Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.002923

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The function of maltodextrins and ziziphus gum in cake and cake batter

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Abstract

Commercial maltodextrins (MD) and ziziphus gum (ZG) have been investigated for their effects on cake quality and possible use in slowing the staling process. The effects of MD and ZG were assessed by analyzing the pasting properties of the wheat flour slurry, the properties of the dough, and the quality of the cake after baking and after three days of storage. The qualities of the gel texture were assessed using a texture profile analysis (TPA) test, the qualities of the dough and cake were assessed using the Micro-doughLab and the TA-TXT texture analyzer, respectively. The evaluation of overall acceptance, texture, aroma, taste, and color was also done using 9 points hedonic sensory methods. Overall, despite their impacts were not similar, MD and ZG had a considerable impact on the quality of the cake, the dough, and the cake batter. By lowering gel hardness, which is the opposite of MD's effect, and raising setback, which appears to support amylose retrogradation, ZG appears to limit amylose retrogradation. Less mixing tolerance index (MTI) and more stability were imparted in the dough by both ZG and MD. ZG and MD both significantly increased the cake volume, although MD did so more. Although the batter density was high, MD greatly increased cake volume. The cake's sensory parameter scores indicated that MD had a positive impact on it, and both the 2% MD blends and the control blends performed equally well in terms of general acceptance.

Keywords: maltodextrins; ziziphus; cake; texture; sensory.

Practical Application: Use of maltodextrin and ziziphus gum hydrocolloid can help to produce better quality bakery products like pan breads and cakes with respect to their dough and batter handling and acceptable sensory attributes. The use of these hydrocolloids improved their textural attributes and less staling during storage.

1 Introduction

Staling is a major issue in the baking industry. This complicated phenomenon arises from multiple physio-chemical events resulting in decrease in the palatability of baked products involves in deterioration in flavor and aroma, mouth feel, loss of crust crispiness and loss of crumb softness (increase in brittleness "crumbliness" of the crumb). These changes in both physical and chemical attributes give bread products a dry and leathery texture. During storage (especially at 4 °C) the textural properties of baked products deteriorated mainly due to starch (Amylose or Amylopectin) retrogradation (recrystallization of the starch molecules or transition from the amorphous state to the crystalline) and moisture loss and redistribution. To ensure prolonged freshness of baked products, it is recommended to use dough improvers. Complex baking improvers (CBI) are ingredients that contain diverse components based on the needed action such as reducing agents, enzymes, emulsifiers, gluten oxidizers and different additives or constitutes with specific impacts (Bilyk et al., 2020). When employed in tiny amounts (1%), hydrocolloids are predicted to increase water retention and bread loaf volume while decreasing stiffness and starch retrogradation (Collar et al., 1999). Hydrocolloid gums resulted in improvements of textural and sensory properties of gluten free cookies (Shahzad et al., 2020). The extremely hydrophilic nature of hydrocolloids also helps to minimize the formation of ice crystals and water migration during frozen storage, which enhances the dough's freeze/thaw stability (Fiszman & Salvador, 2003).

Dextrins are widely used in food processing such as a confectionary as coating to prevent sugar separation. In addition to give desired gloss to bakery products, whereas other dextrins are used for coating water insoluble materials such as fat and flavoring (Mason, 2009). Maltodextrins are water-soluble in cold water, have a bland taste that is low or non-sweet, and are non-hygroscopic and have good water-holding characteristics. They're used as flavor and seasoning spray-drying aids, taste enhancers, carriers for synthetic sweeteners, fat replacers, and bulking agents, among other things. Maltodextrins have a higher viscosity than syrups with a dextrose equivalent (DE) lower than 20, and are consequently favored for applications requiring cohesive and foam stabilizing qualities. Corn, potato, and rice starches are the three botanical sources of commercial maltodextrins (Wang & Wang, 2000). Due to intrinsic changes in their chemical structures, maltodextrins from diverse botanical sources may exhibit different qualities due to their different parent starches. A study found that the chemical structures of maltodextrins determine their physicochemical properties, and that maltodextrins from diverse

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Received 11 Jan., 2023
Accepted 31 Jan., 2023

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botanical sources had similar structures. Increased concentrations of high molecular weight (MW) saccharides in maltodextrins result in higher viscosity, less water sorption, higher freezing point, and a larger retrogradation propensity. At 40% solids, the presence of retrograded amylose increased the viscosity of rice maltodextrins. The physicochemical features of starch hydrolysates, such as retrogradation, are influenced by their distinctive chain lengths. The properties of commercial maltodextrins are effected by the chemical nature of parent starches and the processing conditions (Wang & Jane, 1994). The result of the study by Miyazaki et al. (2004) aimed to examine effect of dextrin on wheat flour, dough properties and bread qualities in addition to determine if dextrins hydrolyzed by yeast enzymes or by native α-amylase perform differently. Whereas, the study by Gerrard et al. (1997) showed starch retrogradation during storage affected by molecular of dextrins, where lower molecular weight dextrins (DE 19, 25 and 40) retarded retrogradation noticeably as compared to higher molecular weight dextrins (DE 3 and 8). This retrogradation of starch due to different types of dextrins was not reflected by softness of crumb. There are no significant differences in loaf volume baked with DE 25 or 40 compared to control at 7.5% substitution. While loaf volume was decreased by dextrins with DE 3, 8, 11 and 19 (Miyazaki et al, 2004).

Fruits from different species of Ziziphus (Rhamnaceae) genus are widely used in Asia as traditional medicine and food. The fruits are claimed to purify the blood and aid digestion (Thanatcha & Pranee, 2011). Among the bioactive constituents, polysaccharides may play an important role (Tripathi et al., 2001; Adeli & Samavati, 2015). The polysaccharide mucilage isolated from the Ziziphus are similar in rheological and functional properties as presented by xanthan and guar gum. The Ziziphus gum is being used as starch modifier and improve the dough handling and baking properties of breads and cakes (Mohamed et al., 2022a; Alamri et al., 2022).

Novel sources and applications for natural gums are a focus of current research. In this study, gum from Ziziphus fruit were extracted for use in cake formulation alongside malto-dextrins (MD). Therefore, the study will look at how the addition of ZG and MD will change the rheological, physical, and physicochemical properties of cake as well as the characteristics of the wheat flour batter. Despite the fact that MD or ZG have been shown to reduce amylose retrogradation, this research is seeking for a synergistic effect of these ingredients on cake quality while it is being stored.

