Comparative Assessment of the Effects of Plant Based Gums on Rheological Characteristics of Maize Dough and its Bread Quality

Tullo T. Ketaso[1, 2], **Kumsa D. Kuffi**[1,*]

[1]School of Chemical and Bio Engineering, Addis Ababa Institute of Technology,
Addis Ababa University, Addis Ababa, Ethiopia.
[2]School of Agricultural and Food Engineering, Department of Food Engineering,
Ambo University.
**Corresponding author's E-mail address: kumsa.delessa@aait.edu.et*

DOI: https://doi.org/10.20372/zede.v42i.10183

ABSTRACT

Bread made from maize is considered as gluten free and thus recommended for people living with celiac disease. However, bread made from maize has inferior quality when compared to bread made from wheat. The aim of this investigation was to explore how plant-based gums affect the rheological attributes of dough made from maize flour and the resulting bread quality. Various types of plant gums were used at a ratio of 3 % to the flour weight basis. Control samples were prepared using maize and wheat flours. To provide a basis for comparison, dough and bread samples made from wheat flour were also used. The study examined the farinographic, pasting, gaseous release and dough development characteristics. Proximate composition, loaf specific volumes, texture character, and sensory qualities of bread were also examined. The inclusion of gums in maize flour reduced the dough's water absorption capacity (WAC) and degree of softening (DS). Treatment with gums also had a considerable impact on most of the pasting profile. Furthermore, treatment with gums improved bread loaf weight and specific volumes. The firmness of the maize bread was higher than the maize bread prepared from the dough samples treated with gums.

Keywords: Bread quality; Celiac disease; Gum; Maize; Rheological property.

1. INTRODUCTION

These days, celiac disease is considered in many nations as one of the main health issues [1]. It affects the mucosa and the lining of the small intestine, which prevents the body from absorbing certain nutrients, most notably wheat gluten [2]. Consumption of gluten protein from commonly available food sources such as wheat, rye and barley may cause celiac disease in people having problems linked to gluten consumption [3]. Approximately1-2 % of the global population is affected by celiac disease, and the most effective solution for managing it is the development of breads that are free from gluten [4].

One of the most significant proteins that build structure is gluten, which gives wheat-based products their desirable structure and quality as well as their dough-like quality [5]. It is responsible for extensibility, elasticity, mixing tolerance, resistance to elongation, and gas holding ability of doughs. Using alternative ingredients that adds the aforementioned qualities to breads made from gluten free cereals is required.

Among the food grains, maize is the most abundant and cheapest crop, particularly in Sub-African nations like Ethiopia. With 17-20 % of the total calories consumed, it gives consumers the largest portion of their calorie intake. However, maize lacks gluten, and thus bread made from maize has low quality as compared to bread made from cereals rich in gluten such as wheat [6].

Complete replacement of wheat flour with maize flour does not result in viscoelastic dough when kneaded in conventional method for bread-making. Hence, they create batter as a replacement compared to dough. Unlike the popular wheat bread, the batter tend to lose carbon dioxide gas during backing process, which result in decreased loaf's unique volume, moisture content and crumb hardness[7].

To improve the quality of bread made from maize and its mixture, various researchers have developed a range of gluten-free formulations by using starches, hydrocolloids, whey proteins, gums and emulsifiers as flour additives[3].

Bread baked without gluten, from maize and chickpea flours, used to be extensively expanded by addition of 3 % (w/w) hydroxypropyl methylcellulose (HPMC) [2]. According to previous study, hydrocolloid, carboxymethylcellulose (CMC) and xanthan gum mixing with flours increased unique extent and decreased crumb firmness of bread baked without gluten from formula containing maize, rice and soya flour [8]. Similarly, the addition of exceptional gums like guar, locust bean and xanthan gums with emulsifiers (Purawave & Datem) to rice dough increased its rheological characteristics significantly [9].

Furthermore, researcher on similar area reported that the incorporation of wheat and maize starch to rice flour extended the precise volume, style and over all acceptability of gluten free bread made from rice [10].

Although these findings have contributed a lot on how to solve the quality issues related to bread without gluten, the availability and affordability of the ingredients on which these studies were focused is still a big challenge for practical use in low- income countries. Therefore, the objective of this research was to examine the impact of gums derived from tree stems and branches on the overall quality and dough rheological characteristics of gluten-free maize based bread.

2. MAT ERIALS AND METHODS

2.1 Sample Collection and Preparation

2.1.1 Gums

About 2 kg of three gum samples, namely *Gumero* gum (GG), *Humera* gum (HG) and *Harar-Sidamo* gum (HSG), were procured from the Ethiopian Forestry Product and Agriculture Enterprise. These gums were produced from Acacia tree stems and branches grown in various regions of Ethiopia [11]. They were identified as nontoxic, odorless and tasteless natural product consisting of high molecular mass polysaccharides and their inorganic salts which hydrolyze to produce glucuronic acid, galactose, arabinose and rhamnose [12]. Before analysis, the gums were milled and dried to 14 % moisture content.

