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THE EFFECT OF USE OF HYDROCOLLOIDS IN DIFFERENT TYPES AND RATIOS ON THE QUALITY OF GLUTEN-FREE BREADS

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ABSTRACT
Hydrocolloids are used as gluten substitutes in gluten-free bread formulation due to providing the improvement on textural, moisture, viscosity and overall quality properties. Although the effect of hydrocolloids on the final product varies, the chemical structure-amount of hydrocolloid used, process parameters and interactions with other components are very important. In our research, the specific volume, moisture, color, texture (hardness, chewiness, elasticity, cohesiveness) and organoleptic properties of gluten-free breads (konjac gum (CG) and xanthan gum (XG), hydroxypropyl methyl cellulose (HPMC), carboxymethyl cellulose (CMC)) effects were investigated. As a result of analytical and sensory analyzes, it was determined that the use of konjac gum at increasing concentrations significantly affected the quality and the consumability of gluten-free breads ($p<0.05$). In this research, the effects of different types of hydrocolloids on gluten-free breads, that were planned to be developed for celiac patients, were investigated and it was determined that the konjac gum among these hydrocolloids which is widely used in the food industry but has a limited usage in gluten-free bread production, significantly improves the physicochemical, textural and sensory properties of the samples.

1.Introduction

Celiac is a chronic inflammatory intestine disease caused by gluten consumption in genetically susceptible individuals (Ballestero-Fernande et al., 2021). This disease is a syndrome that occurs when the alcohol-soluble proteins of rye or barley and the gliadin fraction of wheat gluten damage the small intestinal mucosa. (Benazir et al., 2019). Gluten-free diet is the only effective treatment method that allows the clinical symptoms of celiac patients to disappear and thus the small intestine mucosa to return to its normal structure (Marciniak et al., 2021) and the digestive system to be healthy (Caio et al., 2019). Today, the products for the consumption of celiac patients (bread, pasta, biscuits, cake, pudding) are on the market shelves (Larretxi et al., 2020). Among gluten-free products, bread is one of the foods that is highly preferable and forms an important part of the diet (Houben et al., 2012). However, gluten-free breads have poor nutritional, technological and sensory properties compared to wheat bread due to gluten deprivation (Cappelli et al., 2020). In order to improve the quality of gluten-free breads, some food additives (enzymes, emulsifiers, some polysaccharides), especially hydrocolloids, are added to product formulations as gluten substitutes (Conte et al., 2019; Bender and Schönlechner 2020; Aguiar et al., 2022).

Hydrocolloids are described as water-dispersible and/or soluble, thickening polymeric carbohydrates (Yücel, 2009). In addition to their high water holding capacity, it is reported that they also behave like gluten when mixed with water (Houben et al., 2012). The addition of hydrocolloids to gluten-free bread formulations may have different effects on intermediate and final products (Yano et al., 2017). The hydrocolloids effects are; the increasing viscosity, foam stability, flocculation and the cohesion (Mir et al., 2016; Rai et al., 2018), the improving viscoelastic properties and increasing gas holding capacity in dough structure. (Nishinari et al., 2018) They also have features such as reducing moisture loss, maintaining general quality such as texture, specific volume, crust structure and sensory properties, and extending the shelf life of bread (Jnawali et al., 2016). The effects of hydrocolloids on gluten-free bread quality vary depending on their molecular mass-structure-amount, chain length and bonds, and interactions with other components such as starch (Vidaurre-Ruiz et al., 2019; Clapasson et al., 2020). In researches in the recent years, xanthan gum (XG), guar gum, carob gum, hydroxypropyl methyl cellulose (HPMC), carboxymethyl cellulose (CMC), methyl cellulose (MC) are the leading hydrocolloids used to produce better quality gluten-free bread. It has been emphasized that they increase the quality and improve sensory properties of the final products (Lazaridou et al., 2007; Morreale et al., 2018; Vidaurre-Ruiz et al., 2019). There are studies on gluten-free bread quality of the single and combined use of hydrocolloids, which are frequently mentioned in the literature, but there are insufficient studies on the effects of plant-based konjac gum on gluten-free bread qualities.