2 Material and methods

2.1 Materials

Commercial maltodextrins (dextrose equivalent = 18), wheat flour (protein = 7.9%, moisture = 6.4%, ash = 0.3%, water absorption= 63.3%), salt, sugar, shortening, fat free mike powder, baking powder, vanilla, and eggs were purchased from the local supermarket, Riyadh, Saudi Arabia.

2.2 Ziziphus gum extraction

Extraction of ziziphus gum from the fruits was carried out according to the method followed by Alamri et al. (2022). After 3 minutes of steaming, the ziziphus fruits were carefully washed and destoned to stop the enzymes from turning them brown. Pulp was mixed for 1 minute with distilled water in a 1:3 ratio. The mixture was then strained through muslin cloth and spun at 3000 g for 20 minutes. The liquid left over after centrifuging the material was collected, made neutral, and freeze-dried. Freeze-dried gum was ground into powders, sifted through a 60-mesh sieve, and stored in sealed jars in the refrigerator until it was needed.

2.3 Preparation of flour mixtures

Wheat flour, maltodextrins and Ziziphus gum mixtures were prepared by replacement of the wheat flour with maltodextrins and Ziziphus gum at levels listed below in Table 1

2.4 Solvent retention capacity (SRC)

AACC method no. 56-11(American Association of Cereal Chemists, 2000), a standardized procedure, was used to determine the solvent retention capacity (SRC) of flour mixtures. Four different types of solvents were used in this experiment. Double distilled water, sugar (50% by volume), sodium bicarbonate (5% by volume), and lactic acid (5% by volume) are among them. In 30 mL centrifuge tubes, 25 milliliters of the prepared solvents were added to 1 gram of flour and centrifuged for 15 minutes at 3000 rpm. The weight of the gels (after decantation) was recorded in order to determine SRC values (percent) for each solvent, and the SRC values (%) for each solvent were represented as follows (Equation 1)

$$SRC\ (\%) = \frac{wet\ pellet(g)}{\left[flour\ weight(g)-1\right]}\ x\ \frac{86}{\left[100-flour\ moisture(\%)\right]}\ x100 \quad (1)$$

2.5 Pasting behavior of flour mixtures

Rapid Visco Analyzer (RVA) was used to measure flour mixes' pasting characteristics. The sample (3.5 g) was transferred to RVA canisters with distilled water to make 28.5 g. The slurry was heated to 95 °C at 12.16 °C/minute for 3.14 minutes from 50 °C. The combination was maintained at 95 °C for 2:30 minutes and then cooled to 50 °C at 11.84 °C/min. Thermocline window software was used to process data (Alamri et al., 2013).

Table 1. Composition of cake flour mixtures.

Mixtures	Wheat flour (%)	Maltodextrins (%)	Ziziphus gum (%)
CF0	100	-	-
CF1	98	2	-
CF2	98	-	2
CF3	98	0.5	1.50
CF4	98	1.00	1.00
CF5	98	1.50	0.50

CF0: control (100% cake wheat flour); CF1: 98% cake wheat flour + 2% maltodextrin; CF2: 98% cake wheat flour + 2% Ziziphus gum; CF3: 98% cake wheat flour + 0.5% maltodextrin + 1.5% Ziziphus gum; CF4: 98% cake wheat flour + 1% maltodextrin + 1% Ziziphus gum; CF5: 98% cake wheat flour + 1.5% maltodextrin + 0.5% Ziziphus gum.

2.6 Gel texture

Sandhu & Singh (2007) approach was used to gel RVA flour gels. The gels were held overnight at room temperature and pressed at 0.5 mm/s for 10 mm with a 12.7-mm-wide, 35-mm-long cylindrical probe. Hardness, cohesion, adhesiveness, springiness, gumminess, and chewiness were examined. Hardness, cohesion, elasticity, and adhesiveness were reported. Gumminess was computed from hardness and cohesiveness, and chewiness from gumminess and springiness.

2.7 Dough mixing properties

The Micro-doughLab was used to compute the optimal water absorption capacity for achieving a peak of 500 FU with a 4.00 ± 0.01 g sample at 14% moisture content. Twenty minutes were dedicated to testing samples at 63 rpm and 30 °C. The mixing curve was utilized to determine the dough's mixing tolerance index (MTI), dough development time (min), softening value (FU), dough stability time (min), and Farinograph quality number (American Association of Cereal Chemists, 2000).

2.8 Dough extensibility

Stable micro system (SMS)/Kieffer dough and gluten extensibility rig with TA-XT2 Plus texture analyzer with 50 kg load cell was used to measure extensibility. Flour was mixed with 2% salt and dough was made in a mixer based on dough development time and water absorption. After a rest of 40 minutes, dough roll was created. Then, it was placed on the oiled lower plate of the Teflon mold and crushed with clamps (Kieffer et al., 1998). The dough strips were placed on the device's sample plate. Texture Analyzer (TA-XT plus, Stable Micro Systems, Godalming, Surrey, UK) calibrated for 50 kg load cell to measure dough extensibility. The Kieffer rig's tensile test assessed extensibility using the following parameters: pre-test speed of 2.0 mm/s, test speed of 3.3 mm/s, post-test speed of 10.0 mm/s, distance of 75 mm, trigger force of 5 g, and data rate acquisition of 200 points per second.

2.9 Batter density

The prepared cake batters' density (in g/cm^3) was calculated by comparing the weight of a 50-mL graduated cylinder filled with batter to the volume of distilled water in the same cylinder at room temperature (Qasem et al., 2017).

2.10 Cake baking procedure

The cakes were baked using AACC method No. 10-90 (American Association of Cereal Chemists, 2000). 300 grams of flour, 300 grams of sugar, 60 grams of shortening, 300 grams of fresh eggs, and 12 grams of baking powder were used to make the cakes. The sponge cake was baked at 190 °C after all of the ingredients were mixed according to the recipe. The cooled cakes were sliced, stored, and used for further research.