2.1.2 Flours

Maize was obtained from Holata Agricultural Research Center, and was milled with small scale hammer mill (England Model NO. 212/10 E) to pass through 0.05 mm sieve size. This flour was dried to 14 % moisture content, then enclosed in a polyethylene plastic bag and kept in laboratory shelf with lamination until used. Commercial wheat flour was procured from KOJJ Food Processing Complex (Addis Ababa, Ethiopia). Additional components like live yeast, table salt (edible quality), and sunflower seed oil were bought from the nearby markets in Addis Ababa.

2.2 Dough Preparation

The dough samples were made in accordance with method outlined in previous study [8]. The recipe was: 97 g flour, 2 g sugar, 2 g salt, 3 g yeast, 170 mL water, and 3 % gum, on flour weight base, for gum treated doughs, and 100 g flour for the control ones, as shown in Table 1.

Table1 Ingredients used for dough samples preparation

Ingredients	Dough samples				
	C_1	C_2	T_1	T_2	T_3
Wheat flour (g)	100	---	---	---	---
Maize flour (g)	----	100	97	97	97
Yeast (g)	3	3	3	3	3
Sugar (g)	2	2	2	2	2
Salt (g)	2	2	2	2	2
Water (mL)	170	170	170	170	170
HG (g)	---	---	3	---	---
HSG (g)	---	---	---	3	---
GG (g)	---	---	---	---	*3*

C_1 & C_2 are control samples (without gum) made from wheat and maize flours, respectively while T_1, T_2 and T_3 are maize flours treated with HG, HSG and GG, respectively.

Dough preparation was done as follows: first, bowl used for mixing was washed and then rinsed with water. Then water, salt, sugar, yeast and gum were physically mixed in mixing bowel mixture after being added. Finally, flour was added and combined properly at 160 rpm for 10 min until the dough became smooth and elastic. The resultant dough was kept to ferment at room temperature for about 2 h. Then the fermented dough was divided into small sizes of 100 g, rounded and rested to proof in the fermentation chamber for 10 min at 30°C and 85 % relative humidity.

Breads were made at a temperature of 200°C in an oven for 40 min at (micro mini oven, Germany). Before undergoing a quality assessment, the breads were allowed to cool for one hour at a room temperature.

2.3 Pasting Property Analysis

The samples pasting characteristics were determined by using a rapid Visco-analyzer (Starch Master R & D pack, Anton par, France). For analysis of pasting property maize flours treated with HG, HSG and *GG* were denoted by P_1, P_2 and P_3, respectively. For this analysis, about 3 g flour sample with gums was used for each treatment. Flour was weighed and placed in an aluminum canister and 25 mL distilled water was added to it. Then, the material was rapidly blended for 30 s at 960 rpm with paddle and afterward, under continuous shear during regulated heating procedure and thereafter at 160 rpm during a controlled heating and cooling process under constant shear in the rapid visco-analyzer (RVA). In two minutes, the temperature rose from 50-95°C, then in another two minutes, it dropped to 50°C. Pasting parameters were read from the pasting profile using thermo cline software that was connected to a computer. Pasting parameters include peak viscosity, hold viscosity, breakdown viscosity, final viscosity (also known as paste viscosity) and setback viscosity [17].

2.4. Farinographic Characteristics Analysis

Farinographic characteristics of each flour were determined following the procedure of previous work [13]. For farinographic characteristics analysis, maize flours treated with HG, HSG and were denoted by F_1, F_2 and F_3, respectively. About 300 g of the flour sample was weighed and put in to the farinographic mixing bowl for this analysis. Known volume of distilled water was added to the flour and mixed to form dough. The farinograph recorded a curve on graph paper as the dough was mixed. The curve was centered on the 500 BU line ±20 BU by adding the appropriate amount of water and was run until the curve left the 500BU line. At the end of the test, the farinographic data was recorded on a computer. WAC, dough development time (DDT), uniformity, stability, and softness level are among the parameters that are recorded. Each analysis was done in triplicate.

2. 5 Rheofermentor Test: Dough development and Gas release

Using rheofermentometer (Chopin Rheofermentometer F2, Tripette Renaud, France), the rheology of the dough throughout fermentation was assessed [14]. For this analysis, maize flours treated with HG, HSG and GG were denoted by R_1, R_2 and R_3 respectively. For analysis of gas release and dough development property, 250 g of each flour sample was weighed, which was then combined with water 5 g salt and 3 g yeast in 200 mL of distilled water. The doughs were fermented for 3h in a rheoferementor and then the total carbon dioxide released (CO_2), retained volume of carbon dioxide (R), maximum height of dough development (Hm), maximum height of gaseous emission ((H'm) and maximum height of dough at test completion were recorded.

