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(Original Article)

Effect of Different Gums and Water Content on The Physical, Textural and Sensory Properties of Gluten-free Pan Bread

Abdalla S. Abdel-Gawad; Mokhless A.M. Abd El-Rahman; Safaa A.M. Limam; Asmaa M. Abdel-Rahman and Abdelfatah K. Ali

Food Science and Technology Department, Faculty of Agriculture, Assiut University, Egypt.

*Corresponding author email: abdelfatahkotb@agr.aun.edu.eg
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Abstract

This investigation was carried out to study the effect of three types of gums namely: Arabic gum (AG), guar gum (GG) and xanthan gum (XG) as well as different water amounts on the physical, sensory, and textural properties of gluten-free pan bread (GFPB). The gluten-free composite flour as base formulation consists of 47.5g rice flour, 47.5g cornstarch, and 5g skim milk powder. Firstly, AG, GG and XG were tested, separately, with constant concentration (2g) and at three different amounts of water (90, 100, and 110 ml). The results indicated that the use of XG significantly increase the specific volume, High/Width ratio and yield of GFPB whereas the baking loss decrease with increasing of water amount used. However, these parameters were diminished in the case of AG and GG by using high amount of water (110 ml). The texture profile analysis (TPA) data indicated that hardness and cohesiveness decreased, while springiness and resilience increased with increasing the water amount. Secondly, three different concentrations 2, 3 and 4g of each gum, separately, were tested with a constant amount of water (110 ml). The obtained results showed that the increase of AG or GG concentration led to enhancement of GFPB specific volume. In contrast, the increase of XG from 2 to 4g with the water amount of 110 ml caused decrease in the specific volume. The TPA data showed that higher doses of gum tended to produce breads with higher hardness, gumminess, chewiness and lower springiness. Moreover, the increasing in water amount resulted in softer, spongier and more resilient crumbs. Good physical, textural and sensory acceptable was obtained with formulation supplemented with 2g XG and 110 ml water.

Keywords: *Gluten-free bread, Arabic gum, Guar, Xanthan, Pan bread.*

Introduction

Celiac disease is a very common chronic disease which affects many people all over the world. Celiac disease is considered a genetically transmitted disease (Kaukinen *et al*., 2002). People who suffer from this disease are sensitive to gluten, which is a protein found in wheat flour, (Guandalini and Discepolo, 2022). When a gluten molecule passes into the patient's digestive tract, inflammation of the intestinal mucosa occurs, simultaneously leading to malabsorption in the small

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intestine (Rajput *et al*., 2022). Due to the genetic nature of this disease, scientists have not been able to find a cure for it and following a gluten-free diet has become the ideal solution for Celiac disease patients (Mostafa, 2014).

Wheat is the cornerstone in the most of food industries, especially in Middle East countries (Ferreira *et al*., 2021). Recently, most of researchers focused on replacing wheat flour with other types of gluten-free flour (like rice flour, corn starch, and legume flour) in the food industry to provide healthy gluten-free products, which could be wheat-like products and satisfies the expectations of celiac disease patients (Gao *et al*., 2018).

Bread is considered one of the most widespread bakery products, which were used daily worldwide (Roman *et al*., 2019). Therefore, much of the research is geared towards manufacturing of different types of gluten-free bread. Whereas the absence of gluten in this type of bread has become a controversial issue because lacking a gluten matrix resulted in lower technological quality; low volume, high crumb hardness, and high staling rate; (Pasqualone *et al*., 2010). The gluten plays an important role in the formation of cohesive and elastic dough and works to raise dough by retaining gas during the fermentation process, hence resulting in bread with a spongy texture (Melini *et al*., 2017). Therefore, many scientific efforts have been attempted to solve the obstacles of manufacturing gluten-free bread by using some additives that may compensate for the absence of gluten and give bread its spongy texture (El Khoury *et al*., 2018). As an additive, hydrocolloids were used widely in the manufacturing of gluten-free bread, due to their high ability to modify dough handling, rheology, and keeping qualities of bread, as well as retain gas during fermentation (Williams and Phillips, 2021); therefore, they are often used as gluten substitutes during making gluten-free bread.

In this concept, Yaseen *et al*., (2010) found that the addition of Arabic gum and pectin during making wheat-corn pan bread increased volume, specific volume, enhanced sensory characteristics, and retard the staling of bread. Moreover, different studies added Guar gum to rice bread and found a noticeable enhancement in texture softening of bread samples during storage time (Alizadeh-Bahaabadi *et al*., 2022; Mohammadi *et al*., 2015). In the same trend, Moradi *et al*., (2021) reported that the addition of guar gum during manufacturing of potato bread increased the resistance of the dough, created a gluten network, and improved dough texture. Furthermore, Encina-Zelada (2018) mentioned that the addition of small amounts of xanthan gum and a high amount of water in making of gluten-free dough, formulated with rice flour and maize flour, led to increase in the specific volume, decreasing the firmness and improving the color indices of gluten-free bread. These findings refer to the importance of hydrocolloids as well as water content during making gluten-free bread. The water content is considered one of the most effective factors in manufacturing gluten-free bread (De La Hera *et al*., 2014).

