition of gum to gluten-free bread formulation that caused an increase in porosity and granular appearance of gum-containing samples as compared to the control. W and C2 treatments had the most porosity while C treatment indicated the lowest amount of this index. There were not significant differences between W with C2, K2 with C2, K2 and C1 as well as KC and K1. However all gum-containing treatments showed a significant difference with C treatment ($p<0.01$). The cause of increased porosity observed at gum-containing samples is the fact that gum adds volume to bread. Similar results were obtained by Mezaize *et al*. (2009) who found that gum addition led to the enhancement of porosity.

Results of mean comparison of sensory evaluation of crumb color are presented in Table 8. As it shown, gum addition resulted in an increase in crumb color score for gum-containing samples as compared to C sample. Meantime W and K2 treatments gained highest scores of crumb color where as C treatment had the lowest score. In addition there were not significant differences between W with K2 and C2 as well as between C2 with C1 and KC treatments. All gum-containing treatments had a significant difference with the control treatment ($p<0.01$). The reason for the improvement of crumb color observed in gum-containing samples is related to the structural nature of incorporated gums. Results obtained in this study were in accordance with the findings of Gallagher *et* *al*. (2003). who reported that crumb color is improved with gum addition.

Mean comparison of data related to the aroma of toast bread samples as presented in Table 3, indicates that by incorporation of gum at the formulation of gluten free breads aroma of gum-containing samples is improved as compared to the control. The highest scores of aroma were recorded for Wand K2 treatments while C treatment had improved the score. A slight increase in aroma of gum-containing breads is attributed to the aroma presented in the structure of incorporated gums which was recognized by panelists. These results confirmed the observations by Rosell *et al*. (2001) who found that gums added aroma to gluten-free bread samples (Rosell, 2001).

The results of mean comparison of data related to the taste of toast breads showed that gum-containing samples had better taste than the control sample. W and KC treatments gained the highest taste scores while C treatment received the lowest score. In addition, there was a significant difference between gum-containing rice breads and rice control bread ($p<0.01$). There was not significant difference observed between all gum-containing treatments. In fact structural nature of the incorporated gums led to the formation of a better taste in gum-containing breads as recognized by the panelists when compared to the control breads. Similar results were concluded by Demirkesen *et al*. (2010) who reported that taste of gluten-free breads was improved with gum addition.

The results of mean comparison of data related to the chewiness of toast breads are presented in Table 8. As it shown the addition of both gums to bread formulation led to an increase in chewiness of gum-containing samples as compared to the control sample. The highest scores of chewiness were related to W and K2 treatments while the lowest score was recorded for C treatment. Significant differences were not observed between K2 with W, C1 with C2 and KC with K1 treatments while the control treatment had a significant difference with all gum-containing treatments ($p<0.01$). The increase in chewiness index of gum-containing samples as compared to C sample was due to the water absorption by gum which in turn led to more tenderness of the obtained breads. Results obtained in this research confirmed the findings of Demirkesen *et al*. (2010) who observed positive effect of gum addition on chewiness of gluten-free breads.

Data presented in Table 8 indicated that gum-containing rice breads had better texture than control bread. Regarding this index, W and K2 treatments gained the highest scores, and C treatment gained the lowest score. In addition there was a significant difference between gum-containing samples and control sample ($p<0.01$) significant difference was not observed between all gum-containing samples Improved treatment was the result of gum containing bread. Similar results were detected by Gallagher *et al*. (2004) who reported that gum addition improved the texture of gluten-free breads.

Incorporation of both gums at the formulation of gluten-free bread samples enhanced the scores of internal characteristics of gum breads as compared to the control bread. Among experimental treatments the highest scores of internal properties were assigned to W and K2 treatments and the lowest score of this index was assigned to C treatment. Significant differences were not observed between C2, C1 and KC treatments. In addition there was a significant difference between all gum-containing samples and the control sample. The reason for this enhancement was attributed to the presence of gums which improved the internal properties of gum containing samples as compared to the control. These results were in accordance with the findings of Curic *et al*. (2007) who reported that gum addition had a positive effect on internal properties of gluten- free breads.

The results of mean comparison of the final scores are presented in Table 8 indicating that the addition of *k*-Carrageenan and CMC gums to bread formulation led to an increase in the final scores of gum-containing samples as compared to the control. W and K2 treatments had the most final scores. No significant differences were observed between K2 with C2 and KC with C1 treatments while there was a significant difference between gum- containing samples and the control sample ($p<0.01$). The significant increase in the final scores of gum- containing samples relative to the control sample was due to the presence of gums that improved the internal and external properties of the obtained breads. Similar results were reported by Lazaridou *et al*. (2007); who observed positive effects of gum addition on total acceptability of gluten – free breads.

Sensory evaluation of staling rate are presented in Table 9. As it shown, 24 hours after baking period all the prepared toast breads kept their fresh quality therefore no significant difference was observed between them, i.e. sensory assessors assigned the highest scores to all the samples however 48 hours after baking a slight decrease in the quality of toast breads was observed and the samples were reassessed. Meantime W treatment showed the most freshness (staling retardation) followed by C2. The least amount of freshness was observed at C treatment; however there was no significant difference between experimental treatments (Gambus *et al*., 2007).

Staling evaluation after 72 hours of baking period indicated that the quality of control bread has decreased therefore it scored slightly stale while the other treatments ranked fresh to slighty fresh. The highest scores of freshness were recorded for K2 and W treatments and the lowest score was related to C treatment. In addition no significant differences were observed between KC, C2 and C1 treatments; while all gum- containing treatments showed a significant difference with the control treatment ($p<0.01$). The reason for reduced staling rate of gum-containing rice breads was related to the structure of consumed gums and their water-binding property leading to enhancement of storage time. These results were in line with findings of Gambus *et al*. (2007) who found that staling rate or toughness of gluten-free breads decreased with gum addition.

Conclusion

The results showed that the highest percent of dough yield was related to K_2 treatment and the highest percent of bread yield was related to K_2 and C_2 treatments. Regarding the specific volume, W treatment had the highest score followed by C_2, KC and C_1 treatments. In all cases, control treatment had the lowest scores.

The results showed that the addition of κ-Carageenan and CMC gum at concentrations of 0.5 and 1% had different effects on staling rate and chemical parameters of produced toast breads.

The results of chemical tests carried on wheat flour and rice flour showed that consumed flour was suitable for toast bread making. The results obtained instrumentally from the staling rate test at time intervals of 24, 48 and 72 hours after baking showed that for three time intervals, C treatment had the highest staling rate, and W, K2 and C2 treatments had the lowest staling rate respectively.

Sensory analysis carried out by the panelists indicated that all gum- containing samples had better sensory properties such as aroma and taste, chewiness, crumb texture, fracture and tearing, crust trait, backside uniformity, crust color and shape fitness than the control sample. K2 and C2 treatments showed the best organoleptic characteristics.

The results indicated that after 48 hours of baking W and C2 treatments had the most freshness and after 72 hours of baking K2 treatment showed the highest amount of this index. Control treatment had the least freshness at all the time intervals.

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