2.6 Analysis of Bread Quality

2.6.1 Physical Characteristics of Bread

Specific volumes of bread

The American Association of Cereal Chemist (AACC) approved method 10.05 [13]. was used to measure the loaf volume and specific volume of bread using rapeseed displacement method by using the Eq. (1).

$$\text{Specific volume}\left(\frac{\text{cm3}}{\text{g}}\right)=\frac{Loaf\ volume}{Loaf\ weight} \qquad (1)$$

Crust Firmness of bread:

Using a 500N load cell, the texture analyzer was done (TA Plus, Lloyd Instruments, UK) [8].

2.6.2 Proximate Composition Determination

The ash and moisture content of the bread samples were ascertained using the method 925.09 and 923.03 [15], respectively. Association of Official Chemist AOAC approved Kjeldahl method 979.09, 4.5.01 and 962.09 were used for measuring Protein, fat and crude fiber content of bread respectively.

2.6.3. Sensory Analysis of the Bread

The sensory analysis was carried out using 10 semi trained panelists. They were conversant with a method of sensory evaluation .Using a 9 factor hedonic scale, the freshly baked breads were presented for the acceptance test [16]. Panelists had been requested to determine the breads for acceptance of color, aroma, flavor, taste, texture, and overall-acceptability to rank samples from 1 to 9, with 1 representing the least score (dislike extremely) and 9 the highest score (like extremely).

2.7. Statistical Data Analysis

The data gathered were analyzed through one-approach evaluation of variance (ANOVA). Duncan's multiple tests, which make use of the statistical package for social science (SPSS software) compares differences in means. A P-value of substantially less than 0.05 was formerly considered statistically significant. The mean ± standard deviation was used to express the results.

3. RESULTS AND DISCUSSION

3.1. Pasting Properties

Table 2 provides a summary of pasting characteristics made with the flour samples. The addition of the gums had a substantial impact on the pasting qualities of maize flour, as shown in the table, with the exception of pick time and pasting temperature.

Greater peak viscosity was seen in C_1 and C_2 than in maize flour combined with gums. When compared to its control counterpart, the peak viscosity of maize flour treated with 3 g HG was lowered by around 51%, as indicated in Table 2. Among the samples that were treated, samples treated with GG had a 430.50 RVU peak viscosity, followed by samples treated with HSG, which had a 487.50 RVU peak viscosity. Reduction in peak viscosity of the treated samples could be linked to the capacity of the gums to encapsulate starch granules and limit swelling during gelatinization process. Furthermore, the interactions between mixture's protein, fat and starch components as well as a decrease in starch may be the cause of the reduction in peak viscosity. The outcome agreed with previous findings [18].

According to the claim by previous researchers, interactions between the mixture's protein, fat, and starch components as well as a decrease in starch contribute to the reducing of the trough, break down, setback and, final viscosities [19]. Setback viscosity, which affects the texture of food products containing starch, is a good indicator of starch retro-gradation, or the re crystallization of amylose molecules. When starch paste cools, leached amylose molecules quickly combine to create the amylose connection zones of which then were to blame for the setback [20].

Gum addition significantly decreased the final, setback, trough, and breakdown viscosities of maize flour by 57.3, 15.2, 52.4, and 48.95 %, respectively. The combination of *HG* with maize flour showed reduced values of breakdown (16.85 RVU), setback (415.60 RVU), trough (332.90 RVU), and final (748.5 RVU) viscosities (Table 2).

Table 2 Effect of gums on pasting properties of control and treated flours

Pasting Sample	Parameters						
	Peak viscosity (RVU)	Trough Viscosity (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Pasting temperature (° C)	Pick-time (s)
C_1	1489.50 ± 0.71^{a}	815.50 ± 0.71^{a}	672.00 ± 2.83^{a}	1747.0 ± 0.0^{a}	928.50 ± 0.71^{a}	67.50 ± 0.70^{b}	89.51 ± 0.73^{b}
C_2	689.50 ± 0.71^{b}	579.00 ± 1.41^{b}	110.5 ± 0.71^{b}	1428 ± 0.71^{b}	849.50 ± 0.71^{b}	80.75 ± 0.35^{a}	94.95 ± 0.71^{a}
P_1	349.75 ± 0.35^{e}	332.90 ± 0.14^{e}	16.85 ± 0.21^{e}	748.5 ± 0.71^{e}	415.60 ± 0.85^{e}	80.50 ± 0.00^{a}	94.43 ± 0.11^{a}
P_2	487.50 ± 0.71^{c}	433.50 ± 0.71^{c}	54.00 ± 1.41^{c}	996.0 ± 0.00^{c}	562.50 ± 0.71^{c}	80.00 ± 0.00^{a}	94.90 ± 0.14^{a}
P_3	430.50 ± 0.71^{d}	408.50 ± 0.71^{d}	22.00 ± 1.41^{d}	873.00 ± 1.4^{d}	464.50 ± 0.71^{d}	79.90 ± 0.14^{a}	94.53 ± 0.35^{a}

All the values are mean ± standard deviation of triplicate analysis.
Means within the same column followed by different letter superscripts are different at 5 % level of significance.