2.11 Cake firmness

Cakes were stored at room temperature and the firmness was estimated on fresh and 72 hrs old samples. Cake firmness was determined using AACC (American Association of Cereal Chemists, 2000) method No. 74-09 on a central slice (total thickness 60 mm). For this purpose, a cylindrical probe (20 mm) mounted on a TA-TXT texture analyzer with a 50 kg load cell was used. The cakes were compressed to 25% strain, and the probe was held at this distance in the slice for 60 seconds before returning to its starting position and the percentage of springiness was calculated. The pretest and test speeds were set to 1.0 mm/sec for the experiment.

2.12 Crumb color of cakes

Crumb colors of cake samples were determined using Minolta color grader with a D65 light source. The measurements were made for L* (Lightness), a* (Redness), b* (Yellowness) color characteristics according to the method followed by Alamri et al. (2014).

2.13 Sensory evaluation of cakes

Sensory evaluation of cake samples was performed by a trained panel of judges comprising faculty members and graduate students of the department using a 9-point hedonic scale, with 9.0 representing extremely good and 1.0 representing extremely poor. The selected panelists (10) were asked to evaluate the cakes for parameters like aroma, taste, texture, crumb color, porosity and overall acceptability according to the method followed by Hosseini Ghaboos et al. (2018).

2.14 Statistical analysis

Each measurement was made three times, then averaged. The acquired data were analyzed using a one-way analysis of variance (ANOVA) to determine the significance (at $p \leq 0.05$) of the levels of maltodextrin and ziziphus gum on the rheological, baking quality, and sensory aspects of sponge cakes. The PASW® 18 software utilized the Duncan's multiple range (DMR) test to compare means.

3 Results and discussion

3.1 Pasting properties

Table 2 summarizes the pasting characteristics of the mixtures and the control flour. This research involved replacing some of the flour with ziziphus gum or maltodextrins (MD) (ZG). Peak viscosity (PV) of the control was reduced due to MD or ZG by about 9%. If starch is the primary contributor to PV, then the decrease in PV should have been 2%. This suggests that, in addition to the absence of flour, MD or ZG have a negative impact on the PV. Without distinction between the two treatments, MD and ZG at 2% both significantly lowered the PV ($p < 0.05$). No matter what their ratio, MD and ZG together reduced PV much further. Therefore, neither MD nor ZG had a greater overall impact on the synergy that their combination produced. PV could have decreased as a result of inhibited or accelerated granule swelling that led to faster or limited gelatinization. Literature reports indicated that, some gums boost PV while others reduce it. Okra gum was found to reduce the PV of many starches by preventing starch swelling, in contrast to gums like xanthan, guar, locust bean, alginate, and cordia gum that promoted granule swelling and enhanced the PV (Rojas et al., 1999; Alamri et al., 2012).

Increased viscosity during starch pasting has been connected to gum interactions with leached amylose molecules during the early phases of starch gelatinization, which may help to explain the positive effect of hydrocolloid on PV (Vedantam et al., 2021). The largest loss in PV was observed when 2% ZG was introduced (Table 2). The above results showed that the MD and ZG presence changed the maximum PV of the wheat flour paste, which was mainly caused by interactions between the MD and ZG and the starch granules. Maximum PV measures the ability of the starch granules to swell freely prior to physical breakdown; hence, starch with a high maximum PV also has a high swelling power. Although starch is the most important component of wheat flour in terms of pasting capabilities, additional elements in the flour alter the starch's capacity to paste when compared to pure starch. Due to this, some researchers have noted that there may be some interaction between the hydroxyl groups of the starch and the gum, but it is only limited to the flour suspension (Sudhakar et al., 1995). According to some researchers, the hydrocolloid is only present in the continuous phase, and as long as the starch granules swell, the concentration of the hydrocolloid in the continuous phase rises, leading to a large rise in the viscosity of the continuous phase. Other studies consider starch pastes to be continuous macromolecular mediums that contain swollen granule suspensions (Alloncle et al., 1989). Blends containing 2% ZG or an equal amount of MD and ZG showed a significant increase in setback. This demonstrates the ability of amylose to retrograde and create a structured network, which produced a stronger gel at 50 °C. The addition of MD to the flour suspension illustrates the interaction between amylose and the additional components, which is suggested by the low setback. It is anticipated that MD will diminish setback because it has been shown to reduce amylose retrogradation and shear stress (Katsuta et al., 1992). ZG samples and/or CG blends exhibited a significant reduction ($p < 0.05$) in breakdown and pasting temperatures, whereas 2% MD showed results similar to the control (Table 2). Higher xanthan gum concentrations were said to result in a further reduction in the pasting temperature (PT) (Rojas et al., 1999). Other gums than the ones studied here also exhibited this tendency. Because it signals the onset of starch gelatinization earlier, the PT decline is crucial. As a result, the amount of starch that can be used as an enzyme substrate during baking will increase, which will result in a smaller cake loaf volume.

3.2 Textural properties of flour blends

Data on the textural characteristics of flour gels are shown in Table 3. While the control showed 135 g hardness, the blend's gels hardness reading ranged from 127 g to 111 g. The data showed that the presence of 2% or 0.5% MD significantly reduced the hardness of the wheat gel, whilst the remaining blends demonstrated equal hardness to the control. The decrease in hardness was 18% and 17% for 2% and 0.5% MD, respectively. This means MD prevented amylose molecules to retrograde. The setback information from the earlier section does not support this. This is due to the fact that setback data is gathered at 50°C, where the gel's hardness was after it had been left at room temperature overnight. As seen for CF2 and CF4 in Table 3, a highest ZG concentration and the 50% ZG was more effective in lowering hardness. Hardness is mostly brought about by starch gel retrogradation (amylose molecules association), which is controlled by amylose and amylopectin chain rearrangement. This suggests that MD or ZG interfering with the creation of ordered structures during starch retrogradation by creating

Table 2. Effect of Maltodextrin and Ziziphus gums on the pasting properties of cake flour mixtures.

