IMPROVING THE QUALITY OF GLUTEN-FREE BREAD MANUFACTURED FROM PROSO MILLET USING HYDROCOLLOIDS

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ABSTRACT

The aim of this study was to investigate the role of some hydrocolloids in improving the physical and sensory properties of gluten-free bread manufactured from millet flour. Whole grain millet flour (T2), whole grain millet flour with xanthan gum (T3), whole grain millet flour with guar gum (T4), unprocessed millet flour with extraction rate of (71%) with xanthan gum (T5), unprocessed millet flour with extraction rate of (71%) with guar gum (T6) ,were used to prepare gluten free bread beside another treatment manufactured by the same ingredients with replacing the sugar by glycerol (T7).The wheat flour was used as standard (T1). The results of the chemical composition showed that whole-grain Proso millet flour had higher percentages of fat, protein, ash and fiber, and lower moisture and carbohydrates content, in comparison to wheat flour. The amylose content were (38.46 - 26.25%) for wheat flour and whole grain millet flour respectively, which indicates that Proso millet is a non-waxy cultivar. The results of the physical properties of the baking product, represented by volume and specific volume, showed that T1 and T3 outperformed over the rest treatments. A sensory evaluation indicated that gluten-containing bread was more acceptable to consumers. Followed by gluten-free bread with xanthan gum, as the total scores for these two treatment were (94.73 , 85.92). While for T2, T3, T4, T6, T7 treatments were (44.44, 77.62, 54.72, 62.39, 82.45).

Keyword; xanthan gum, glycerol, sensory properties, soaking, proso millet.

تحسين جودة الخبز الخالي من الكلوتين المصنوع من دخن البروسو باستخدام الغروانيات المائية

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المستخلص

هدفت هذه الدراسة الى معرفة دور بعض الغروانيات المائية في تحسين الخصائص الفيزيائية والحسية للخبز الخالي من الغلوتين المصنوع من دقيق الدخن. إذ تم استعمال كامل الحبوب (T2) ودقيق الدخن والحبوب الكاملة مع صمغ الزانثان (T3) ودقيق الدخن والحبوب الكاملة. مع صمغ الغوار (T4)، دقيق الدخن غير المعالج بمعدل استخلاص (71٪) مع صمغ الزانثان (T5) ، دقيق الدخن غير المعالج بمعدل استخلاص (71٪) مع صمغ الغوار (T6)، تم استخدامه لتحضير الخبز الخالي من الغلوتين بجانب معالجة أخرى مصنوعة بنفس المكونات مع استبدال السكر بالجلسرين (T7)، تم استخدام دقيق القمح كمعاملة قياسية (T1). أظهرت نتائج التركيب الكيميائي أن دقيق الدخن بروسو كامل الحبوب يحتوي على نسب أعلى من الدهون والبروتينات والرماد والألياف، وانخفاض محتوى الرطوبة والكربوهيدرات. وبالمقارنة مع دقيق القمح فإن محتوى الأميلوز كان (38.46 – 26.25٪) لدقيق القمح ودقيق الحبوب الكاملة على التوالي، مما يدل على أن بروسو الدخن صنف غير شمعي. أظهرت نتائج الخواص الفيزيائية لمعاملات الخبز، ممثلة بالحجم والحجم النوعي، أن T1 و T3 تفوقوا في الأداء على باقي المعالجات. أشار تقييم حسي إلى أن الخبز المحتوي على الغلوتين كان أكثر قبولًا للمستهلكين. يليه الخبز الخالي من الغلوتين مع صمغ الزانثان، حيث كانت النتائج الإجمالية لهذه المعاملات (94.73، 44.44، 77.62، 54.72، 85.92، 62.39، 82.45).

الكلمات المفتاحية: صمغ الزانثان، الكليسيرول، الخصائص الحسية، النقع، دخن البروسو.