The resistance of disintegration under heating and shearing is exhibited by the low breakdown viscosity displayed by the control and gum-treated maize flours. The creation of a gel network and the final viscosity of the cooled starch granules, especially amylose, indicate re-association during the chilling period after gelatinization [21].

The inclusion of gums had no discernible impact on the temperature of the paste or the pick-up time. However, it was discovered that maize flour, whether it included gum or not, had a substantially lower pasting temperature than wheat flour. The pasting temperature indicates the lowest temperature needed to cook the flour; the higher the pasting temperature, the more firmly connected and organized the starch granule structure will be [22].

In an earlier study, pasting characteristics of maize-starch were reported as 1836 cP, 2760 cP, 1074 cP, 924 cP, 2910 cP, 5.43 min and 75.80°C for trough viscosity, peak viscosity, set back viscosity break down viscosity, final viscosity, pick time and pasting temperature, respectively [23]. Pasting characteristics of the current study were less than the pasting characteristics reported in the previous study. In general, the low pasting property exhibited by dough combined with gums suggest they would be better suited for creating additional gluten-free product such as biscuit, cookies and cakes rather than to make gluten free bread of the same quality as wheat bread.

3.2. Farinographic, Gas release and Dough Development Properties

The results of dough farinography, out gassing character and dough spreading properties measured are shown in Table 3. As shown in this table, gums added at a 3 % concentration had a significant effect on the coloring properties of the dough. The control samples had significantly greater capacity to retain water than the gum treated one. Among the treated samples, GG treated sample had reduced water absorption capacity (52.95 %). Conversely though, HSG treated samples showed the maximum water-absorbing capacity (54.65 %). WAC of gum-treated samples may be due to low water-holding ability of the gum. According to pervious study, the incorporation of hydrocolloids (gums) increased the water-absorbing ability of rice flour from 60.5 % to 67 % [24]. Therefore, the results of this study did not match with prior findings due to the difference in water holding ability of gums used in present study and that used in previous study. The inclusions of gums greatly enhanced the maize flour's dough formation and stability times. The wheat dough produced the quickest development times (3.45 min), while the dough with HG produced noticeably longer development times (10.35 min).There was no noticeable difference found in the remaining dough samples [25]. A study on similar topic indicated that, dough protein level and dough development time are positively correlated, and strong dough has a longer dough development time [25]. Following the dough mixed with HG (16.55 min), the dough treated with GG had the high stability time (11.65 min). The stability value indicates the dough’s strength and specifies a duration at which the dough maintains its maximum consistency. Furthermore, previous study showed that the longer the stability, the higher the force needed for mixing and the bigger the fermentation tolerance [26]. The integrations of gums resulted in reduction in softness value. The dough treated with HG softened substantially less (90.50BU) than the others. Dough with a softness values between 80 and 100 BU is frequently considered adequate [27]. This is due to the fact that the earlier the weakening occurs, the shorter the fermentation time and the less abuse the flour can bear [26]. The low WAC and degree of softness of the dough incorporated with gums suggest that they may be better suitable for manufacturing other gluten free products such as biscuit, cookies and cakes rather than to make gluten -free bread of equivalent quality to wheat bread. The results of the gaseous release and dough development properties of the maize flour during fermentation showed that the additions of gums greatly affected the gaseous release and dough development properties. The increased retention coefficient of the maize flour dough could be attributed to the gums’ high gas retention ability. The inclusion of the gums greatly enhanced the Hm, H'm and h. The GG had a higher Hm (66.75 mm) than the other two gum types, although HSG had a higher H'm (7.00 mm) and h (3.10 mm). In terms of h values, there was no considerable difference between dough combined with HG (1.85 mm) and GG (1.65 mm). The h values obtained from present study agree with the findings of previous study [28].

Table 3 Effects of gums on farinographic, gas release and dough development parameters of maize flour dough