	Peak visc. (cP)	Breakdown (cP)	Final visc.	Setback (cP)	Pasting Temp (∘ C)
CF0	3253.33 ± 61.42^{a}	1062.67 ± 88.15^{c}	3718.33 ± 37.87^{a}	1527.67 ± 128.10^{b}	69.08 ± 0.46^{a}
CF1	3001.67 ± 47.72^{b}	1109.33 ± 47.50^{c}	3460.00 ± 38.97^{b}	1567.67 ± 60.72^{ab}	68.85 ± 0.95^{a}
CF2	2958.33 ± 18.34^{b}	1268.67 ± 91.48^{a}	3363.33 ± 45.24^{d}	1673.67 ± 80.03^{a}	65.23 ± 0.80^{d}
CF3	3015.33 ± 13.58^{b}	1233.33 ± 42.78^{ab}	3408.67 ± 12.58^{bcd}	1626.67 ± 42.85^{ab}	67.75 ± 0.05^{b}
CF4	2964.00 ± 19.97^{b}	1248.00 ± 43.51^{a}	3393.67 ± 10.50^{cd}	1677.67 ± 38.84^{a}	66.38 ± 0.40^{c}
CF5	3009.00 ± 17.69^{b}	1130.33 ± 29.67^{bc}	3433.33 ± 16.50^{bc}	1554.67 ± 44.74^{ab}	67.70 ± 0.09^{b}

cP = centipoise; CF0: control (100% cake wheat flour); CF1: 98% cake wheat flour + 2% maltodextrin; CF2: 98% cake wheat flour + 2% Ziziphus gum; CF3: 98% cake wheat flour + 0.5% maltodextrin + 1.5% Ziziphus gum; CF4: 98% cake wheat flour + 1% maltodextrin + 1% Ziziphus gum; CF5: 98% cake wheat flour + 1.5% maltodextrin + 0.5% Ziziphus gum. Values followed by different letters in columns are significantly different at $p \leq 0.05$.

Table 3. Effect of Maltodextrin and Ziziphus gums on the textural properties of gels obtained from cake flour mixtures.

	Hardness (g)	Gumminess (g)	Chewiness (g)	Springiness (mm)	Cohesiveness	Adhesiveness (mJ)
CF0	135.33 ± 4.50^{a}	67.71 ± 4.37^{a}	672.06 ± 32.07^{a}	9.93 ± 0.20^{a}	0.50 ± 0.017^{ab}	0.43 ± 0.43^{b}
CF1	127.33 ± 5.77^{a}	67.11 ± 4.71^{a}	663.91 ± 37.90^{a}	9.90 ± 0.20^{a}	0.53 ± 0.015^{a}	1.13 ± 1.13^{a}
CF2	111.00 ± 7.93^{b}	55.80 ± 2.73^{b}	546.92 ± 33.09^{b}	9.80 ± 0.26^{a}	0.50 ± 0.015^{ab}	1.37 ± 1.36^{a}
CF3	124.33 ± 2.51^{a}	57.99 ± 4.60^{b}	578.03 ± 47.32^{ab}	9.97 ± 0.05^{a}	0.47 ± 0.04^{b}	1.17 ± 1.16^{a}
CF4	112.33 ± 6.02^{b}	56.05 ± 0.53^{b}	560.41 ± 4.84^{ab}	10.00 ± 0.17^{a}	0.50 ± 0.03^{ab}	1.30 ± 1.30^{a}
CF5	134.33 ± 6.50^{a}	70.76 ± 6.62^{a}	628.87 ± 124.95^{ab}	8.83 ± 1.06^{b}	0.53 ± 0.04^{a}	0.57 ± 0.56^{b}

CF0: control (100% cake wheat flour); CF1: 98% cake wheat flour + 2% maltodextrin; CF2: 98% cake wheat flour + 2% Ziziphus gum; CF3: 98% cake wheat flour + 0.5% maltodextrin + 1.5% Ziziphus gum; CF4: 98% cake wheat flour + 1% maltodextrin + 1% Ziziphus gum; CF5: 98% cake wheat flour + 1.5% maltodextrin + 0.5% Ziziphus gum. Values followed by different letters in columns are significantly different at $p \leq 0.05$.

hydrogen bonds with amylose molecules may be the cause of the decrease in hardness. It is anticipated that MD and ZG will have a comparable effect on gel setback and gel hardness, which are results of amylose retrogradation. The samples with 1.5% MD recorded the least setback and a sample with 50% ZG produced the greatest setback, whereas the samples with 2% ZG and 50% ZG recorded the least gel hardness and the one with 1.5% MD the highest compared to the control. Because of this, the sample with the least setbacks is typically thought to have the desired performance. The measuring conditions are the cause of this disparity, as setback was measured at 50°C while hardness was assessed at room temperature. Adhesiveness is defined as the measure of the energy needed to overcome the forces of attraction between a food's surface and the surfaces of other materials it comes into direct contact with. Except for the 1.5% MD sample, all other blends significantly increased the adhesiveness of the flour gel. The gel adhesiveness evaluated ranged from 0.43 to 1.37 (m.J). Therefore, it required more effort to penetrate the gel in samples with higher ZG. Once again, samples containing ZG showed increased adhesiveness, replicating the effect of ZG on setback. With the addition of MD, cohesiveness significantly increased ($p > 0.05$), with the following order: CF5 > CF1 > CF4 > CF0 > CF2 or CF3. It is clear that samples containing ZG had the lowest cohesion. This demonstrates that the control gel and the MD-containing gel have higher resistance to degradation. The energy required to break down food before swallowing is directly reflected by gumminess, which is the product of hardness x cohesiveness. The control and samples containing MD had significantly more gumminess and hardness, which is consistent with the notion that gumminess depends on hardness and that ZG greatly reduced gumminess. These results are consistent with the pure wheat starch even though the wheat flour used in this experiment contains ingredients other than simply wheat starch. Certain gel properties evaluated in this study were concentration dependent, which means that changing the amount of MD added made a big difference in these variables.