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INTRODUCTION

Agriculture represented the main lever for the establishment of successive human civilizations because agriculture is the cornerstone in the structure of the economy. However, agriculture lost its importance and the level of its presence in societies due to a combination of several reasons, including the migration of labor from the countryside to the cities, and as a result of the current prevailing conditions of climate change. In addition, water scarcity, increasing population and rising food prices have affected agriculture and food security worldwide (11,23). Cereal crops, especially wheat, are a major part of the human diet and an important source of energy. In order to face food insecurity, an alternative grain should be explored for wheat. The millet crop is the largest candidate for this, as it is the most resistant to drought and its nutritional composition is similar and even superior to some of the other main grain components, and its gluten-free proteins are a new food source for patients with celiac disorders (the gluten-free diet is the only treatment available so far for this disease). (Category), in addition to the rise in the culture of consumption of gluten-free foods (due to consumer awareness of gluten-related disorders) which drives an increase in demand for this type of food. However, gluten is a structural building protein necessary for optimal dough development. Therefore, obtaining High-quality gluten-free bread presents a technical challenge (1, 12, 25). There is a regenerate interest in using millet in food applications in many countries due to competition with other common grains such as wheat and maize. Millet is still a non-genetically modified grain, millet is a small seed, has a short ripening time, requires minimal water to grow to maturity, and grows well in drought conditions. Most importantly, it contains macronutrients and is similar to other large grains, even slightly higher in essential amino acids like lysine than corn and wheat. Millet is an essential ingredient for the production of many foodstuffs such as alcoholic and non-alcoholic beverages, porridge and flatbreads in Africa, India, China and some other Asian countries. (1,16,19). Bread has been viewed for centuries as one of the most popular and attractive food products due to its nutritional value and unique organoleptic properties (texture, taste and flavor). However, as the demand for gluten-free products increases, many new products must be designed with quality characteristics similar to wheat products. The use of millet in the production of gluten-free bread (GFB) can be enhanced by the addition of hydrocolloids. They have been used to produce properties similar to those of viscoelastic gluten and to contribute to improving the bread's structure, chewiness in the mouth, acceptability and shelf life. These substances react with water and produce a gelatinous network structure that increases the viscosity of the batter and the gas-holding capacity during fermentation and baking (roasting), improving the texture, volume and structure of baked goods. The hydrocolloid materials showed promising results with other flours free from gluten to produce high-quality bread acceptable to the consumers, such as Xanthan, hydroxyl propyl methyl cellulose (HPMC), guar gum, Arabic gum, psyllium husks and CMC carboxyl methylcellulose or a mixture thereof. The baked goods containing these compounds showed the ability to retain water and increase the moisture of the loaf, which helped to increase the volume of the loaf and make it softer (5, 18). This work aims to assess the gluten-free bread manufactured from Iraqi proso millet (using hydrocolloids) concerning its sensory acceptability among the different spectrums of the Iraqi people in order to determine its contribution to reducing the consumption of wheat products and to help people with celiac disease in finding alternatives with high nutritional value and low prices that can be Home-made compared to the expensive products obtainable in the market.

MATERIALS AND METHODS

Samples preparation; the millet under study were collected from the local markets in Iraq / Baghdad, represented by the local variety (Proso grown in Iraqi lands "Al-Qadisiyah Governorate") and from 2020 harvest. The samples were thoroughly cleaned to remove all foreign materials, broken, and immature grains and the grains were washed after soaking for 15 minutes. The grains were dried using direct sunlight "for 10 hr." from March to April.

The grinding and crushing millet grains

Grinding; the millet was crushed using coffee grinder (Chinese origin) to produce whole grain flour (100% extraction rate) to manufacture gluten-free whole grain bread.

Milling; millet grains are milling (to produce flour) Using the German Quaternary Brabender Mill (Department of Food Science/Collage of Agricultural Engineering Sciences).

The amount of extraction was determined using standard sieves according to the following equation:

Extraction (%) = ((flour weight) / (bran weight + flour weight)) x 100

Purification; The standard sieve No. 70 (Mesh 212 µn) to standardize the characteristics or the size of the particles of all types of flour resulting from the grinding and crushing processes. All the products (whole grain flour - flour extracted) were kept in polyethene bags freezing at a temperature of (-18° C) until the subsequent tests were performed.

Determination of chemical components of samples of millet grains , millet flour and wheat flour (Turkish);

Determination of moisture, ash and protein; The percentages of moisture, ash and protein were estimated using the standard method followed by (4) using the Inframatic device from Perten instruction compan Swedish. As for the percentage of fat, it was estimated using method described by Al-Mihyawi (3),

The total fiber ratio; was estimated according to AL-Abas and Nasser (3)

Carbohydrate estimation;

Total Carbohydrates were calculated by the difference

-Determination of amylose and amylopectin levels according method described by Whaib and Mousa (26).