Konjac gum (CG) has important technological properties due to its high water holding capacity, gelling property and improving dough rheology (Wang et al., 2017). Demirkesen et al (2010) reported in their study that the use of xanthan gum (XG) in combination with konjac gum caused a synergistic interaction each other in the dough structure and this effect improved the textural properties of gluten-free products.

In our research, the effects of using different types of hydrocolloids (CG, X, HPMC, CMC) in increasing concentrations (2%, 4%, 6%) on the physicochemical, textural and sensory properties of gluten-free breads were investigated. With this research, it was aimed to produce gluten-free bread suitable for the consumption of celiac patients, and at the same time, it was aimed to reveal the effects of konjac gum, which has limited studies in the literature.

2. Materials and methods

2.1. Materials

2.1.1. Samples

Corn starch (10.65% moisture, 0.13% ash, 0.18% crude fat, 0.4% protein, 88.65% total carbohydrate), granulated sugar, sun flower oil, salt, compressed yeast (Saccharomyces cerevisiae), milk powder purchased from local market. The hydrocolloids Konjac gum (CG) Xanthan (XG), hydroxypropylmethyl cellulose (HPMC) and carboxymethyl cellulose (CMC) obtained from Tunckaya and Demeter Chemical substances companies (Turkey). Gluten-free wheat starch (11.4% moisture, 0.11% ash, 0.17% crude fat, 0.35% protein, 87.97% total carbohydrate), purchased from Demeter Chemical (Turkey). This starch has a certificate analysis and the gluten content is given as 10 ppm (according to the International Food Standard Gluten Content should be less than 20 ppm).

2.1.2. Gluten-free bread production

In gluten-free bread production, for each formulation 70% of the water (Table 1) was put into the kneading bowl of the mixer (KitchenAid, USA), and after the salt and sugar were dissolved in water, compressed yeast was added and mixed for 30 seconds. Subsequently, the other solid components were taken into the kneading bowl and the remain of the water was added, and the mixing process was continued for 5 minutes after obtaining a homogeneous mixture in the 3rd cycle. Doughs prepared and poured into 165 g molds (inner part; 14.3x7.9 cm, bottom part; 12.9x6.4 cm and inner depth; 5.7 cm) were fermented for 70 minutes at approximately 30°C in the fermentation cabinet set. Afterwards, the doughs were baked in the oven at 210°C for 30 minutes. After the breads were cooled on wire racks at 25°C, they were stored in polyethylene bags until analysis were performed. Analysis were made 6 hours after baking (Tumer, 2018).

Table 1. Main ingredients and production formulations of gluten-free bread

Ingredients (%)	Formulations											
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
Konjac	2.0	0	0	0	0	0	0	0	0	0	0	0
	0	4.0	0	0	0	0	0	0	0	0	0	0
	0	0	6.0	0	0	0	0	0	0	0	0	0
XG	0	0	0	2.0	0	0	0	0	0	0	0	0
	0	0	0	0	4.0	0	0	0	0	0	0	0
	0	0	0	0	0	6.0	0	0	0	0	0	0
HPMC	0	0	0	0	0	0	2.0	0	0	0	0	0
	0	0	0	0	0	0	0	4.0	0	0	0	0
	0	0	0	0	0	0	0	0	6.0	0	0	0
CMC	0	0	0	0	0	0	0	0	0	2.0	0	0
	0	0	0	0	0	0	0	0	0	0	4.0	0
	0	0	0	0	0	0	0	0	0	0	0	6.0
Corn Starch	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
Gluten-free wheat starch	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Sugar	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Sunflower Oil	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
SSL	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Salt	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Compressed Yeast	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Powder Milk	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Water	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

2.2. Methods

2.2.1. Moisture Analysis

The moisture content of gluten-free breads was calculated gravimetrically. The samples were kept in an oven at 130 °C for 5 hours to calculate their % moisture values (Ozturk and Mert, 2018). Six replications were carried out for moisture content analysis.

2.2.2. Specific Volume

The weights of the gluten-free breads were determined and the volume was measured on the basis of displacement with rapeseed. The average of these obtained values was taken and the volume was divided by the weight, and the specific volume used to determine the quality of the breads was obtained (Zorzi et al., 2020). Six replications were carried out for the analysis.