3.3 Dough mixing properties

DoughLab was used to determine the dough mixing properties, as shown in Table 4. The amount of water needed to reach 500 BU in 2 minutes after mixing starts is known as water absorption (WA). The results of this investigation demonstrated that adding MD or ZG significantly decreased the amount of water needed for dough development, but that the effect on water absorption was stronger when ZG were added individually or in combination with MD. This information conflicts with observations in the literature that suggested that adding MD and gums to bread flour, which has a higher protein content, increased water absorption in comparison to the cake flour utilized in this study (lower protein content) (AbuDujayn et al., 2022). The WA value varies depending on how chemically the additional ingredients are made up and how well they can absorb water; additional ingredients with high WA values will prevent flour from absorbing water and forming the proper dough. There have been reports that gums like guar and cordia gum reduce WA of wheat flour (Linlaud et al., 2009). The amount of time needed after the addition of water and mixing flour dough for it to attain its maximum consistency is referred to as "dough development time" (DDT). The blend with 2% MD required the lowest DDT and the blend with 2% ZG required the highest, but the other blends including the control were remarkably similar. The DDT ranged from 0.77 to 0.83 min. This data was different from wheat flour samples based on bread flour. When MD and ZG are used together, this data is consistent with the literature; however, when MD and ZG are used separately, it is not. When MD and ZG are employed separately, the data presented here support the effects of k-carrageenan or HPMC; however, some researchers reported an increase in DDT when hydrocolloids like xanthan, alginate, or guar were added (Rosell, Rojas and De Barber 2001). When hydrocolloids are added, the DDT rises, and vice versa when the DDT is lowered, the dough matrix forms more slowly. The delay may be induced by the competition for water or by the interaction of developing gluten with MD or ZG. The dough's stability, which is determined by its ability to maintain its consistency over time, is a good indicator of its mechanical strength. Dough stability varied from 0.70 to 1.43 minutes (Table 4). The blend with 2% ZG showed the highest level of stability, but the other blends and the control showed no significant variation in stability. Overall, ZG appeared to contribute to dough stability more then MD. Since this is a low protein flour (Cake flour), the stability is much lower than bread flour. In contrast to MD, it may be concluded that ZG improved dough stability. The difference between the BU at the peak of the dough development curve and the value at the peak of the curve five minutes later is MTI, which measures dough softening during mixing. Because it shows how smoothly the flour mixes, an MTI value of 30 Brabender Units (B.U) or less is regarded as particularly good for bread wheat flours. A flour with an MTI more than 50 FU has a lower mixing tolerance and

Table 4. Effect of Maltodextrin and Ziziphus gums on the dough mixing properties of cake flour mixtures.

	WA as is (%)	DDT (min)	Stability (min)	Softening (FU)	MTI (FU)	FQN (mm)
CF0	56.67 ± 0.28^{a}	0.77 ± 0.05^{ab}	0.73 ± 0.1^{b}	218.23 ± 41.63^{a}	134.97 ± 30.35^{a}	26.57 ± 9.17^{a}
CF1	54.93 ± 0.11^{b}	0.73 ± 0.05^{b}	0.77 ± 0.20^{b}	194.90 ± 10.10^{a}	116.67 ± 10.40^{ab}	32.07 ± 2.65^{a}
CF2	54.33 ± 0.57^{c}	0.83 ± 0.05^{a}	1.43 ± 0.15^{a}	186.57 ± 7.63^{a}	101.67 ± 10.40^{b}	35.60 ± 2.34^{a}
CF3	54.80 ± 0.00^{bc}	0.80 ± 0.00^{ab}	0.97 ± 0.20^{b}	183.23 ± 10.40^{a}	103.33 ± 10.40^{ab}	35.50 ± 3.00^{a}
CF4	54.83 ± 0.288^{bc}	0.80 ± 0.00^{ab}	0.70 ± 0.10^{b}	194.90 ± 20.00^{a}	118.30 ± 17.51^{ab}	32.40 ± 5.65^{a}
CF5	55.07 ± 0.11^{b}	0.80 ± 0.00^{ab}	0.93 ± 0.11^{b}	184.90 ± 17.32^{a}	96.67 ± 12.58^{b}	36.47 ± 3.82^{a}

CF0: control (100% cake wheat flour); CF1: 98% cake wheat flour + 2% maltodextrin; CF2: 98% cake wheat flour + 2% Ziziphus gum; CF3: 98% cake wheat flour + 0.5% maltodextrin + 1.5% Ziziphus gum; CF4: 98% cake wheat flour + 1% maltodextrin + 1% Ziziphus gum; CF5: 98% cake wheat flour + 1.5% maltodextrin + 0.5% Ziziphus gum. WA = Water absorption; DDT = Dough development time; BU = Brabender units; MTI = mixing tolerance index; Farinograph Quality Number; Values followed by different letters in columns are significantly different at $p \leq 0.05$.

is more likely to cause problems with mechanical handling and dough formation. Since all samples including the control exhibited MTI more than 95 BU, this is a clear proof of a low protein flour suitable for cake and soft wheat products (Table 4). MTI has a range of 97 to 135 BU. The data presented here did not reveal any particular patterns, with the exception of the control showing the greatest MTI. Overall, compared to pure MD, ZG improved MTI, while 1.5% MD had the lowest MTI. Strong gluten hard red spring wheat flour's MTI was found to be decreased by gums such xanthan, guar, and alginate at 2% and higher, although alginate at 2% reduced MTI to zero BU, in contrast to the type of flour (soft wheat) utilized in this study (Simsek, 2009). These results, where MTI was decreased by MD or ZG, are supported by the data. The variation in MTI across the tested flours appeared to be mostly caused by the quantity of wheat protein present, as some high protein bread flour showed an increase in MTI due to MD or ZG (AbuDujayn et al., 2022), while other bread flour showed a decrease in MTI (Simsek, 2009). FQN is the distance in mm from the point of water addition to the point where the height at the curve's center has dropped by 20 BU along the time axis. Table 4's data didn't indicate a significant rise in FQN, but the control showed the lowest values and the mix with 1.5% MD the highest. Since bread flour exhibits FQN more than 60 mm, as described in a prior article, the maximum FQN of the flour utilized here is less than 40 mm, making it ideal for cake baking.