Many previous studies focused on manufacturing of gluten-free bread by using several types of gums with different concentrations, while others used different water amounts during making of gluten-free dough (Dizlek and Ozer, 2016); (De La Hera *et al*., 2014). However, there is a need to find the proper combination between gum concentration and water amount during making of gluten-free bread. Therefore, this study was carried out to define the perfect combinations between concentration of each Arabic gum, guar and xanthan gums and water amount that required for preparation of good quality gluten-free bread. In addition, study the effect of these treatments on the physical textural and sensory properties of gluten-free bread.

Materials and Methods

Materials

AG and GG were obtained from El-Gomhoria Chemicals Company at Assiut, whereas XG was obtained from Alpha Chemica, Indian company. Rice grains, corn starch and skim milk powder used in bread were purchased from the local market in Assiut Governorate, Egypt.

Methods

Preparation of rice flour

Rice grains were milled into fine powder using a Laboratory mill from Kenwood Company and sieved to fine flour.

Preparation of gluten-free composite flour

Gluten-free composite flour used in this study was consisted of 47.5g rice flour, 47.5g corn starch and 5g skim milk powder.

Preparation of GFPB

The base formula consists of 100g gluten-free composite flour, 3g fat, 6g sugar, 1g salt and 1g Baker's yeast. The concentration of any gum and water amount were variable as shown in Table 1 and 2. Gluten-free pan bread were prepared using a straight-dough method according to Abdel-Gawad *et. al*., (2018). After mixing the components, dough sample was placed in metal pan (8 cm length x 5 cm Width and 6.5 cm Height) and put into a fermenter at 30ºC for 35 min. Finally, the leavened dough was baked in an electric oven at 220ºC for 30 min, then cooled for two hours at room temperature on metal racks.

Table 1. Gluten-Free Pan bread (GFPB) formulated with different levels of water.

Code of Treatments	AG (g)	GG (g)	XG (g)	Water (ml)	Base Formula
A	2	-	-	90	100 g Gluten-free composite flour + 3%fat +6% sugar + 1% salt + 1% Baker's yeast
B	-	2	-	90	
C	-	-	2	90	
D	2	-	-	100	
E	-	2	-	100	
F	-	-	2	100	
G	2	-	-	110	
H	-	2	-	110	
I	-	-	2	110	

Two experiments were designed each consisted of nine different treatments; the first to study the effect of different water amounts (Table 1) and the second to study the gum concentrations (Table 2) on the physical, textural and sensory properties of GFPB.

Table 2. Gluten-Free Pan bread (GFPB) formulated with different concentrations of gums.

Code of Treatments	AG (g)	GG (g)	XG (g)	Water (ml)	Base Formula
K	2	-	-	110	**100 g Gluten-free composite flour + 3%fat +6% sugar + 1% salt + 1% Baker's yeast**
L	-	2	-	110	
M	-	-	2	110	
N	3	-	-	110	
O	-	3	-	110	
P	-	-	3	110	
R	4	-	-	110	
S	-	4	-	110	
T	-	-	4	110	

Physical properties

Dough yield: Dough yield was estimated for all treatments as described by (Movahed *et al.* 2012) and according to the following equation: P = (W1 / W2) ×100; where, P is dough yield, W1 is dough weight (flour + all additives) and W2 is flour weight.

Bread yield: After cooling for 2 hrs., the bread samples were weighed to calculate bread yield values according to Movahed *et al*., (2012), and based on the following equation: P1 = (W3 /W2) ×100; where, P1 is bread yield, W3 is bread weight and W2 is flour weight.

Bread volume: The volume of GFPB as cm^3 was determined by rapeseed displacement method as described by (A.A.C.C. 2000).

Specific volumes of the bread samples were calculated by dividing volume (cm3) by weight (g) of bread, as described by Keskin *et al*. (2004).

Baking loss was calculated as described by Bhay and Gupta (2015) according to the following equation:

$$\text{Baking loss} = \frac{\text{Initial loaf weight before baking} - \text{The loaf weight after 2 hrs. of baking}}{\text{initial loaf weight before baking}} \times 100$$

Texture profile analysis (TPA) of GFPB

TPA of GFPB crumbs was performed using a texture analyzer (Brookfield, CT3, U.S.A.) equipped with a 5-gram force load cell at the compression rate of 2 mm/s. A sample of bread crumb with a height of 2.5 cm was cut from the middle of the loaf and removed from the crust. The samples were compressed in the center to 40% deformation by a stainless-steel cylinder probe with a diameter of 3.5 cm in two-cycle with a 4s delay. The resulting hardness at the first cycle expressed as bread staling. Whereas cohesiveness (area under the second peak divided by area under the first peak), springiness (distance during the second compression divided by distance during the first compression), and chewiness (hardness × cohesiveness × springiness) of the crumbs were evaluated by Texture Pro CT 1.9.35 software and used as indicators of textural analysis of bread crumb.

Sensory evaluation of GFPB

The sensory characteristics of fresh GFPB samples after two hrs of baking were evaluated by 10 trained panelists from the Food Science and technology Department, Assiut University. The GFPB samples were evaluated as described by Stolman and Lundgren (1987) with some modifications for general appearance (20 points), crust color (15 points), crumb color (15 points), crumb cell distribution (15 points), flavor (10 points), taste (10 points), and freshness (15 points) to have 100 points as total.

Statistical analysis

The obtained data were subjected to the statistical analysis of complete randomized design according to Gomez and Gomez (1984); by using CoStat6.303. The significant means of any trait studied were compared using L.S.D at 5% probability level according to Waller and Duncan (1969).