Rheological tests: Rheological tests for wheat flour samples and millet flour treatments were carried out in this study using the Farinograph test. According to the method mentioned in (2000) AACC No. (54-21), using 300 grams of flour with a moisture content of 14%.

The baking test ; the straight dough method was used according to the method mentioned in (16) with an adjustment for the proportions of some ingredients, baking time and the method of preparing the control group. The research included the following treatments (**duplicates):**

T1; Wheat flour control treatment according to AACC, number (10-10) described by Al-Hammoud et al. (12) with a total weight of 139 g.

T2; Whole grain proso millet flour with main ingredients

T3;Whole grain proso millet flour, with 2% xanthan gum, with main ingredients

T4;Whole grain proso millet flour, with 2% guar gum, with main ingredients

T5 ;Extracted millet proso flour (extraction 71%),with 2% xanthan gum, with the main ingredients

T6 ; Extracted millet proso flour (extraction 71%),with 2% guar gum,with the main ingredients

T7 ;Extracted millet flour (extraction 71%), 20 g glycerol with 40 ml of water, with 2% xanthan gum.

- The straight dough method was used to prepare gluten-free laboratory bread. The whole eggs were stirred for two minutes on high speed, then the sugar was added and continue stirring for one minute on medium speed. Then add the rest of the ingredients (100 gm flour, 2 gm yeast, 2 gm salt, 10 gm fat, 20 gm sugar) and mix for two minutes, adding half the amount of water. Finally, the remaining water was added (after heating to 85°C and mixing with the hydrocolloid well with an egg) and the rest of the ingredients for another three minutes at full speed. Finally, divide the mixture into equal weights in two metal molds, and placed in the fermentation chambers at a temperature of 40-45°C for 60 minutes. Then the process of baking (barbecuing) took place in the preheated oven at a temperature of 180 - 190°C for 20 minutes. The control group was prepared by following the straight dough method. The dry ingredients (flour, sugar, fat, salt and yeast) are placed in the Kenwood stand mixer bowl. Mixture was mixed for a minute. Water gradually added until a cohesive dough is formed that can be rotated and shaped quickly without sticking. The kneading process continued until a perfect dough was obtained. 139 grams of the obtained dough were take (equivalent to the weight of gluten-free dough). The dough was shaped (moulded) and placed in greased and marked moulds. Then the dough was fermented and baked under the same conditions as previously described.

Sensory evaluation of standard and gluten-free bread (loaf);: Specific volume measurement; The method described by

Hammoud et al. (12) and Nasser et al. (20) was followed in calculating the specific volume:

1. The samples were cooled to room temperature
2. The bread pieces were weighed using a digital scale with an accuracy of 0.01 g
3. The volume of each piece (cm^3) was measured by the method of displacement of rapeseed
4. The specific volume was calculated according to the following equation:

Specific volume (cm^3/g) = loaf volume /loaf weight

The bread piece with the highest specific volume was assigned a score of 30 , and The volumes of the remaining pieces were attributed to the volume of this piece.

Measurement of the bread density; The density of standard bread was estimated by Hammoud et al., (12) according to the following equation:

The density of bread (g/cm3) = weight of bread / volume of bread)

Measuring the lost in bread weight according to the following equation:

The lost in bread weight = (weight of dough before baking- weight of bread after baking/weight of dough before baking) x 100

Color degree measurement; The chromatic properties of bread crust and crumb were estimated by using a color measuring device (Brightness and color meter) according to the method described by Singh and Mishra, (23) by determining the color space values L*a*b* (duplicate for each indicator).