3.4 Wheat flour dough extensibility

The extensibility of the dough, which also helps to the uniformity and quality of the finished baked product, is its main strength. But understanding what is extensibility, is not enough. Extensibility of the dough is one aspect of a finely balanced act that begins with mixing. When the gluten matrix is developed, either extensible and elastic properties or the ability to stretch and restore its original shape, are established. If one of these qualities is stronger than the other, the dough won't function properly as it expands and contracts during the fermentation, proofing, or baking processes. Table 5 shows the results for dough extensibility (EX) and resistance to extension (RE). The sample's tensile strength, sometimes referred to as the elastic limit, is calculated from the highest peak force employed here to determine dough extensibility; the greater the value, the more elastic the dough is. The dough begins to deform once it reaches its elastic limit, and eventually breaks. Unlike bread flour, the development of soft wheat varieties for cake manufacturing would be easier if there was a closer link between the desirable dough properties of extensibility and strength. The data in Table 5, showed dough resistance to extension. The control samples, CF2 and CF3, showed the strongest resistance to extension, whereas CF1, CF5, and CF4 samples showed the least. Given that the samples with the lowest RE levels include more MD than ZG, the detrimental impact of MD on RE is readily apparent. As a result, ZG and RE are found to be in a positive relationship. The RE varied from 38 to 58 g, with the sample containing 2% ZG registering the highest RE and the sample containing 2% MD showing the lowest RE. Again, since RE or EX are not a consideration in cake baking, the RE of the flour used here is far lower than that of bread flour. The dough matrix is made up of two phases: a continuous phase symbolized by high molecular weight glutenin, which is formed as a result of the emergence of disulfide bonds and is illustrated by the elastic property, and a discontinuous phase represented by low molecular weight gliadin, which is indicated by the viscous property. MD and ZG are found in the discontinuous phase because they have a lower molecular weight than glutenin, which serves to balance the dough's extensibility and elasticity. Cake flour has a significantly lower Ex than bread flour, while samples with a greater MD concentration had the highest EX values. Ex ranged from 13.7 to 19 mm, and the order of the blends is CF5 > CF1 > CF4 > CF0> CF3 > CF2. Dough extensibility has been observed to be decreased by several gums, including xanthan gum. Based on the extensibility test and the results of this study, all blends will work well for baking bread, however mixes with 2% or 1.5% ZG will work best in cake baking.

Table 5. Effect of Maltodextrin and Ziziphus gums on the dough extensibility of cake flour mixtures.

	Resistance to Extension (g)	Extensibility (mm)
CF0	50.85 ± 1.28^{b}	15.82 ± 0.84^{bc}
CF1	37.93 ± 0.07^{e}	17.22 ± 1.32^{ab}
CF2	57.51 ± 1.19^{a}	13.74 ± 1.56^{c}
CF3	50.31 ± 0.24^{b}	15.35 ± 1.45^{bc}
CF4	45.64 ± 0.18^{c}	16.08 ± 1.13^{bc}
CF5	43.57 ± 0.24^{d}	19.22 ± 2.66^{a}

CF0: control (100% cake wheat flour); CF1: 98% cake wheat flour + 2% maltodextrin; CF2: 98% cake wheat flour + 2% Ziziphus gum; CF3: 98% cake wheat flour + 0.5% maltodextrin + 1.5% Ziziphus gum; CF4: 98% cake wheat flour + 1% maltodextrin + 1% Ziziphus gum; CF5: 98% cake wheat flour + 1.5% maltodextrin + 0.5% Ziziphus gum. Values followed by different letters in columns are significantly different at $p \leq 0.05$.

3.5 Solvent retention capacity (SRC)

In order to detect the better swelling behavior of specific polymer networks in a limited number of diagnostic solvents, the SRC test is a solvation assay for flours. Its purpose is to determine the functional contribution of each unique flour component. The original purpose of SRC testing was to evaluate the performance of soft wheat flour (Table 6). Most of the active components in flour include damaged starch, gluten proteins, and arabinoxylans. Ultimately, all water-absorbing components have an impact on the flour's water retention capacity (WRC). The properties of the gluten protein are related to the lactic acid retention capacity (LARC), the amount of damaged starch is related to the sodium carbonate retention capacity (SCRC), and pentosans are associated to the sucrose retention capacity (SuSRC). While MD had no effect on WRC, adding ZG significantly ($p \leq 0.05$) decreased the WRC of the flour regardless of the additional level. The WRC varied from 76 to 96, with 2% ZG accounting for the most of the drop. Again, compared to bread flour, soft wheat flour (cake flour) was less influenced by MD or ZG gum because adding MD or ZG decreased the WRC, whereas adding MD and ZG to bread flour raised the WRC. The WRC of bread flour was boosted by other gums like cordia (Mohamed et al., 2022b). The effect of SuSRC showed no significant difference between the control and the blends, but a drop in SuSRC of the blends was lower than the control. The SCRC of the blends, which is connected to flour starch damage, was greatly decreased by the 1.5% ZG or (1% MD +

Table 6. Effect of Maltodextrin and Ziziphus gums on the Solvent retention capacity properties of cake flour mixtures.

	WRC	SuSRC	SCRC	LARC	GPI
CF0	96.08 ± 5.54^{a}	113.22 ± 13.75^{a}	101.90 ± 6.43^{a}	120.56 ± 20.74^{a}	0.56 ± 0.11 ^{b}
CF1	96.09 ± 6.25^{a}	101.59 ± 3.48^{a}	95.78 ± 9.64^{ab}	133.11 ± 19.08^{a}	0.68 ± 0.09 ^{ab}
CF2	76.19 ± 5.73^{b}	91.80 ± 26.62^{a}	89.05 ± 12.85^{ab}	114.75 ± 27.10^{a}	0.63 ± 0.11 ^{ab}
CF3	77.11 ± 4.21^{b}	95.78 ± 19.83^{a}	85.68 ± 1.06^{b}	121.48 ± 10.07^{a}	0.68 ± 0.13 ^{ab}
CF4	84.45 ± 3.18^{ab}	99.45 ± 6.77^{a}	84.76 ± 4.24^{b}	137.09 ± 1.41^{a}	0.74 ± 0.02 ^{a}
CF5	85.68 ± 16.66^{ab}	107.71 ± 7.81^{a}	90.27 ± 7.80^{ab}	141.68 ± 15.26^{a}	0.72 ± 0.03 ^{ab}

CF0: control (100% cake wheat flour); CF1: 98% cake wheat flour + 2% maltodextrin; CF2: 98% cake wheat flour + 2% Ziziphus gum; CF3: 98% cake wheat flour + 0.5% maltodextrin + 1.5% Ziziphus gum; CF4: 98% cake wheat flour + 1% maltodextrin + 1% Ziziphus gum; CF5: 98% cake wheat flour + 1.5% maltodextrin + 0.5% Ziziphus gum. WRC = Water retention capacity; SuSRC = Sucrose retention capacity; SCRC = Sodium carbonate retention capacity; LARC = lactic acid retention capacity. GPI = gluten performance index. Values followed by different letters in columns are significantly different at $p \leq 0.05$; GPI= lactic acid SRC/(sodium carbonate SRC + sucrose SRC)