2.2.3. Color Analysis

Gluten-free bread color intensity measurements were determined by Konica Minolta CM-5 (Japan) calorimeter. This instrument makes the three-dimensional color measurement, L* (lightness) on the Y axis; 0=black to 100=white, for example light-darkness, a on the X-axis; green (-a), red (+a), b on the Z axis; yellow (+b), blue (-b) indicate color size or location (Ozkoc and Seyhun 2015). Six replications were carried out for the analysis.

2.2.4. Texture Analysis

The textural properties of the gluten-free breads were determined using the TA.XT-plus Texture Analyzer (Stable Micro Systems, UK). Two slices of 12.5 mm thick bread that did not contain the crust were analyzed by stacking them on top of each other. The slices were pressed down at a speed of 1 mm/s using a 50 mm cylindrical probe and pressed until 50% deformation was applied to the breads, and the load was kept on the breads for 30 seconds. Hardness, chewiness, cohesiveness and springiness values were measured (Kiumarsi et al., 2019). This analysis was made in six replications.

2.2.5. Sensory Analysis

In sensory evaluation trials, breads were presented to panelists whole and sliced (thickness 15 mm), coded with three-digit random numbers. Panelists, consisting of 13 faculty members from Çukurova University's Department of Food Engineering, evaluated crust color, inner color, taste and odor, texture, chewiness and general acceptability parameters for gluten-free breads. Before the sensory panel, panelists were given training on the criteria they were asked to evaluate. A hedonic scale from 1 (very poor) to 5 (very good) was used for sensory analysis (Mudgil et al., 2016).

2.5. Statistical analysis

The data obtained in the study were evaluated using the SPSS 20 (SPSS Inc., USA) statistical program, ANOVA analysis of variance ($p<0.05$). Significant differences were determined using the Duncan multiple comparison test**.**

3.Results and discussions

3.1. Gluten-free Bread Analyses

3.1.1. Specific Volume Analysis

The specific volume values of the gluten-free bread samples produced with different hydrocolloid rates are given in Table 2. According to the analysis results, the specific volume values vary between 2.42 cm3 /g and 5.54 cm3 /g. Whilst the highest specific volume was obtained from gluten-free breads with 6% konjac gum (F3), the lowest value was determined in 2% CMC (F10). In our research, it was determined that the specific volume of gluten-free bread samples increased statistically with the addition of hydrocolloid (CG, X, HPCM and CMC) at different rates (2, 4, 6%) ($p<0.05$). The reason for this overall increase may be related to the structure of the hydrocolloids of high capasities on water holding, retaining moisture and stabilizing. Andresson et al. (2011) investigated that the effect of different hydrocolloids in the production of corn starch (100%) based gluten-free bread, in the research, HPMC, MC and guar gum were used at the rates of 2-2.5-3 % and they stated that 2% HPMC had the best gluten-free bread properties. Lazaridou et al. (2007) added XG and CMC at different rates (1% and 2%) in gluten-free bread formulation, the researchers emphasized that while no change was observed in the volume of breads with XG addition at the rate of 1%, there was an increase in the bread volume due to the increase in the hydrocolloid ratio. Chakraborty et al. (2020) reported that the effect of XG was the highest compared to other hydrocolloids in their study, in which they examined the effect of adding 2%-5% guar, XG, CMC, HPMC to corn flour-based gluten-free bread formulations on bread volume ($p<0.05$). In the literature, it has been determined that the effects of different hydrocolloids sources on gluten-free bread quality have been investigated. But; among these sources, studies on the effects of konjac gum on bread quality are limited. In our study, it was determined that konjac gum increased the specific volume of gluten-free breads compared to other hydrocolloids (X, HPMC, CMC) ($p<0.05$).

Laignier et al. (2021) reported in their research that konjac gum used in gluten-free product formulation improves the expansion ability of dough and provides volume increase by keeping the CO2 (g) in its structure during baking. Konjac gum provided the stability to the cells against various processing conditions and gas expansion by both creating an interface at the boundaries of the gas cells and increasing the specific volume of breads (Sutrisno et al. 2021). Due to its techno-functional properties, konjac gum plays an important role in increasing the specific volume of gluten-free bread.