RESULTS AND DISCUSSION

The chemical composition of wheat and millet flour: Table (1). shows the percentages of the chemical components of wheat flour (Turkish) and whole grain millet flour (Proso) and millet flour with an extraction rate of (71%). It was noted that the moisture percentage in the above flour samples were 11.63, 3.57, 9.30 %, and the low moisture content in whole millet flour was due to the non-tempering grain which used in preparing this flour. It was observed that the moisture percentage in white wheat flour was within the required range for bakers, which ranges from (11.50 - 15.20%). The results of moisture content in wheat flour were close to those indicated by Kazim *et al.* (15) and less than that mentioned by Nasser *et al.* (20). As it is known that the moisture content is a critical factor in determining the quality of flour and its rate of water absorption (17). Protein content of the experimental flour were 10.50, 10.93, and 30.9% for white wheat flour , whole millet flour and millet flour with an extraction rate (71%), respectively. The results for white wheat flour were similar to those reported by Kazim *et al.* (15) and Nasser *et al.* (20) and it is lower than that recorded in the relevant studies (9, 10, 14) this could be attributed to the different varieties and methods of cultivation or fertilization and others, as well as the loss of protein as a result of extracting process. The percentage of fat in white wheat flour, was 1.25%, while for millet flour it reached 5.48 and 4.30 % in whole grain flour and in flour with an extraction rate of 71%, respectively. Relevant studies indicated that the percentage of fat in millet flour for the same variety was lower, and others recorded higher readings for the percentage of fat (8). As for the percentage of fat in white wheat flour, it was less than that found by Kazim *et al.* (15) and Nasser *et al.* (20). The percentage of fiber and ash in the samples under study were (0.48, 11.4, 1.81 %) and (0.88, 5.08, 1.62 %) for white wheat flour, whole grain millet flour , and millet flour with an extraction rate of 71%, respectively. These results of white wheat flour were lower than Naser *et al*. (20) finding and higher than Kazim *et al*. (15) results for the ashes percentages, and similar to that was found by Nasser *et al*. (20) and higher than that reported by Kazim*et al.*(15) for the fibers. While, the results indicate that the percentage of fiber in extracted millet (71%) was higher than that shown by Amadou *et al*. (6) where it was (0.7%) and lower that indicated by Hymavathi *et al.* (13) as it was (3.91%). It was also lower than the findings reported by Karkannavar *et al.* (14) for two varieties of peeled millet, with a percentage of (2.66 and 2.37%), respectively. The results indicated that the percentage of carbohydrates was (74.38%) in the wheat flour, which was higher than that found by Kazim *et al.* (15), while it was similar to Nasser *et al* (20) finding. Percentage of carbohydrates was (63.54, 73.17) in whole millet flour and the extracted flour (71%), respectively, which is less than the result indicated by Amadou *et al*. (6) and higher than that indicated by (10, 13).

Table 1. Percentages of chemical components of wheat flour, whole grain proso millet flour and proso millet flour with an extraction rate of 71% are under study

Flour type	Moisture	Protein	Fat	Total Fiber	Ash	Carbohydrates	Amylose/ Amylopectin Content
Wheat flour	11.62	10.64	2.00	0.48	0.88	74.38	38.46 / 61.54
Proso millet flour (Whole Grain)	3.57	10.93	5.48	11.4	5.08	63.54	26.25 / 73.76
Proso millet flour (71 %)	9.30	9.80	4.30	1.81	1.62	73.17	-----