1%) ZG combination when compared to the control, whereas the SCRC of the other mixes was comparable to each other but significantly lower than the control. With regard to a variety of end-use applications, including cake baking, the behavior patterns of the SCRC values are connected to the effectiveness of flour in baking. Because starch damage is a significant issue that affects cake quality, as cake volume is mostly defined by starch quality, as opposed to bread, where protein is the key factor that defines the bread's final quality. Since protein is not a decisive factor on the quality of soft wheat, the LARC values as expected indicated no significant difference between the control and mixes. According to Guttieri et al. (2001), soft wheats with relatively high LARC values have strong gluten and are excellent for flatbread, whereas those with low LARC values have weaker gluten and are best for pastries. Table 6 displays the control and blends' gluten performance indexes (GPI). The mixes with 1.5 MD and 1% + 1% MD and ZG had the highest GPI among all the samples, as was to be expected, and this was in line with the dough stability found in Table 4. The following is the order of the GPI data: 1% MD > 1.5 ZG > 2% MD > 2% ZG > 1.5% MD > control. GPI has proven to be a highly accurate predictor of gluten's overall performance in a setting where flour polymer networks are in control.

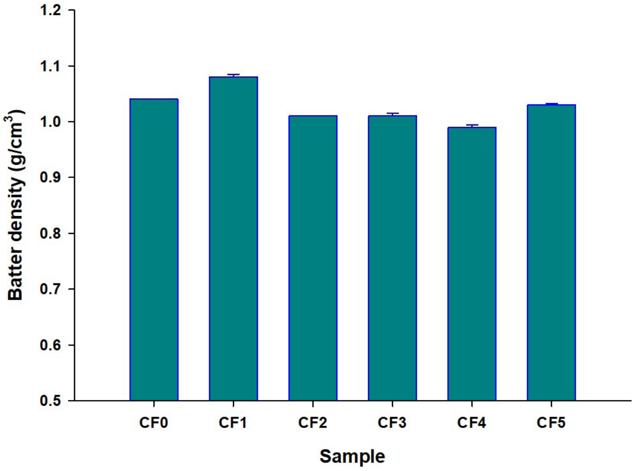

Figure 1. Effect of Maltodextrin and Ziziphus gums on the batter density of different flour mixtures. CF0: control (100% cake wheat flour); CF1: 98% cake wheat flour + 2% maltodextrin; CF2: 98% cake wheat flour + 2% Ziziphus gum; CF3: 98% cake wheat flour + 0.5% maltodextrin + 1.5% Ziziphus gum; CF4: 98% cake wheat flour + 1% maltodextrin + 1% Ziziphus gum; CF5: 98% cake wheat flour + 1.5% maltodextrin + 0.5% Ziziphus gum.

3.6 Batter density (g/cm^3) and cake volume

In batter preparation, one of the main functions of fat is to trap air during the creaming step of cake making, but MD appears to do the opposite where higher MD (CF1) reduces entrapped air leading to higher batter-viscosity and density. Similar effect of insoluble fiber on cake batter characteristics was also reported by (Gómez et al., 2007). Batter density values shown in Figure 1 ranged between 0.99 and 1.08 g/cm^3, indicates significant differences among treatments. The increase in the density of the batter could be attributed to the increase in viscosity caused by the 2% MD. No significant difference between CF0 and CF5 in addition to no significant difference between CF1 and CF2. The effect of MD on batter density was more pronounced in the presence of MD compared to ZG, whereas the blend of 1% MD+1%ZG exhibited the least density. According to reports in the literature, adding okra gum to cake batter caused the density to rise in proportion to the okra gum percentage, resulting in a low cake volume. The information provided here demonstrated that a rise in density brought on by MD increased the volume of the cake (Figure 1). This discrepancy arises from the cake system, where high density reduces volume in a cake system prepared with the addition of water, yet cake prepared with eggs rather of water exhibited volume reduction at greater batter viscosity. In addition to having various chemical structures, maltodextrins and okra gum were used in varied cake formulations.

Cake volume is one of the most important quality factors because it has an impact on how customers will react to the final product. Additionally, the ingredients used, particularly those that directly affect batter aeration and foam stability, like the fat level, have an effect. Compared to samples containing 1% cordia gum, cake samples containing 2% cordia gum had a larger volume. On the other hand, reports in the literature have indicated that ziziphus gum has a beneficial effect when used alone, which could be attributable to this gum's impact on batter viscosity, causing it to delays air diffusion and makes it possible to be held early in the baking process (Alamri et al., 2022). In this study, the presence of MD decreased the effectiveness of ZG (Table 7). Furthermore, the high batter density brought on by MD, as seen in Figure 1, did favorably affect the cake volume. Moreover, ZG had cake volume larger than the control, but

Table 7. Effect of Maltodextrin and Ziziphus gums on the volume and weight of cake samples.

	Cake Volume (cm^3)	Cake Weight (g)	Specific Volume (cm^3/g)
CF0	340.67 ± 2.89^{f}	271.83 ± 5.66 ^{b}	1.25 ± 0.02 ^{e}
CF1	591.67 ± 2.89 ^{b}	274.60 ± 9.35 ^{ab}	2.16 ± 0.07 ^{a}
CF2	371.67 ± 2.89 ^{e}	273.90 ± 1.91 ^{ab}	1.36 ± 0.02 ^{d}
CF3	511.67 ± 2.89 ^{c}	284.00 ± 4.00 ^{a}	1.80 ± 0.03 ^{b}
CF4	461.67 ± 2.89 ^{d}	279.07 ± 5.13 ^{ab}	1.65 ± 0.02 ^{c}
CF5	601.67 ± 2.89 ^{a}	277.20 ± 2.99 ^{ab}	2.17 ± 0.07 ^{a}

CF0: control (100% cake wheat flour); CF1: 98% cake wheat flour + 2% maltodextrin; CF2: 98% cake wheat flour + 2% Ziziphus gum; CF3: 98% cake wheat flour + 0.5% maltodextrin + 1.5% Ziziphus gum; CF4: 98% cake wheat flour + 1% maltodextrin + 1% Ziziphus gum; CF5: 98% cake wheat flour + 1.5% maltodextrin + 0.5% Ziziphus gum. Values followed by different letters in columns (under cake) are significantly different at $p < 0.05$.