Results and Discussion

Effect of gum type and water content on the physical properties of GFPB

Gum type and water content used in making of GFPB affected the physical properties of bread as shown in Table 3. Addition 2g of any gum and 90 ml water to a base formula resulted in different physical characteristics of GFPB depending on the type of gum. The used of GG or XG resulted higher specific volume than AG. Moreover, GG recorded the highest yield of GFPB indicating its high-water binding capacity and gas retaining of dough at addition of 2g gum and 90 ml water. The XG showed the highest High/Width ratio of bread and lowest baking loss (Table 3) indicating that XG increased batter consistency and water binding capacity (Aboulnaga *et al.*, 2018).

Table 3. Physical Characteristics of Gluten-Free Pan Bread

Treatments	Bread Weight (g)	Volume (cm^3)	Specific Volume (cm^3/g)	Hight/ Width ratio	Yield of bread %	Dough yield %	Baking loss %
A	$174.57^{g} \pm 0.39$	$327.97^{h} \pm 0.44$	$1.85^{e} \pm 0.02$	$1.17^{f} \pm 0.00$	$184.00^{g} \pm 0.27$	$199.12^{i} \pm 0.33$	$15.54^{c} \pm 0.16$
B	$177.77^{f} \pm 0.16$	$365.37^{c} \pm 0.36$	$2.05^{bc} \pm 0.01$	$1.26^{d} \pm 0.01$	$187.04^{f} \pm 0.22$	$211.73^{g} \pm 0.16$	$14.18^{de} \pm 0.05$
C	$174.84^{g} \pm 0.29$	$351.54^{f} \pm 0.31$	$2.01^{c} \pm 0.00$	$1.36^{c} \pm 0.01$	$184.08^{g} \pm 0.33$	$213.56^{f} \pm 0.28$	$13.95^{ef} \pm 0.05$
D	$179.66^{e} \pm 0.14$	$344.92^{g} \pm 0.28$	$1.92^{d} \pm 0.00$	$1.24^{e} \pm 0.00$	$189.00^{e} \pm 0.22$	$208.78^{h} \pm 0.27$	$17.30^{b} \pm 0.02$
E	$182.69^{d} \pm 0.09$	$358.34^{d} \pm 0.38$	$1.96^{d} \pm 0.00$	$1.25^{de} \pm 0.01$	$191.81^{d} \pm 0.38$	$217.49^{e} \pm 0.42$	$14.36^{d} \pm 0.06$
F	$180.48^{e} \pm 0.48$	$383.29^{b} \pm 0.41$	$2.07^{b} \pm 0.03$	$1.50^{b} \pm 0.00$	$189.91^{e} \pm 0.55$	$221.17^{d} \pm 0.51$	$13.82^{f} \pm 0.13$
G	$185.59^{c} \pm 0.22$	$327.26^{h} \pm 0.48$	$1.76^{f} \pm 0.00$	$1.09^{g} \pm 0.00$	$195.21^{c} \pm 0.32$	$222.54^{c} \pm 0.30$	$19.40^{a} \pm 0.12$
H	$191.84^{a} \pm 0.20$	$355.42^{e} \pm 0.34$	$1.83^{e} \pm 0.01$	$1.24^{e} \pm 0.00$	$201.57^{a} \pm 0.41$	$227.30^{b} \pm 0.29$	$14.37^{d} \pm 0.11$
I	$188.63^{b} \pm 0.32$	$420.55^{a} \pm 0.26$	$2.23^{a} \pm 0.00$	$1.57^{a} \pm 0.00$	$198.21^{b} \pm 0.54$	$231.22^{a} \pm 0.57$	$14.11^{de} \pm 0.08$
L.S.D. (0.05)	0.835	1.1	0.04	0.02	1.13	1.09	0.29
F Test	***	***	***	***	***	***	***

Means ±SD (standard deviation) with different small letters in the same column differ significantly at $p<0.05$.

Furthermore, Encina-Zelada *et al*., (2018) found that adding xanthan gum in the manufacturing of Gluten-free bread led to decrease baking loss values. The baking loss value was the highest in the case of AG which might be due to its weak holding capacity of water and produce lower batter consistency (Hussain *et al.* 2022). On the other hand, the increase of water amount from 90 to 100 ml using 2g of XG led to increasing in specific volume, high/width ratio and bread yield with decreasing the baking loss when compared with AG and GG (Table 3). The impact of different hydrocolloids on the characteristics of dough and bread quality is known to be highly dependent on raw materials, the nature and quantity of hydrocolloids (Mir *et al.,* 2016). Both, XG and water content affected the rheology of gluten free batter, as increased the batter stickiness (Zelada *et al.,* 2018). XG was the hydrocolloid that most improved gluten-free-bread quality and the formulations with high water content, batter consistency is strongly associated with bread volume (Pe´rez *et al.,* 2010). When the water increased to 110 ml the specific volume of GFPB decreased in the case of AG and GG. Excess water with weak hydrocolloid caused overexpansion during baking and resulted in collapsed loaves (Han *et al*., 2012); which could explain the decrease in specific volume in the case of AG and GG samples with the increase of water level to 110 ml.

It is noteworthy that the XG recorded the highest specific volume, high/width ratio and bread yield as well as the lowest baking loss value. Sciarini *et al*., (2010) found that XG was the better gum for the quality of gluten-free bread rather than carrageenan alginate, carboxymethylcellulose and gelatin. The increase of water amount to 110 ml with 2g gum resulted in enhanced specific volume, high/width ratio in the case of XG followed by GG and the least AG. Finally, it can be observed that the physical properties of GFPB are affected by the type of gum used and water amount required for preparing gluten-free batter.