Rheological properties of wheat and millet flour: Table (2) shows the rheological properties of wheat flour and the treatments of millet flour with guar gum and xanthan gum (2%). The results indicated a decrease in the percentage of absorbed water for all treatments of millet flour compared to wheat flour except for treatment T6. The percentage of absorbed water for T1, T2, T3, T4, T5, T6, and T7 were 63.2, 47.2, 58.2, 57.4, 56.9, 68.8, and 52.4%, respectively. This may be attributed to the type of millet proteins, the type of starch (different proportions of amylose and amylopectin), the milling methods, and the size of the flour particles (percentage of damaged starch) and the lack of gluten. The stability values (the farinoghraph reading) for the dough of the treatments under study were (6.53, -, 8.4, -, 2.8, 8.44, and 6.2 minutes), respectively. This difference may be due to the type of protein available, the presence or absence of gums and their different types. In fact, the rheological examination requires more experiments to reach the ideal proportions for making bread, and at the same time it does not give a real idea about what the baked product is, due to different manufacturing methods and working conditions. Therefore, the baker's examination remains the ideal test for the evaluation of final product quality (usually the conditions for the farinograph examination are carried out at 30°C) , whereas for the treatments with gums the temperature raised up to 85°Cto ensure that the hydrocolloid acts (as a binder) as a substitute for gluten. The high percentage of fiber in whole millet could weaken the bonding forces between starch and protein, and it might also have an effect on the amount of water retained inside the dough, and this was reflected in the development time of the dough, which increased in millet flour treatments (except for treatment T6). This was confirmed by Al-Jubouri (2), who stated that the reason for the delay in the arrival of the compound flour dough (wheat + barley) may be due to the presence of a high percentage of fiber and its retention of water, which delayed the arrival of the dough to the required consistency. This is attributed to the weakness of the viscous dough formed, as the characteristic of the time of maturation of the dough is an indication to the completion of the gluten network formation and the completion of the homogeneity of the dough. Dough development time and stability increase with the rate of wheat flour extraction. It is highly dependent on the amount of hydroxyl groups in the fibers that allow water to bind. Moreover, the consistency and stability of the dough is directly affected by the interactions between the higher molecular weight proteins such as the glutenin proteins and the hydrogen bonds of the different groups (11) . Therefore, the stability of the dough varies from one type to another according to these factors. Whereas, the high percentage of total protein and hydrated gluten is positively associated with an increase in the stability of the dough and hence its ability to form a strong gluten network capable of retaining fermentation gases during bread making (12) . The results obtained were useful in identifying the characteristics and strength of the flour, the most important of which were the degree of water absorption of the flour and the best time for rolling the dough.

Table 2.Rheological properties for wheat and millet flour

Treatments	Water absorption (%)	development time (min)	consistency (B.U)	stability (min)
T1	63.2	4.52	490	6.53
T2	47.2	18.05	108	---
T3	58.2	9.9	486	8.4
T4	57.4	15.02	156	---
T5	56.9	5.2	434	2.8
T6	68.8	3.28	510	8.44
T7	52.4	8.4	476	6.2

T1 = Wheat flour (control) according to AACC, weighing 138 g. T2 = Whole grain proso millet flour. T3= Whole grain proso millet flour with 2% xanthan gum. T4= Whole grain proso millet flour with 2% guar gum. T5 =Extracted millet proso flour (71%) with 2% xanthan gum.T6= Extracted millet proso flour (71%), with replaced 2% guar gum.T7=Extracted millet proso flour (71%), sugar replaced by glycerol (20 g), with 2% xanthan gum

Manufacturing and evaluation of gluten-free bread: Table (3) shows the values of the volume, weight, and specific volume, density of the bread and the percentage of loss in the weight of the bread after baking. Treatments T1, T3 and T5 had the highest volume values among the treatments under study. The volume values of the treatments were (510, 210, 465, 260, 490, 250, 425 cm3) respectively, and significant differences were recorded among the treatments. The results show that the treatments containing xanthan gum (T3, T5, and T7) recorded higher volumes than the treatments containing guar gum. Meanwhile the weight of T1, T2, T3 and T5 were higher than the rest, where the values were (128.14, 122.36, 123.92, 115.7, 124.63, 112.67, 114.10 g) respectively, with no significant differences except treatment T6 compared with the treatment T1. The specific volume values, were significantly different and T1, T3, T5 and T7 recorded higher value as compared to the rest (3.98, 1.72, 3.75, 2.26, 3.93, 2.22, 3.72, cm3/g), respectively. The results showed that xanthan gum improved the specific volume of the treatments, and this may be due to its ability to form a network that helped to trap the gases formed in the dough, which reflected positively on the volume and specific volume of the obtained bread. The values of bread density were (0.25, 0.58, 0.27, 0.44, 0.25, 0.45, 0.27 g/cm^3) respectively, and the percentage of loss in weight of bread after baking was (7.15, 10.28, 10.20, 24.66, 9.69, 29.67, 10.90%) respectively, the highest losses were recorded in T4 and T6.

Table 3. Values of volume, weight, specific volume, bread density, and weight loss percentage after roasting for wheat flour bread and millet bread treatments

Treatment	Volume (cm^3)	Weight (g)	Specific volume (cm^3/g)	The density of bread (g/cm^3)	Percentage of weight loss (%)
T1	510	128.14	3.98	0.25	7.15
T2	210	122.36	1.72	0.58	10.28
T3	465	123.92	3.75	0.27	10.20
T4	260	115.17	2.26	0.44	24.66
T5	490	124.63	3.93	0.25	9.69
T6	250	112.67	2.22	0.45	29.67
T7	425	114.10	3.72	0.27	10.90
L.S.D.	58.96 *	14.61 *	1.70 *	0.215 *	5.76 *
			* (P≤0.05).		