Table 2. Specific volume, moisture and texture properties of gluten-free breads

Sample No	Specific Volume	Moisture	Hardness	Chewiness	Elasticity	Cohesiveness
F1	3.26±2.22^{f}	46.12±0.83$^{b.c}$	963.47±2.67^{d}	1208.21±3.33^{d}	0.99±0.01$^{d.e}$	0.72±0.01^{b}
F2	4.60±5.03^{b}	47.38±0.09^{b}	709.09±9.73^{e}	759.28±1.34^{f}	0.99±0.00$^{d.e}$	0.72±0.00^{b}
F3	5.54±4.66^{a}	47.52±0.78^{b}	570.85±9.14^{f}	752.25±16.22^{f}	1.02±0.02$^{c.d}$	0.73±0.01^{a}
F4	4.09±2.23^{e}	43.91±0.72^{d}	542.05±7.92^{f}	957.31±2.82^{e}	0.99±0.01$^{d.e}$	0.72±0.01^{b}
F5	4.27±1.19^{d}	44.87±0.93$^{c.d}$	1066.94±29.04^{c}	937.97±12.11^{e}	1.01±0.01$^{c.d}$	0.74±0.00^{a}
F6	4.42±2.20^{c}	46.89±1.38^{b}	1447.60±34.92^{b}	759.65±4.85^{f}	1.06±0.02^{c}	0.74±0.03^{a}
F7	2.99±3.47^{h}	46.15±1.27$^{b.c}$	957.03±5.12^{d}	2147.36±58.14^{b}	0.96±0.00^{e}	0.73±0.00^{a}
F8	3.18±1.34^{g}	47.99±1.18^{b}	1174.54±11.75^{c}	1237.48±30.73^{d}	0.99±0.00$^{d.e}$	0.74±0.05^{a}
F9	3.21±1.84^{g}	49.62±0.79^{a}	1497.39±55.24^{b}	723.34±28.63^{f}	0.99±0.00$^{d.e}$	0.74±0.03^{a}
F10	2.42±3.30^{j}	44.36±1.31^{d}	1052.06±3.92^{c}	1251.09±99.80^{d}	1.03±0.06$^{c.d}$	0.72±0.01^{b}
F11	2.71±2.43^{i}	46.62±0.86^{b}	1457.57±63.29^{b}	1516.37±37.32^{c}	1.26±0.00^{b}	0.72±0.00^{b}
F12	2.97±2.67^{h}	46.69±0.15^{b}	2569.02±3.29^{a}	2678.5±4.73^{a}	2.14±0.04^{a}	0.73±0.01^{a}

The differences between the values indicated with same letter in the same column in the table are significant in accordance with the 0.05 confidence limit.

3.1.2. Moisture Analysis

As seen from Table 2, the moisture content in gluten-free breads varied between 43.91% and 49.62%. In Table 2, it was determined that the gluten-free breads with the lowest and the highest moisture content were 2% X (F4) and 6% HPMC (F9), respectively. In our research, it was determined that the moisture content of the samples increased depending on the increase in the hydrocolloid concentration, regardless of the source of the hydrocolloids. The increase in moisture content is thought to be related to the constant dough consistency and the water holding capacity of hydrocolloids (Rosell et al., 2001; Guarda et al., 2004). Mohammadi et al. (2014) reported that the use of hydrocolloids in the gluten-free bread formulations due to their high water holding capacity causes an increase in the amount of moisture in the bread. Gambus et al (2007) reported that the addition of XG at increasing concentrations to corn starch-potato starch based gluten-free breads significantly increased the moisture content of the samples compared to the control group ($p<0.05$). This was explained by the fact that XG was able to stabilize starch gels, thus reducing starch retrogradation and maintaining the moisture content of the samples (Brennan et al., 2004). Calle et al (2020) added HPMC, XG and guar gum into the gluten-free product formulation. The moisture value of the samples was determined as 58.74% in the application of HPMC use only and 58.80% in the equal use of HPMC, XG and guar gum, and the results were found to be statistically significant ($p<0.05$). Maghaydah et al (2013) investigated the effect of using equal proportions of XG, pectin and carrageenan on the moisture content of rice and corn flour added gluten-free breads and the researchers found the moisture values of the samples as 1% XG-1% carrageenan 43.09%, 1% XG-1% pectin 43.31% and 1% carrageenan-1% pectin 40.66% and reported that they found a significant difference compared to the control group ($p<0.05$) so, this difference has been attributed to the hydrophilic nature of the hydrocolloids. As seen above; our research is in line with the other corresponding researches and the use of hydrocolloid caused an increase in the moisture content of the gluten-free breads.