Effect of water content on TPA parameters of GFPB

The evaluation of texture properties of bread crumbs is necessary for its quality assurance and consumers' acceptability. Besides, it is important for assessing the effects of addition of various dough ingredients and processing conditions. The values of TPA (including hardness, cohesiveness, springiness, gumminess, chewiness, and resilience) of GFPB crumbs baked with 2g AG, GG or XG as well as at different amounts of water are shown in Fig. 1. Hardness represents the maximum force necessary to cause a deformation in bread samples, and usually taken at the first cycle which reflects bread staling. Hardness results ranged between 3.41 to 9.03 N, similar to study of Collar *et al.,* (2014) with bread enriched with cereals, pseudocereals and vegetables and similar to the study of Koletta *et al.* (2014) in which white flour bread has been replaced by rye whole meal flour and/or whole barley flour and/or oat bran. In addition, the results in Fig. 1 showed that increasing of water levels from 90 to 110 ml had a significant impact on decreasing of hardness values of GFPB in all tested gums, which imply a decline in staling rate. These results are in good agreement with those obtained by Encina-Zelada *et al*., (2018), Maleki and Milani, (2014) and Cauvain and Young (2007). Furthermore, Stauffer (2000) reported that the increase in moisture content of bread caused an increase in shelf life by alter the rate of bread firming. The results in Fig. 1 showed also that the decrease in hardness with increasing the water amount was evident by using XG than the AG and GG.

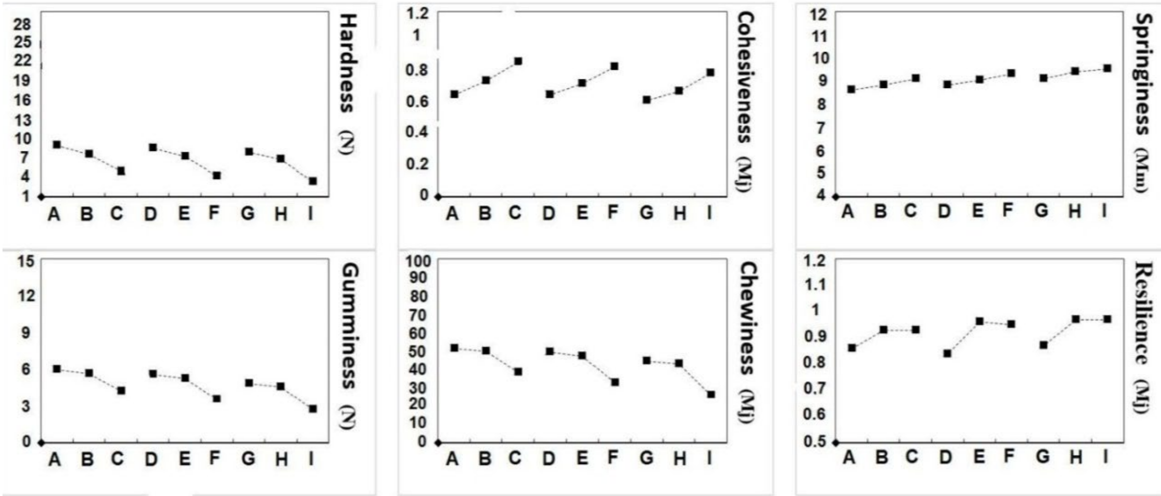

Fig1.Effect of water amount on TPA Parameters of GFPB baked with 2% of different gums.

Cohesiveness quantifies the internal resistance of food structure (Nishinari *et al*., 2013), and represents the ability of a material to stick to itself. Scheuer *et al.,* (2016) described cohesiveness is as elastic behavior. The Results showed the cohesiveness value was the best in bread baked by XG followed by GG and the least AG (Fig. 1). The increasing of water content used for preparation of dough from 90 to 110 ml led to simple drop in the cohesiveness values of GFPB (Fig.1). Springiness values express the softness of bread, and are the opposite of the hardness (Rosenthal, 2010). Springiness is associated with a fresh and elastic product; therefore, high quality bread will be related to high springiness values. The obtained data in Fig. 1 showed the enhancement of springiness values with the increase of water level. Likewise, De La Hera *et al*., (2014) reported that the increase in water level during gluten-free bread making resulted in more springiness value of bread. Gumminess is determined by hardness multiplied by cohesiveness (Nishinari *et al*., 2013). The chewiness is determined by gumminess multiplied by springiness and represents the amount of energy needed to disintegrate a food for swallowing (Mau *et al*., 2020). It can be observed from Fig. 1 that gumminess and chewiness values of GFPB made with 2g of different types of gums were decreased with the increasing of water amount used for bread making. These results are in good agreement with that reported by Amin *et al*., (2019).

Resilience indicates the ability of a material to return to its original shape after stressing and considered one of the most important TPA parameters which has a great role in bread acceptable (Cornejo and Rosell 2015). The resilience values of GFPB made with different types of gums were slightly affected by increasing of water level and ranging from 0.84 to 0.97. Similar result was found by De La Hera *et al*., (2014). However, Encina-Zelada *et al*., (2018) found that increasing water content from 90 to 110 ml led to an increase in resilience value from 0.188 to 0.217. Generally, the results in Fig. 1 for TPA parameters indicated that in formulations with 2g XG and high water content (110 ml), textural properties of studied GFPB substantial improved comparing with other gums. The improvement was in hardness springiness, gumminess, and chewiness values. XG treatments recorded the highest values of freshness (lowest hardness) followed by GG, whereas AG samples recorded the lowest values (highest hardness). The positive effect of XG on bread freshness may be attributed to the ability of XG in binding more water and increased the viscosity of dough (Aboulnaga *et al*., 2018).