Farinographic samples		**Farinographic parameters**			
		WAC (%)	DDT (min)	Stability (min)	DS (BU)
C_1		61.55 ± 0.21^{a}	3.45 ± 0.07^{c}	3.45 ± 0.07^{c}	151.50 ± 0.71^{b}
C_2		59.20 ± 0.42^{b}	4.45 ± 0.35^{b}	4.60 ± 0.42^{c}	193.00 ± 8.49^{a}
F_1		53.00 ± 0.14^{d}	4.75 ± 0.63^{b}	16.55 ± 1.77^{a}	90.50 ± 0.71^{d}
F_2		54.65 ± 0.07^{c}	4.15 ± 0.07^{bc}	10.25 ± 0.07^{b}	121.50 ± 0.71^{c}
F_3		52.95 ± 0.07^{d}	10.35 ± 0.07^{a}	11.65 ± 0.07^{b}	96.50 ± 0.71^{d}
Gas release and dough development Parameters					
Rheofermentor samples	V_{CO2} (ml)	RC (%)	Hm (mm)	H'm (mm)	h (mm)
C_1	1858.00 ± 0.71^{a}	74.33 ± 0.01^{a}	76.00 ± 0.14^{a}	58.80 ± 0.14^{a}	$41.50\pm.71^{a}$
C_2	1358.75 ± 0.35^{e}	62.56 ± 0.20^{d}	52.35 ± 0.07^{e}	0.00 ± 0.00^{e}	0.00 ± 0.00^{d}
R1	1578.95 ± 0.07^{d}	65.77 ± 0.01^{b}	64.00 ± 0.14^{d}	6.15 ± 0.07^{d}	1.85 ± 0.07^{c}
R_2	1662.50 ± 0.71^{b}	65.61 ± 0.01^{b}	65.35 ± 0.07^{c}	7.00 ± 0.14^{b}	3.10 ± 0.14^{b}
R_3	1639.50 ± 0.71^{c}	64.52 ± 0.01^{c}	66.75 ± 0.07^{b}	6.65 ± 0.07^{c}	1.65 ± 0.07^{c}

F_1-HG treated farinographic dough; F_2-HSG treated farinographic dough; F_3-GG treated farinographic dough; R_1-HG treated rheofermentor dough; R_2-HSG treated rheofermentor dough and R_3- GG treated rheofermentor dough.

3.4. Physical Characteristics of Bread

3.4.1. Specific Volume of Bread

Table 4 demonstrates the influence of the plant-based gums on the loaf weight and loaf volume of the loaves manufactured. The addition of gums had a substantial impact on the loaf volume and specific volume of the bread. The wheat bread had the maximum loaf volume (399.93 cm^3) and specific volume (2.85 cm^3/g), whereas the maize bread had the lowest value for both parameters. A significant ($P<0.05$) difference in loaf and specific volume were observed among the breads. The breads made with GG dough had much larger loaf and specific volume than the maize bread, but it had significantly lower loaf and specific volume than the bread sample made with HG and HSG treated dough. There was also significant difference in the loaf and specific volume of bread made from HG and HSG treated dough. The disparities in loaf and specific volume among the bread samples could be linked to the changes in the gas retention, water holding capacity, and gums fiber concentrations. According to Asghar et al. [29], the addition of gums enhances the loaf volume and specific volume of the bread. many factors influence specific volume and , including water, fiber, starch, and protein content of the flour, as well as processing aid [30].

Table 4 Effects of gum types on the loaf weight and loaf volume of bread

Bread Samples	**Parameters**		
	Loaf weight (g)	Loaf volume (cm^3)	Specific-volume (cm^3/g)
C_1	139.83 ± 0.25^{e}	399.93 ± 0.11^{a}	2.85 ± 0.00^{a}
C_2	149.50 ± 0.71^{d}	200.10 ± 0.14^{e}	1.33 ± 0.00^{e}
T_1	152.90 ± 0.14^{b}	297.95 ± 1.20^{c}	1.94 ± 0.00^{c}
T_2	155.23 ± 0.38^{a}	314.87 ± 0.18^{b}	2.03 ± 0.00^{b}
T_3	151.80 ± 0.23^{c}	288.77 ± 0.32^{d}	1.90 ± 0.00^{d}

3.4.2. Bread Texture

Firmness is a textural property related with bread crumb and is defined as the bread crumb's ability to deform in response to compression force [31]. The results of the crumb firmness of the bread are shown in Figure 1. It can be seen from the figure that incorporation of gums considerably reduced the bread firmness. The maize bread had the highest firmness value (18.09 N), followed by bread made from the GG treated dough (17.393 N).

Significant differences were also observed among breads made from dough treated with gums. Wheat bread produced the softest bread; with firmness value of 8.078 N. The decrease in bread hardiness, when compared to the control maize bread, is due to the high water and gas retention capacity of the gums, which results in a greater porosity of bread. The result on bread hardiness obtained in present study agrees with previous work on similar topic [17].

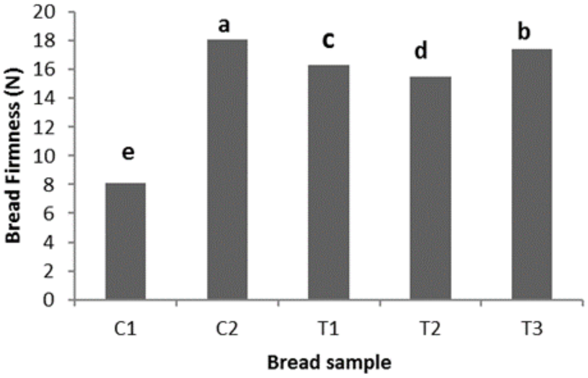

Figure 1 Effect of gums on the firmness values of breads

3.5. Proximate Chemical Composition and Sensory Attribute of Bread

Table 5 indicates the impact of various plant-based gums on the proximate composition, sensory properties, and overall acceptance of bread. It was discovered that the addition of gums had a significant influence on the bread moisture level. The wheat bread had the greatest moisture level (43.20 %), but it did not differ substantially from the HSG-treated dough bread.