3.1.3. Texture Analysis

When the texture analysis results of gluten-free breads were examined, it was seen that the lowest hardness value was determined in the bread groups with 6% konjac gum (F3) addition, while the highest hardness value was determined in the bread groups with 6% CMC addition (F12). When the samples were examined among themselves, it was determined that the hardness values increased with the increase in the hydrocolloid concentration (Table 2). Naji-Tabasi and Mohebbi (2015) investigated the effect of using hydrocolloid in gluten-free formulation in terms of bread quality and they reported that XG reduces the hardness value of breads and delays the staling during storage due to its improved moisture retention ability. It has been reported by researchers that the addition of hydrocolloid into the gluten-free bread formulation reduces the hardness of the bread by increasing the amount of water in the dough and consequently the moisture content of the bread due to the high water holding capacity of hydrocolloids (Zhao et al., 2021). According to Renzetti and Rosell (2016), HPCM and XG are frequently used as gluten substitutes in different formulations in gluten-free bread formulation. During cooking, these water-soluble polymers with high surface activity maintain homogeneity and stability and do not cause any negative effects on the textural parameters of the final product. In general, they improve the quality of gluten-free breads and contribute to the development of products with high specific volume and low hardness (Mccarthy et al., 2005; Djordjevic et al., 2018). As for the chewiness parameter, it was determined that the chewiness value decreased statistically as the hydrocolloid usage rate increased in the gluten-free bread groups except for CMC (2%-6%) ($p<0.05$). Liu et al. (2018) examined the effects of 0.5%, 1%, 2% usage rates of CMC, XG and HPMC on the chewiness of gluten-free breads and stated that the addition of XG reduced the chewiness, while HPMC did not affect it and the use of CMC increased the chewiness value. Similarly, Patil and Arya (2019) reported that the use of increasing concentrations of hydrocolloid (XG, guar gum) reduces the chewiness of gluten-free breads and this is due to the ionic interactions detected between proteins and hydrocolloids that provide the formation of hydrophilic complexes (Rosell et al., 2007). The elasticity data of the samples varied in the range of 0.96 N-2.14 N (Table 2), it was determined that the elasticity values increased with increasing usage rates regardless of the type of hydrocolloids ($p<0.05$). Similarly, Mohammadi (2014), Encina- Zelada (2018) and Bravo-Nunez (2019) reported that different types of hydrocolloids used as gluten substitutes increase the elasticity of breads. As seen in Table 2, it was determined that the cohesiveness values of the gluten-free breads varied between 0.72 and 0.73 and the cohesiveness increased significantly as the hydrocolloid concentration in the product formulation increased ($p<0.05$). Belorio and Gomez (2020) added 2% HPMC, XG and psyllium to corn starch-based gluten-free breads and determined the cohesiveness values as 1.011, 0.964 and 0.974, respectively. While no significant difference was observed between XG and psyllium added breads, a difference was observed in HPMC added breads ($p>0.05$). This was associated with the significant effect of hydrocolloids on the cohesiveness of starches. In addition, the change in HPMC gels after firing was also revealed as the reason for the high cohesion. Bravo-Nunez (2019) determined the cohesiveness values of 2% HPMC-added gluten-free breads on different storage days (1st and 5th), respectively, as 0.47 and 0.66, and reported a significant difference between the values. ($p<0.05$). The cohesion values determined in the literature are within the ranges determined in our research.