Effect of gum concentration on specific volume and TPA parameters of GFPB

The effect of the hydrocolloid concentration on the specific volume of GFPB is shown in Fig.2. It has been observed that increasing AG or GG concentration from 2, to 4g led to an increase in the specific volume of GFPB. On the contrary, the increase in the XG concentration led to a decrease the Specific volume, which may be attributed to the high viscosity of XG which led to a weak ability of gas to expand inside the dough. These results are in good agreement with that reported by Chochkov *et al*., (2019) who referred to the negative impact of xanthan gum quantity increase on bread volume. Likewise, Mandala (2005) reported that Xanthan gum decreased loaf volume depending on the dose.

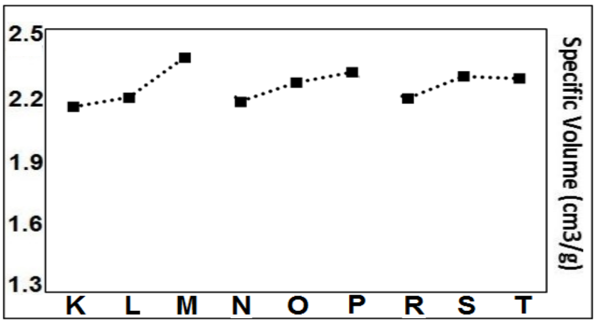

Fig.2. Effect of gum concentration on specific Volume of GFPB

The values of TPA parameters for GFPB samples baked with different gums concentrations (2, 3 and 4g) with 110 ml water are shown in Fig.3. The results indicated that the increase in concentration of used gums from 2 to 4g led to enhancement of hardness values. Despite the fact that hydrocolloids required to building up network structures responsible for bread quality and to mimic the viscoelastic properties of gluten (Mir *et al*., 2016), but the increase of gum dose produce very cohesive dough which plays important role in increasing the hardness of bread (Zoghi *et al*., 2021). Moreover, Sidhu and Bawa (2004) mentioned that increasing the acacia gum concentration during making wheat bread led to an increase in firmness of bread. The effect of gum concentration on hardiness indicated that the increase of XG dose has a slight impact on hardness of bread comparing to AG and GG. Cohesiveness values of GFPB increased by increment of gum concentration (Fig. 3), and this may be due to the high ability of gums to bind the flour particles with each other and thus increase the cohesiveness of the bread.

Springiness values of GFPB were decreased as the gum content increase in bread formula (Fig. 3). The obtained results are consistent with previous study reported by Hamdani *et al*., (2020) how found a decrease in springiness values with the enhancement of gum concentration in bread formula. The gumminess and chewiness values of GFPB showed increasing as the gum concentration in bread formula increased (Fig.3). Amin *et al*., (2019) reported that the gumminess values of bread made from *Bruguiera gymnorrhiza* and wheat flour mixtures, increased by adding hydrocolloids. On the Other hand, resilience of GFPB was increased the by AG content increase in BFPB formula, while increasing of GG or XG dose decreased resilience values. Salehi and Kashaninejad (2021) reported an increase in resilience of carrot sponge cake with increasing GG dose. In contrary, Encina-Zelada *et al*., (2019) found that increasing the dose of guar gum led to improve resilience values of gluten-free bread.

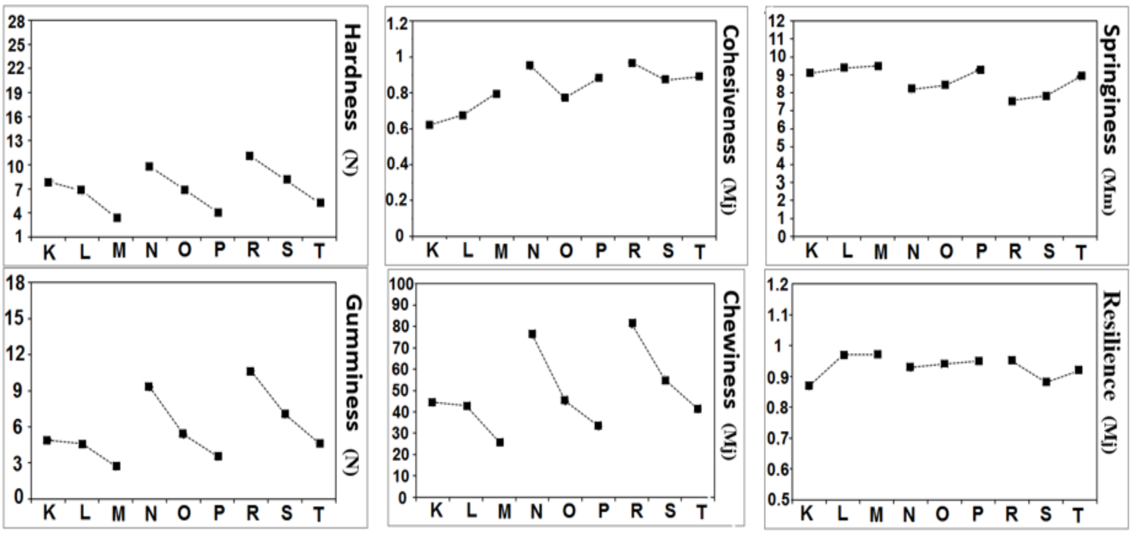

Fig 3. Effect of gum concentration on TPA Parameters of GFPB baked with 110% water.