The moisture level of bread manufactured from maize flour was much lower (35.95 %) than that of bread added with gums. The moisture content elevation of gum-containing bread could be linked to the gums' high water absorption ability when compared to maize bread. With respect to protein amount, wheat bread had a much greater protein content (13.71 g/100 g) compared to the others. According to the findings of this investigation, the inclusion of gums lowered the protein level of maize bread. However, there were statistically significant differences among the loaves made from gum-treated doughs.

When compared to the control and treated maize bread, the wheat bread had lower fat, ash, fiber, and total carbohydrate content. The inclusion of gums lowered the fat and total carbohydrate content of the maize bread while increasing the ash and fiber content. The maize bread had much higher fat value (2.72 g/100 g) than the GG treated dough bread sample. When compared to HSG (2.47 g/100 g) and HG (2.37 g/100 g), the bread sample made from GG dough had the lowest fat level (2.25 g/100 g) which could be linked to the variations in fat content among the gum types. The ash level of the maize bread (2.15 g/100 g) was similar to that of the breads made from HG (2.26 g/100 g) and GG treated doughs (2.26 g/100g), but it was less than that of the bread prepared from HSG treated dough (2.37 g/100 g) which indicates the mineral content of HSG is most probably greater than the maize flour and the other gums. The bread sample established from HSG treated dough, on the other hand, had much greater fiber level (7.61 g/100 g) than the samples prepared from the other gums.

There was significant difference in fiber content between bread sample prepared with

GG (7.04 g/100 g) and that prepared with HG (7.34 g/100 g). This difference could be linked to the difference in fiber content of the two gums. The maize bread exhibited the highest total carbohydrate content (49.94 g/100 g) compared to the samples of bread prepared from HG (47.89 g/100 g) and HSG (45.16 g/100 g) treated doughs, which shows the gums have lower carbohydrate contents than equal amount of maize flour. The moisture, ash, and fiber values agreed with previous study [19]. The higher fiber and ash contents of the maize bread may be attributed to the gums' high ash and fiber contents, whereas the higher moisture level might be related to the gums' water retention ability.

Wheat bread scored considerably ($p<0.05$) higher in all sensory attribute than the other bread samples. The addition of gums increased the scent, taste, flavor, and texture of the maize bread significantly. However, there were no considerable differences in color score between maize bread and breads made from dough treated with gums. In terms of scent, taste, and flavor, there were no discernible variations between the loaves created from treated doughs. The bread cooked with HSG has got a considerably higher texture level (6.6) than the bread made with HG (5.6) and GG (5.4). General acceptance was much greater for wheat bread, which was followed by breads made from HG and HSG treated doughs, respectively. In general, the control maize bread performed poorly in terms of most sensory qualities. The current findings were similar with previous findings [30], who discovered that gum Arabic improved the flavor and taste of bread. Similar studies have found that gum Arabic lowers the stiffness of bread [17]. The changes in various sensory qualities found among the bread samples, such as texture, could be attributed to variations in the WAC of the gums.

Table 5 Effect of gums on the proximate composition and sensory attribute and over acceptability maize bread

Bread Samples	Parameter					
	Moisture (%)	Protein (g/100 g)	Fat (g/100 g)	Ash (g/100 g)	Fiber(g/100 g)	CHO(g/100 g)
C_1	43.20 ± 0.56^{a}	13.71 ± 0.27^{a}	0.57 ± 0.01^{d}	0.94 ± 0.02^{c}	0.84 ± 0.01^{e}	41.18 ± 0.84^{d}
C_2	35.95 ± 0.35^{d}	9.23 ± 0.05^{b}	2.72 ± 0.04^{a}	2.15 ± 0.01^{b}	5.64 ± 0.06^{d}	49.94 ± 0.43^{a}
T_1	40.22 ± 0.01^{b}	7.28 ± 0.02^{c}	2.37 ± 0.08^{bc}	2.26 ± 0.08^{ab}	7.34 ± 0.04^{b}	47.89 ± 0.16^{b}
T_2	42.65 ± 0.30^{a}	7.36 ± 0.01^{c}	2.47 ± 0.08^{b}	2.37 ± 0.08^{a}	7.61 ± 0.01^{a}	45.16 ± 0.45^{c}
T_3	38.87 ± 0.49^{c}	7.26 ± 0.01^{c}	2.25 ± 0.08^{c}	2.26 ± 0.08^{ab}	7.04 ± 0.08^{c}	49.36 ± 0.65^{a}
Sensory attributes						
Bread Samples	Color	Aroma	Taste	Flavor	Texture	Overall acceptability
C_1	8.3 ± 0.16^{a}	7.8 ± 0.19^{a}	7.9 ± 0.22^{a}	7.8 ± 0.17^{a}	8.3 ± 0.17^{a}	7.9 ± 0.16^{a}
C_2	5.5 ± 0.16^{b}	3.5 ± 0.19^{c}	4.0 ± 0.22^{c}	3.6 ± 0.17^{c}	3.2 ± 0.17^{d}	3.4 ± 0.16^{d}
T_1	6.0 ± 0.16^{b}	5.8 ± 0.20^{b}	5.7 ± 0.23^{b}	5.5 ± 0.17^{b}	5.6 ± 0.17^{c}	6.1 ± 0.16^{b}
T_2	5.9 ± 0.16^{b}	6.0 ± 0.19^{b}	5.8 ± 0.22^{b}	5.9 ± 0.17^{b}	6.6 ± 0.17^{b}	6.0 ± 0.16^{b}
T_3	5.7 ± 0.16^{b}	6.0 ± 0.19^{b}	5.6 ± 0.22^{b}	5.5 ± 0.17^{b}	5.4 ± 0.17^{c}	4.5 ± 0.16^{c}