T1 = Wheat flour (control) according to AACC, weighing 138 g. T2 = Whole grain proso millet flour. T3= Whole grain proso millet flour with 2% xanthan gum. T4= Whole grain proso millet flour with 2% guar gum. T5 =Extracted millet proso flour (71%) with 2% xanthan gum.T6 = Extracted millet proso flour (71%), with 2% guar gum.T7=Extracted millet proso flour (71%), sugar replaced by glycerol (20 g), with 2% xanthan gum.

Singh and Mishra (23) reported that the specific volume of millet bread significantly lower ($P < 0.05$) than wheat bread. The specific volume of whole wheat bread and the bread of nine varieties of untreated prosso millet (Cobb, Don, Illybeard, Huntsman, Minkow, Panhandle, Plateau, Rice, Sunrise) were (1.97 - 3.58 cm3 / g). The same researcher indicated that the addition of cornstarch and isolated millet starch to millet bread caused a significant increase in the specific volume compared to whole millet, in contrast adding potato starch, showed a significant decrease ($p\leq0.05$). While the addition of carboxymethyl cellulose (CMC) and Ticaloid 313 resulted bread with much better specific volume than xanthan gum and Ticaloid 345. Moreover the researcher also indicated that increasing the concentration of hydrocolloid had no significant effect on the volume of bread.This was also confirmed by Schober *et al.*, (22), who observed a decrease in the volume of gluten-free sorghum bread with increased levels of xanthan gum. Singh and Mishra (23) also stated that the percentage of loss in bread weight after baking for whole wheat bread and prosso millet bread of the nine varieties was ranged (10.89 - 18.43). While the loss for the treatments in which starch and xanthan gum were added at a rate of 2% was ranged (18.06 - 21.27%), and in the treatments in which xanthan gum was added at a rate of 3%, the loss was less being (17.06, 17.86, 17.35, 21.02%) . This is attributed to the role of gums and their ability to retain moisture, but this made the volume smaller and the texture of crumb dense and closed and less acceptable to the consumer. Consumer acceptance decreased further after a storage period of five days and after wrapping the pieces in thick polyethylene bags, as the hardness and dry texture increased. The amylose content was significantly affected the specific volume of bread, as a positive relationship was found between them. Low-amylose proso millet varieties produced low-volume bread. During the baking process, water absorption of amylose causes the starch granules to swell faster, resulting in a poor structure-holding capacity, consequently, a decrease in product volume. Hydrocolloids can promote dough growth and gas retention by increasing dough viscosity. Colloids such as CMC have a hydrophilic nature that enhances water holding properties. However, they also contain hydrophobic groups which promote heterotrophic properties, including increased interfacial activity within the dough during fermentation (such as emulsification) and the formation of gelatinous networks upon heating during the bread-making process. These lattice structures increase viscosity and strengthen the expanding cell walls in the dough, thus increasing gas retention during baking resulting in better loaf volume (23). Table 4. shows the degrees of color of the crust and crumb of wheat and millet bread according to the Lab colorimeter. The results indicate that the millet flour used in bread manufacturing significantly affected the color of the final product. Crust and crumb color of millet bread was darker than that of wheat bread, so the millet flour resulted in reduced L* value for both crust and crumb. The results indicate that all bread treatments represented by wheat bread (T1) and millet extracted achieved a lighter color crust (*L) than bread produced from whole millet flour. The value of crust color was higher for bread produced from wheat and lower for bread produced from millet treatment, except for treatment T7, where the values of the treatments under study were (60.07, 33.4, 52.84, 41.37, 57.50, 48.56, 63.04), respectively. The degree of yellownesh of the crust of the treatments (b*) under study ranged from 19.52 - 35.25, where the color was darker for whole millet bread due to the colors present in the outer layers of millet (bran). The degree of rednesh of the crust of the treatments (a*) under study ranged between 10.71-17.03 .