Effect of Water amount used for baking on Sensory evaluation of GFPB

Sensory evaluation of GFPB baked by different water levels are presented in Table 4. The obtained results showed that there are high significant differences ($p < 0.05$) in all sensory tested parameters between GFPB baked by 90 ml sample C and 110 ml water Sample I. General appearance scores of GFPB ranged from 16.45 for sample C to 19.23 for sample I as shown clear in Fig.4. These results indicated that using high water amount in gluten- free bread making led to improve the general appearance in the presence of XG and this could be producing high volume bread which considers the main factor that impacts consumer acceptability (Mariotti *et al*., 2014). Besides, colors of crumb and crust were slightly positive improved by increasing water from 90 to 110 ml. The scores of pores distribution of GFPB crumb showed significant increment ($p < 0.05$) by increased water level (Table 4). McCarthy *et al*., (2005) reported that increasing of water amount used in baking led to high bread volume and more pores distribution in crumb. Moreover, Różyło *et al*., (2015). Stated that high water level can play an important role in decreasing batter viscosity which allows gas to extend and gives more pores distribution in the crumb during fermentation.

In addition, it has been noted that assessors gave higher taste and flavor scores for bread sample I which baked by 110 ml water as compared to samples C and F (Table 4) which may be due to increasing the water amount reduced the sharpness of the XG taste which was not desirable by assessors. Freshness is considered one of the important parameters in bread sensory analysis which indicates the softness of bread. Freshness score increased significantly ($p < 0.05$) as the water-added level increased. This could be due to the influence of high water addition on increasing sponginess, softness, and pores distribution of bread crumb (Fadda *et al*., 2014). Total sensory scoring (Table 4) indicated that sample C baked by 90 ml water gained the lowest total score (85.61), whereas the sample I (baked by 110 ml water) had the highest score (94.91). It has been noted that the increase of acceptability to GFPB are associated with the increase in water amount used during bread making. In this concept, Różyło *et al*., (2015) mentioned that using high water levels in manufacturing corn bread gave good quality bread and high acceptability by consumers.

Table 4. Effect of water amount for baking on Sensory evaluation of GFPB.

Treatments	General appearance (20)	Color of crust (15)	Color of crumb (15)	Pores distribution of crumb (15)	Flavor (10)	Taste (10)	Freshness (15)	Total score (100)
C	16.45^{b} ± 0.86	12.5^{c} ± 0.83	13.91^{b} ± 0.46	14.02^{b} ± 0.29	7.78^{b} ± 0.87	7.97^{b} ± 1.23	12.98^{c} ± 0.35	85.61^{c}
F	16.87^{b} ± 0.82	12.8^{b} ± 0.65	13.82^{b} ± 0.27	14.22^{b} ± 0.21	7.68^{c} ± 0.36	8.68^{c} ± 0.98	13.27^{b} ± 0.44	87.34^{b}
I	19.23^{a} ± 0.96	13.87^{a} ± 0.41	14.53^{a} ± 0.47	14.72^{a} ± 0.43	8.82^{a} ± 0.49	9.58^{a} ± 0.76	14.16^{a} ± 0.38	94.91^{a}
LSD (0.05)	0.93	0.05	0.65	0.70	0.08	0.04	0.11	1.58
F test	***	***	***	***	***	***	***	***

Means ±SD (standard deviation) with different small letters in the same column differ significantly at p<0.05.

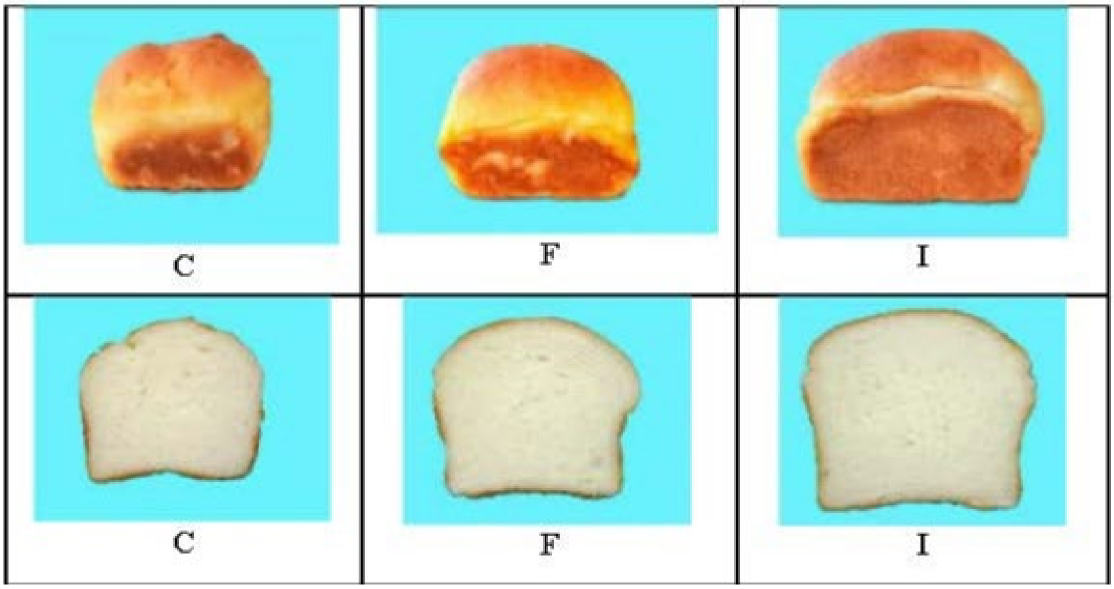

Fig.4. Gluten- free bread characteristic as affected by water amount.