3.1.4. Color Analysis

The L* parameter, which expresses the lightness of the crust values of the breads, varies between 83.78-58.99 (Table 3). When the crust color values of gluten-free breads were examined, an increase was observed in the lightness values of the samples with konjac gum, HPMC and CMC added with the increase in the use of hydrocolloid. This increase in L* value was associated with the reduction of Maillard reaction rate by affecting the water distribution of the hydrocolloid added into the product formulation (Torbica et al., 2010). Sciarini et al. (2010) investigated the effects of XG and guar gum on gluten-free breads produced using rice flour and corn starch and it has been observed that the use of both gums separately and in combination caused the darkest the color of the bread crust. Marco et al. (2008) examined the effect of HPMC which is used at different rates as a water retainer in rice flour-based gluten-free breads and it was determined that the breads using 4% had the highest brightness value on the crust. Belorio and Gomez (2020) reported that the addition of 2% HPMC into gluten-free bread formulation caused a reduction in L* value and it was reported by the researchers that the detected decrease was caused by the Maillard reaction and sugar caramelization. In our research, crust a* value of breads varied between 0.21 (2% HPMC) - 8.81 (6% Konjac) and b* value ranged from 14.90 (4% XG) to 32.85 (4% CMC). The increases detected are supported by previous researches that are associated with the source, type, and increased concentration of the hydrocolloids used in the product composition (Gonzales et al., 2010). Kringel et al (2017) determined the a* value of the samples with 2% methylcellulose added to the rice flour-based samples in gluten-free bread production as 4.02. Similarly, when Mancebo et al. (2017) added 2% HPMC to the bread formulation, they observed a significant increase in a* value compared to the control group and reported that the crust color darkened. Martinez and Gomez (2017) found the crust b* value to be 19.32 as a result of the addition of HPMC as a hydrocolloid at a usage rate of 2.2% in corn starch-based gluten-free bread production, the crust b* value of 26.08 as a result of the addition of 2% CMC to rice flour-based gluten-free breads, Kringle et al. (2017) and Paciulli et al. (2016) investigated the effects of 2% HPMC and 2% guar gum added on the color values of corn starch-based gluten-free breads and they reported that the addition of hydrocolloids increased the b* value ($p<0.05$).

Table 3. Instrumental color properties of gluten-free bread (n=3)

Sample Number	**Hunter Color Values**		
	L*	**a***	**b***
F1	58.99 ± 0.15^{ı}	2.17 ± 0.31^{g}	$18.65\pm0.84^{c.d}$
F2	74.61 ± 0.69^{e}	$3.50\pm1.12^{b.c}$	$29.68\pm1.49^{a.b}$
F3	83.75 ± 0.54^{a}	8.81 ± 0.23^{a}	$25.41\pm2.78^{a.b.c}$
F4	76.92 ± 0.56^{d}	$1.40\pm0.35^{f.g}$	$22.67\pm3.04^{b.c.d}$
F5	70.54 ± 0.56^{f}	2.65 ± 0.40^{c}	14.90 ± 3.69^{d}
F6	62.97 ± 0.51^{h}	4.53 ± 2.28^{b}	$31.21\pm0.55^{a.b}$
F7	$81.40\pm0.74^{b.c}$	$0.21\pm0.09^{e.f}$	16.45 ± 0.28^{d}
F8	81.76 ± 0.19^{c}	0.65 ± 0.91^{d}	$19.62\pm12.6^{c.d}$
F9	82.44 ± 0.35^{b}	$1.54\pm0.56^{f.g}$	$25.15\pm0.65^{a.b.c}$
F10	68.60 ± 0.73^{g}	2.98 ± 0.18^{c}	$28.38\pm1.64^{a.b}$
F11	68.99 ± 0.80^{g}	$3.60\pm0.18^{b.c}$	32.85 ± 0.38^{a}
F12	70.58 ± 0.35^{f}	$3.20\pm0.17^{b.c}$	$31.04\pm0.66^{a.b}$

The differences between the values indicated with same letter in the same column in the table are significant in accordance with the 0.05 confidence limit.

3.1.5. Sensory Analysis

Sensory evaluation scores of the effects of different hydrocolloids in different ratios on gluten-free bread quality are given in Table 4. Appearance plays an important role in consumers' preference for the bakery products. In our research, an increase in crust color was observed due to the increase in hydrocolloid concentrations. When the sensory analysis data of hydrocolloids (Konjac gum, XG, HPMC and CMC) were compared among themselves, a statistical difference was observed ($p<0.05$). It has been observed that the breads with the addition of Konjac gum are mostly liked by the consumers in terms of crust color. When bread crumb color, taste and odor parameters were examined, similar results were obtained with crust color. When evaluated in terms of general acceptability, konjac gum added gluten-free breads received the highest score by the panelists, as in other parameters. The use of Konjac gum in bakery products improves the quality characteristics of the final product by improving its sensory and physicochemical properties (Sutrisno et al., 2021).