Table 4. The crust and crumb color degrees of wheat bread and proso millet bread according to Lab colorimeter

Treatment	Crust color				Crumb color			
Color classification	L*	a*	b*	L*/b*	L*	a*	b*	L*/b*
T1	60.07	17.03	35.25	1.70	71.93	1.15	11.51	6.25
T2	33.48	10.71	19.52	1.72	45.47	0.19	17.67	2.57
T3	52.84	14.06	27.28	1.94	51.07	2.47	20.59	2.48
T4	41.37	13.29	23.14	1.79	50.32	5.88	19.88	2.53
T5	57.50	14.75	23.40	2.46	58.77	8.53	19.60	3.00
T6	48.56	12.67	27.02	1.80	66.93	4.54	21.26	3.15
T7	63.04	12.13	32.82	1.92	65.18	3.67	24.35	2.68
L.S.D.	6.68 *	3.04 *	5.81 *	0.735 *	8.92 *	2.69 *	5.32 *	1.98 *
* ($P \leq 0.05$).								

T1 = Wheat flour (control) according to AACC, weighing 138 g. T2 = Whole grain proso millet flour. T3= Whole grain proso millet flour with 2% xanthan gum. T4= Whole grain proso millet flour with 2% guar gum. T5 =Extracted millet proso flour (71%) with 2% xanthan gum.T6 = Extracted millet proso flour (71%), with 2% xanthan gum.T7=Extracted millet proso flour (71%), sugar replaced by glycerol (20 g), with 2% xanthan gum.

Singh and Mishra (23) indicated that gluten-free bread produced from whole millet flour had a darker crust color compared to bread manufactured from wheat and millet with added 2% starch and gum. The crust color (L*) value was lower for whole millet bread and higher for corn starch-containing bread compared to wheat-based bread. The values of the color of the crust of wheat bread, whole millet bread, and millet bread with corn starch - potato starch - isolated millet starch were ranged (43.86 - 73.17). At the same time, the degree of yellownesh of the crust of the above-mentioned treatments were ranged (25.35 - 34.82). It is noted that the highest value was recorded for whole millet bread. (All these values were within the percentages obtained from the treatments under study, except for the treatment of wheat bread, which was higher). The same researcher indicated that hydrocolloid compounds had no significant effect on the color of the crust, but increasing the level from 2% to 3% reduced the (L*) values in whole millet bread and the rest treatments. However, this effect did not show a significant change among the treatments. This may be due to moisture retention, which has limited/or delayed some moisture-requiring color interactions during the baking period (7,23).

Sensory evaluation of wheat and millet bread (gluten-free bread): Table 5. shows the sensory evaluation of the experimental bread, wheat flour bread (control treatment) and millet bread (gluten-free) with two types of gum. The scores of the total sensory evaluation indicated significant differences among the treatments. T1 recorded the highest values (94.73%) for all external and internal characteristics due to the general acceptance of this product and consumers' habituation to eating it. There were no significant differences between T5 and T1, this supports the possibility of using millet flour with an extraction rate of 71% with 2% xanthan gum in the production of gluten-free bread .Additionally there was no significant differences between T5 and T7, however T7 differed significantly with T1. As T7 gained 82.45 for total evaluation so it is acceptable to the consumer even the sugar replaced by glycerol. T2 recorded the lowest acceptability score as compared to T1, T5, T7, because it contain high percentage of insoluble fiber and has undesirable flavor. Its crust color was darker and the coarse crumb, and unusual flavor which may be due to the presence of phenolic compounds, all these decreased its acceptability. These results were similar to that reported in related studies (used whole millet and legumes) , and even from compound flour to which fiber is added, and this is due to the general decrease in volume and the increase in coarseness of the product. However, it is noted that the internal and external sensory characteristics improved in T3 after the addition of xanthan, and it was highly acceptable. It is also noted from the obtained results, that the gluten-free bread with guar gum is not favored by the consumer, as it had a low volume, dense crumb, difficult to chew, dark color and dry. This may be because these treatments lost more moisture than the others. It is also noted that its volume is smaller as it did not retain gases due to the weakness of the network formed in the presence of guar gum. Xanthan gum is composed of repeating units of five sugars, which include glucose, mannose, and glucuronic acid in molar ratios of 2:2:1. Guar gum consists of polysaccharides, which include galactose and mannose. Its backbone is a linear chain of β1,4-linked mannose residues, to which a galactose residue is attached on every second mannose molecule in the sequence, forming side branches. Xanthan gum is capable to bound water more than guar gum, so it is more able to form a network that can retain the gases and produce gluten-free bread with high acceptability.