4. CONCLUSIONS

The rheological properties of dough and final quality of bread made from maize were altered by the addition of gums. Maize flours mixed with gums resulted in doughs having low water absorption capacity, peak viscosity, and degree of softening and high dough development time and stability. Even if the addition of gums into maize flour improved the dough development and gaseous release properties, the extent of improvement was still less than the properties obtained from wheat flour.

In terms of baking properties, breads containing gums had a higher loaf and specific volumes but lower firmness than breads made from maize flour alone. This suggests that the gums improve bread baking characteristics. Moreover, addition of gums improved the fiber and ash contents as well as the sensory properties of the breads. HSG produced the best dough characteristics and quality bread of the three gums tested.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge Ambo University and Addis Ababa Institute of Technology for the financial and material support.

REFERENCES

[1] Elkhalifa, A.B.D., Elmoneim, O., Mohammed Ashwag, M., Mustafa Mayada, A. and El Tinay Abdullahi, H. *"Use of guar gum and gum Arabic as bread improvers for the production of bakery products from sorghum flour"*, Food Science and Technology Research, vol. 13, 2007, pp. 327-331.

[2] Rostamin, M., Milani, J.M. and Maleki, G. "Physical Properties of Gluten-Free Bread Made of Maize and Chickpea Flour", International Journal of Food Engineering, vol. 10, 2014, pp. 467- 472.

[3] Meybodi, N., Mollakhalili Mohammadifar, M.A. and Feizollahi, E. "Gluten-Free Bread Quality : A Review of the Improving Factors", Journal of Food Quality and Hazards Control, vol. 2, 2015, pp. 81-85.

[4] Bhattacharya, S. and Shanthilal, J. "Rheology of Rice Flour Dough with Gum Arabic: Small and Large-Deformation Studies, Sensory Assessment and Modeling", Journal of Food Science, vol. 80, 2015, pp. 1735-1745.

[5] Tzia, C. and Sabanis, D, "Effect of hydrocolloids on selected properties of gluten-free dough and bread", Food Science and Technology International. vol. 17, 2011, pp.279-2911.

[6] Katjiuongua Hikuepi, B. and Asfaw Muleta, "Cereal Market Performance in Ethiopia: Policy Implications for Improving Investments in Maize and Wheat Value Chains", Agriculture Global Practice GFA13, 2018.

[7] Bourekoua, H., Różyło, R., Benatallah, L., Wójtowicz, Ł., Grzegorz, Z., Mohammed, N. and Sujak, A. "Characteristics of gluten-free bread: quality improvement by the addition of starches/hydrocolloids and their combinations using a definitive screening design", European Food Research and Technology, vol. 244, 2018, pp. 345–354.

[8] Sciarini, L.S., Ribotta, P.D., Leon, A.E. and Perez, G.T., "Incorporation of several additives into gluten free breads:Effect on dough properties and bread quality", Journal of Food Engineering, vol. 111, 2012, pp. 590-597.

[9] Rostamin Mohammad, M., Jafar, M. and Maleki, Gi. "Physical Properties of Gluten-Free Bread Made of Maize and Chickpea Flour", Journal of Food Science and Technology, vol.10, 2014, pp. 467–472.

[10] Camino, M. M., Cristina, M., Mario M. M. and Manuel, G. "Mixture design of rice flour , maize starch and wheat starch for optimization of gluten free bread quality", Journal of Food Science and Technology, vol. 52, 2015, pp. 6323-6333.

[11] Tadesse Wubalem, Getachew Desalegn and Ricardo, A., "Natural gum and resin bearing species of Ethiopia and their potential applications Natural gum and resin bearing species of Ethiopia", Investigación Agraria: Sistemas y Recursos Forestales, vol. 16, , 2007, pp. 211-221.