Table 4. Sensory properties of gluten-free breads

Sample Number	Sensory Properties					
	Crust Color	**Crumb Color**	**Taste**	**Odor**	**Chewiness**	**Overall Acceptability**
F1	3.48±0.36[a]	3.22±0.01[b]	3.21±0.01[c.d]	3.36±0.01[a]	3.22±0.01[a]	4.03±0.01[a]
F2	3.50±0.1[a]	3.27±0.01[b]	3.22±0.01[b]	3.39±0.01[a]	3.27±0.01[a]	4.04±0.01[a]
F3	3.50±0.1[a]	3.37±0.01[b]	3.31±0.01[a]	3.46±0.01[a]	3.40±0.01[a]	4.11±0.01[a]
F4	3.11±0.01[b]	3.11±0.01[b]	3.16±0.01[d]	3.30±0.00[a]	3.11±0.01[a.b]	3.79±0.00[a]
F5	3.13±0.02[b]	3.13±0.01[b]	3.18±00[c.d]	3.33±0.00[a]	3.13±0.01[a.b]	3.79±0.03[a]
F6	3.15±0.04[b]	3.17±00[b]	3.20±0.01[c.d]	3.41±0.01[a]	3.17±0.01[a.b]	3.82±0.02[a]
F7	2.98±0.01[c]	2.54±00[b]	2.32±0.02[f]	2.65±0.01[b]	2.54±0.00[c]	2.17±0.01[b]
F8	2.99±0.01[c]	2.42±0.02[b]	2.10±0.01[h]	2.39±0.01[b]	2.42±0.02[c]	2.10±0.01[b]
F9	2.99±0.01[c]	2.28±00[b]	2.08±0.01[h]	2.10±0.01[b]	2.28±0.00[c]	2.04±00[b]
F10	2.80±0.01[c.d]	3.01±0.01[b]	2.65±0.09[e]	3.01±0.01[a]	3.01±0.01[c]	3.61±0.01[a]
F11	2.82±0.02[c.d]	3.04±00[b]	2.31±0.01[f]	3.02±0.01[a]	3.04±0.00[c]	3.66±0.00[a]
F12	2.81±0.01[c.d]	3.07±0.01[b]	2.16±0.01[g]	3.04±0.01[a]	3.07±0.01[c]	3.85±0.00[a]

The differences between the values indicated with same letter in the same column in the table are significant in accordance with the 0.05 confidence limit.

4. Conclusions

Hydrocolloids are an indispensable part of the gluten-free product industry. Especially in the bakery industry, the interest in these ingredients is constantly increasing due to their properties such as increasing the volume of the products, improving the texture and delaying staling and increasing the shelf life in gluten-free product formulations to which they are added. In this research, the effects of adding different hydrocolloids (Konjac gum, XG, HPMC, and CMC) at different rates (2, 4, 6%) into the combination of corn starch (70%) and gluten-free wheat starch (30%) on gluten-free bread quality were investigated. When the analyzes were examined, it was determined that konjac gum was more effective in increasing the moisture due to increasing concentrations and improving the textural properties (especially hardness) of the samples due to gluten deprivation. When gluten-free breads were evaluated in terms of sensory, it was determined that the group that was most liked by the panelists and provided product development was F3 (Konjac gum 6%). When evaluated in general, it has been determined that konjac gum is the best hydrocolloid for developing gluten-free breads and can be used for the production of high quality products that can be accepted by the consumers. Konjac gum has been used in the food industry of many countries in the recent years due to its high level of glucomannan content and the wide ability to cultivate the plant from which it is obtained. However, when the literature is examined, it has been determined in our research that the use of konjac gum as a hydrocolloid in gluten-free bread composition is limited. In this context, it is thought that our study is pioneering and that konjac gum can be used as a different hydrocolloid alternative in many gluten-free products..

5.References

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