Table 5. Sensory evaluation of wheat flour bread and millet flour bread (gluten-free).

Characteristics	Degree	T1	T2	T3	T4	T5	T6	T7	L.S.D.
Type of gum	---	---	---	Xanthan gum	Guar gum	Xanthan gum	Guar gum	Xanthan gum	
Specific volume	30	30.00	12.96	28.26	17.04	29.62	16.73	27.36	5.02 *
Symmetry of form	5	4.83	1.00	3.00	2.00	4.00	3.00	4.33	1.58 *
Evenness of bake	5	4.83	1.02	3.67	2.67	4.17	3.17	4.67	1.42 *
Crust color	10	6.91	6.99	7.89	7.28	10	7.32	7.8	2.33 *
Grain of crumb	10	9.33	4.26	7.50	2.50	8.00	6.10	8.33	1.96 *
Texture of crumb	10	9.50	5.10	8.00	6.85	8.33	6.33	8.67	2.37 *
Crumb color	10	10	4.11	3.97	4.05	4.8	5.04	4.29	2.61 *
Taste and Aroma	20	19.33	9.00	15.33	12.33	17.00	14.70	17.00	3.88 *
Total	100	94.73	44.44	77.62	54.72	85.92	62.39	82.45	9.74 *

T1 = Wheat flour (control) according to AACC, weighing 138 g. T2 = Whole grain proso millet flour. T3= Whole grain proso millet flour with 2% xanthan gum. T4= Whole grain proso millet flour with 2% guar gum. T5 =Extracted millet proso flour (71%) with 2% xanthan gum.T6 = Extracted millet proso flour (71%), with replaced 2% xanthan gum.T7 Extracted millet proso flour (71%), sugar replaced by glycerol (20 g), with 2% xanthan gum.

The use of millet for the production of gluten-free bread (GFB) can be enhanced by the addition of hydrocolloids to the bread mix ingredient. Hydrocolloid absorbs water and produces a gelatinous network that increases the viscosity of the mixture, beside increases the holding capacity of the gas produced during the fermentation and baking processes, which improves the texture, volume and structure of the bread. Xanthan gum was used in this study because it forms a plastic network. Moreover, the xanthan side chains of mannose and glucuronic acid are hydrophilic and are used to increase the ability of GFB to bind water and increase the moistness of the loaf (21, 24). Alvarenga *et al*. (5) mentioned to the possibility of using hydrocolloid materials in bakery products to improve the texture and appearance of gluten-free baked goods. In this context, gluten in wheat-based bread slows down the movement of water after baking. The slightly higher moisture content in gluten-free bread can be attributed to the water-retaining properties of hydrocolloids because one of the characteristics of these compounds is the high tendency to bind with water. The same researcher found that the moisture content of bread with gluten, and gluten-free bread made from a mixture of corn, rice and tapioca flour (1: 1: 1 w/w/w with 0.5% agar gum) was (39.6 , 40.2%), respectively. Moreover, the pH of bread with gluten remained higher than that of gluten-free as the values were (6.51 , 6.01) respectively, which may affect the color and hardness properties of different types of bread. The researcher also indicated , the measure of hardness and penetration, and cutting strength were consistently higher in gluten-free bread (this effect is similar to what was found in this study). Accordingly, the overall effect on the mechanical properties of the gluten-free bread structure may have caused the increased hardness in the product due to the decreased swelling of the starch granules and the decreased leaching of amylose from these granules. According to the total scores of sensory evaluation of the fresh bread under study, (especially the taste and flavor) the bread manufactured from wheat (was favored by evolution team). However, the gluten-free formulation under study (T3, T5, T7) were considered acceptable. As they gained scores close to the wheat bread scores, this was confirmed by (5), who found that the total sensory evaluation scores for gluten-free bread and wheat bread were (68.1 , 70.4), respectively.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DECLARATION OF FUND

The authors declare that they have not received a fund.

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