Effect of gum concentration used for baking on Sensory evaluation of GFPB.

The mean scores of sensory acceptability test of the GFPB samples are shown in Table (5). Generally, all the samples were found acceptable to the panelists. Sensory parameters results showed a highly significant difference ($p < 0.05$) between bread samples with different xanthan gum concentrations. The general appearance score was 19.23 for sample M which baked using 2g XG while, by increasing the XG concentration to 3 and 4g the general appearance scores significantly ($p < 0.05$) declined to 17.54 for sample P and 17.11 for sample T, as shown also in Fig. 5. Likewise, the obtained scores for crust and crumb color of GFPB declined by increasing XG dose. Results of pores distributions of GFPB crumb (Table 5) indicated that sample M (with 2g XG) had the highest scores for pores distributions of crumb and by increasing XG dose to 3 and 4g in samples P and T; respectively, these values significantly ($p < 0.05$) decreased which may be due to the use of high gum dose led to high viscosity batter which impedes the expansion of gas during fermentation and baking (Sahin, 2008).

The sample M baked with 2g XG had the highest scores for flavor and taste followed by sample P and the lowest sample T (Table 5). Similar findings obtained by Maleki *et al*., (2013) who found that high doses of XG in bread manufacturing led to decrease flavor scores in sensory analysis. On the other hand, Shittu *et al*., (2009) reported that increasing XG concentration from 1% to 2% led to a negative impact on the taste and aroma scores in sensory evaluation. Another conspicuous effect of XG concentration is that reflected on bread freshness. Bread samples containing high XG doses 3 and 4g had drier crumbs compared to sample baked by 2g XG. As the XG concentration increased, the freshness significantly ($p < 0.05$) decreased; this could be due to that higher dose of XG led to more sticky loafs which made assessors feel lacking freshness. The lack of crumb freshness observed by Guarda *et al*., (2004) with high xanthan content. The highest total scoring was 94.91 for sample M, followed by sample P (89.69) and the lowest (88.42) for sample T as shown in Table 5. It is very clear that there is a negative relation between increasing XG dose and decreasing total scores of GFPB acceptability. The sensory analysis allows concluding that the addition of a low dose (2g) of XG improves the sensory properties of GFPB and gives higher scores for overall acceptability. Similar findings were reported by Gadallah *et al*., (2016), as they noticed a decline in sensory properties of GF bread associated with XG dose increase.

Table 5. Effect of gum concentration used for baking on Sensory evaluation of GFB.

Treatments	General appearance (20)	Color of crust (15)	Color of crumb (15)	Pores distribution of crumb (15)	Flavor (10)	Taste (10)	Freshness (15)	Total score (100)
M	$19.23^{a} \pm 0.63$	$13.87^{a} \pm 0.71$	$14.53^{a} \pm 0.35$	$14.72^{a} \pm 0.54$	$8.82^{a} \pm 0.64$	$9.58^{a} \pm 0.22$	$14.16^{a} \pm 0.76$	94.91^{a}
P	$17.54^{b} \pm 0.61$	$13.18^{b} \pm 0.59$	$14.42^{b} \pm 0.25$	$14.02^{c} \pm 0.76$	$7.82^{b} \pm 0.42$	$8.78^{b} \pm 0.95$	$13.97^{b} \pm 0.19$	89.69^{b}
T	$17.11^{c} \pm 0.78$	$13.20^{b} \pm 0.77$	$13.71^{c} \pm 0.26$	$14.32^{b} \pm 0.25$	$7.65^{c} \pm 0.39$	$8.65^{c} \pm 0.54$	$13.78^{c} \pm 0.13$	88.42^{c}
LSD (0.05)	0.65	0.57	0.06	0.41	0.07	0.06	0.07	0.94
F test	***	***	***	***	***	***	***	***

Means ±SD (standard deviation) with different small letters in the same column differ significantly at $p<0.05$.