[12] Rao, M. A. and Mothe, C.G., "Thermal behavior of gum arabic in comparison with cashew gum", Thermochimica Acta, vol. 357, 2000, pp. 9-13

[13] AACC International., "Rheological Behavior of Flour by Farinograph: Constant Flour Weight Procedure", in AACC International Method, 54-21, 2011, pp.1-8,.

[14] Sidhu, Singh Jai Pal and Bawa, Amarinder Singh "Dough Characteristics and Baking Studies of Wheat Flour Fortified with Xanthan Gum", International Journal of Food Properties, vol. 5, 2007, pp.1-11.

[15] A.O.A.C., "Analytical methods for determination of moisture. ash,proteine, fat contene", 2000.

[16] Sharadanant R. and Khan K.,"Effect of Hydrophilic Gums on the Quality of Frozen Dough", Journal of Food technology, vol. 80, 2003, pp. 773-780.

[17] Sagbo, F. S. Y., Aissi, M. V., , Hounkpatin, W. A., Houedo, C., Dans, A. and Soumanou, M. M. "Physicochemical and pasting properties of some local and improved maize varieties cultivated in Benin", International Journal of Biological and Chemical Sciences ,vol. 11, 2017, pp. 1753-1765.

[18] Shahzad, S. A., Hussain, S., Mohamed, A. A., et. al., "Gluten-free cookies from sorghum and Turkish beans; effect of some non-conventional and commercial hydrocolloids on their technological and sensory attributes", Jouranl of Food Science and Technology, vol. 41, 2021, pp.15–24.

[19] Ocheme, Ocheme Boniface, Chinma,C hiemela Enyinnaya, Adedeji, Olajide Emmanuel, Yakubu, Caleb Maina and Ajibo, Ugochukwu Happiness, "Proximate composition, functional, and pasting properties of wheat and groundnut protein concentrate flour blends", Food Science and Nutrition, vol. 6, 2018, pp. 1-6.

[20] Chisenga, S.M., Workneh, T.S., Bultosa, G. and Laing, M., "Characterization of physicochemical properties of starches from improved cassava varieties grown in Zambia", Jouranal of Hydrocolloid, vol. 4, 2019, pp .939–966.

[21] Julianti, E., Rusmarilin, H., Ridwansyah, R. and Yusraini, E. "Functional and rheological properties of composite flour from sweet potato , maize, soybean and xanthan gum", Journal of the Saudi Society of Agricultural Sciences, vol.16, 2017, pp.171-177. doi.org/:10.1016/j.jssas.2015.05.005

[22] Eggleston G., Swennen R., and Akoni S., "Physicochemical studies on starches isolated from plantain cultivars, plantain hybrids and cooking

bananas", Starch-Stärke, vol. 44, 1992, pp. 121-128.

[23] Moses M. O. and Olanrewaju M. J., "Evaluation of functional and pasting properties of different maize starch flours", International Journal of Food Scince and Nutrition, vol. 3, 2018, pp. 95-99.

[24] Lazaridou, A. "Effects of hydrocolloids on dough rheology and bread quality parameters in gluten-free formulations", Journal of Food Engineering, vol. 79, 2007, pp.1033-1047

[25] Yaseen, A.A., Shouk, A.A. and Ramadan, M.T. "Maize-Wheat Pan Bread Quality as Affected by Hydrocolloids", Journal of American Science, vol. 6, 2010, pp. 684- 690.

[26] Chen, R.Y., Seabourn, B.W., Xie, F. and Herald, T.J., "A modified extensigraph method for evaluating dough properties of hard wheat breeding lines", Cereal Chemistry, vol. 86, 2009, pp. 582-589.

[27] Munteanu, M.G., Voicu, G., Ungureanu, N., Zăbavă, B.Ș., Ionescu, M, Constantin, G. and Istrate, I. "Methods for determining the characteristics of flour and dough", In 5th International Conference on Thermal Equipment, Renewable Energy and Rural Development, 2016, pp. 349-355.

[28] Sidhu, J. P. S., and Bawa, A. S. "Dough Characteristics and Baking Studies of Wheat Flour Fortified with Xanthan Gum", Interantional Journal of Food Properties, vol.5, 2007, pp. 1-11.

[29] Asghar, A., Traig, M.W., Anjum, F.M. and Hussain, S., "Effect of Carboxy Methyl Cellulose and Gum Arabic on the Stability of Frozen Dough for Bakery Products", Turkish Journal of Biology, vol. 29, 2005, pp. 237-241.

[30] Trappey, E.F., Khouryieh, H., Aramouni, F. and Herald, T., "Effect of Sorghum Flour Composition and Particle Size on Quality of Gluten-Free Bread", Food Science and Technolology International, vol. 21, 2015, pp.188-202.