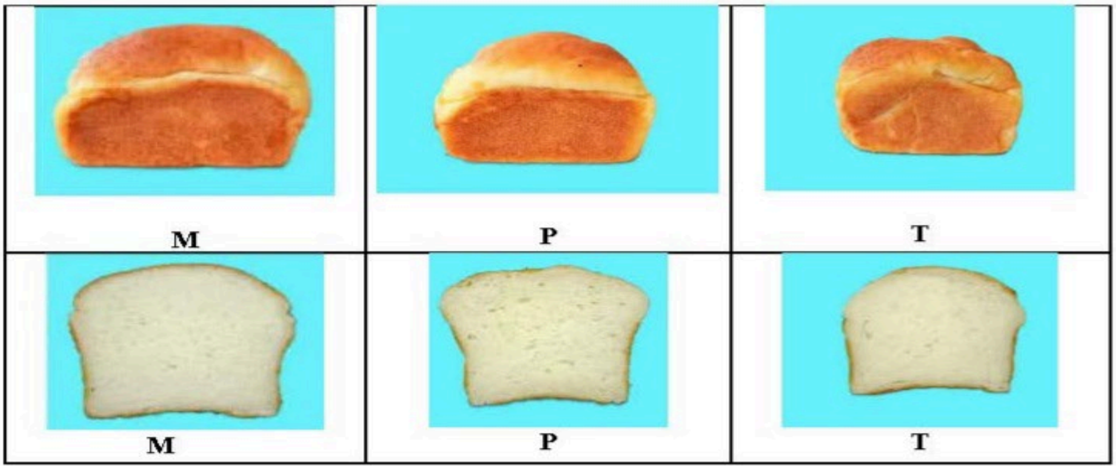

Fig 5. Effect of gum concentration on bread characteristics.

Conclusion

In the bakery industry, hydrocolloids are of increasing importance as breadmaking improvers. They are widely used in baked goods to enhance dough handling properties, overall quality and to extend shelf-life. The use of hydrocolloids represents the most widespread approach used to mimic gluten in the manufacture of gluten-free breads, due to their structure-building and water-binding properties. In the present study three different hydrocolloids (Arabic gum, Guar and Xanthan) were tested, separately, with gluten-free composite flour which consisted of rice flour (47.5%), corn starch (47.5%) and skim powder milk (5%) for preparation of gluten-free pan bread. The goal of skim powder milk addition was to increase the protein content and as source of animal protein. Three water amounts (90, 100 and 110 ml) and three concentrations (2, 3 and 4g) were tested with each gum. The indicative optimal formulation was using 2g xanthan gum and 110 ml water for production of high quality gluten-free bread with good taste, appearance and acceptability as well as suitable for celiac patient.

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تأثير الصموغ المختلفة والمحتوى المائي على الخصائص الفيزيائية والتركيبية والحسية للخبز الخالي من الجلوتين

عبد الله صالح عبد الجواد، مخلص احمد محمد عبد الرحمن، صفاء عبد الحميد محمد لمام، اسماء محمد عبد الرحمن، عبد الفتاح قطب علي

قسم علوم وتكنولوجيا الأغذية، كلية الزراعة، جامعة أسيوط، مصر.

الملخص

تم إجراء هذه الدراسة لمعرفة تأثير ثلاثة أنواع من الصموغ المختلفة وهي: الصمغ العربي، صمغ الجوار وصمغ الزانثان بالإضافة الي معرفة تأثير استخدام كميات ماء مختلفة أثناء العجن على الخصائص الفيزيائية والحسية وخصائص القوام لخبز القوالب (التوست) الخالي من الجلوتين. ولقد تكونت الخلطة الاساسية للدقيق من 47.5٪ دقيق أرز، 47.5٪ نشا ذرة و5٪ مسحوق لبن فرز.

أولاً: تم دراسة كلا من الصمغ العربي، صمغ الجوار وصمغ الزانثان بتركيز ثابت (2جرام) مع ثلاثة مستويات مختلفة من الماء (90، 100 و110 مليليتر). واظهرت النتائج أن استخدام صمغ الزانثان أدي الي زيادة الحجم النوعي للخبز، والنسبة بين ارتفاع وقاعة الخبز وتصافي الخبز بينما أدت زيادة كميات الماء المضاف أثناء العجين الي تقليل قيم فقد الرطوبة أثناء الخبيز، بينما انخفضت قيم نتائج الاختبارات السابقة في حالة استخدام الصمغ العربي وصمغ الجوار مقارنة بصمغ الزانثان عند كمية ماء (110 مليليتر. كما أظهرت نتائج تحليل القوام إلى انخفاض قيم صلابة وتماسك الخبز، وزيادة الإسفنجية ومرونة لباب الخبز مع زيادة مستوى الماء المضاف.

ثانياً: تم دراسة ثلاثة تراكيز مختلفة (2، 3، 4 جرام) من كل صمغ مع كمية ماء ثابتة (110 مليليتر) حيث أستبان من النتائج المتحصل عليها أن زيادة تركيز الصمغ العربي وصمغ الجوار أدي إلى زيادة في الحجم النوعي للخبز الناتج وعلى العكس فأن زيادة نسبة أضافة صمغ الزانثان من 2 جرام إلى 4 جرام عند مستوي ماء 110 مليليتر أدت إلى انخفاض في الحجم النوعي للخبز الناتج. ولقد أظهرت نتائج تحليل قوام الخبز التوست الخالي من الجلوتين أن استخدام جرعات عالية من الصموغ تميل إلى إنتاج خبز توست خالي من الجلوتين ذو قيم مرتفعة من الصلابة والصمغية والمضغ، وذو قيم إسفنجية منخفضة. ومن ناحية اخري فان زيادة نسبة الماء المضاف أثناء العجن أدي إلى الحصول على لباب خبز ذو درجات عالية من الطراوة والإسفنجية والمرونة. واستبان من ملخص هذه الدراسة ان استخدام صمغ الزانثان بنسبة 2 جرام لكل 100جرام دقيق خالي من الجلوتين في صناعة الخبز التوست الخالي من الجلوتين مع كمية ماء 110 مليليتر أدت الي انتاج خبز ذو خصائص فيزيائية وخصائص حسية وتركيبية جيدة.