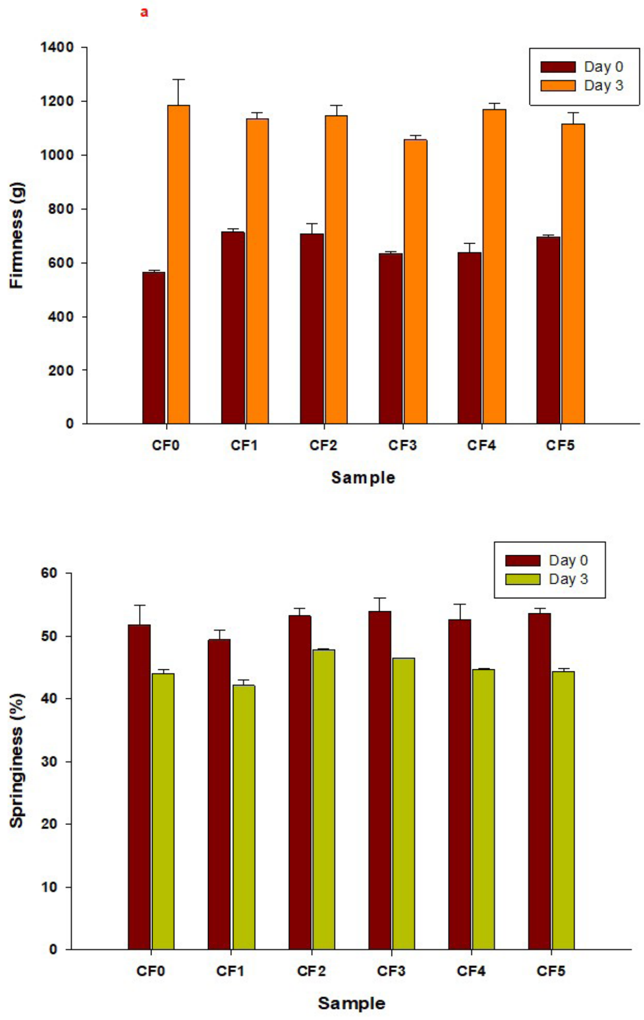

Figure 2. Effect of Maltodextrin and Ziziphus gums on the firmness of samples. a= Firmness; b= springiness; CF0: control (100% cake wheat flour); CF1: 98% cake wheat flour + 2% maltodextrin; CF2: 98% cake wheat flour + 2% Ziziphus gum; CF3: 98% cake wheat flour + 0.5% maltodextrin + 1.5% Ziziphus gum; CF4: 98% cake wheat flour + 1% maltodextrin + 1% Ziziphus gum; CF5: 98% cake wheat flour + 1.5% maltodextrin + 0.5% Ziziphus gum.

MD or 1.5% MD mixes had the largest cake volume; synergy between MD and ZHG was not observed. Significant cake weight differences were found between the blends and the controls, with the 1.5% ZG cake having the highest weight and the control having the lowest. Due to the fact that MD and ZG help the cake mix retain moisture when baking, the inclusion of these substances significantly increased cake weight. As a result of the relationship between the starch gelatinization temperature and batter viscosity, raising the gelatinization temperature raises cake volume. For instance, it was observed that pectin and cellulose derivatives (HPMC) lowered batter viscosity whereas xanthan and guar gums increased it by raising the starch gelatinization temperature (Gómez et al., 2007). We previously stated that ziziphus gum raised the gelatinization temperature of wheat starch (Mohamed et al., 2022a), implying that the addition of ziziphus gum would enhance cake volume. The data presented here did confirm this notion.

3.7 Cake firmness and springiness

Figure 2 displays the cake firmness after Zero or 3 days of storage. Regardless of concentration and storage time, the data demonstrated that the cake was firmer when MD and ZG were present. Despite the fact that there was no significant variance in firmness between samples with 2% MD or ZG and the 1.5% MD, these samples had the maximum firmness. After three days, the control and the sample with an equal amount of MD and ZG both showed the highest levels of firmness, whereas the remaining samples demonstrated lower levels of firmness with no noticeable variation. The control (1183 g) was the firmest, whereas the sample (1.5% MD) was the least firm (1114 g). Alginate and locust bean gums were observed to inhibit cake firmness whereas xanthan and guar gums were reported to increase cake firmness (Paraskevopoulou & Kiosseoglou 1997). This suggests that cake firmness is dependent on the hydrocolloid type with regards to their ability to hold moisture and prevent amylose retrogradation. The rate at which a material recovers to its original state once a deforming force is removed is known as springiness. It represents an evaluation of elastic recovery. It is the texture quality that baked products like cake typically have. Regardless of storage time, samples with gum exhibited much more springiness. The sample with 2% MD had the least springiness after zero day storage, followed by the control, 2% ZG, and 1%+1% MD and ZG. The highest springiness was observed under 1.5% MD and 1.5% ZG. Overall, compared to zero day, the cake's springiness was significantly less after 3 days of storage. Additionally, the effect of the gum after three days was different from its effect after zero days; 2% MD was more successful at reducing springiness. Because the cake loses its capacity to expand back to its former size and becomes denser after compression, lowering the springiness is viewed as a drawback in the cake's quality. Of course, a sample's firmness, which determines how much force is required to compress it, may not be a good indicator of how quickly the energy used to deform the cake will be recovered. As in the case of the CF1 (2% MD) sample shown in Figure 2 after zero day, a sample may exhibit high firmness and low springiness. With the exception of CF2 (2% ZG), the same was true for all samples, where high firmness resulted in low springiness.

3.8 Cake color

Table 8's variation in color values of the cake demonstrates how the presence of gums altered the cake's crumb's color. With the exception of the 1.5% MD, samples with additional gum were darker (lower L*) than the control. L* displayed a 71-76 range, with CF1 showing 71 and CF5 (1.5% MD) showing 76. The darker color of the crumb looks to be caused by ZG without having any noticeable effects from the concentration of ZG. Red color was most prominent in the darkest sample and least apparent in the lightest. The red color came in at positions CF2 > CF3 > CF1 > control > CF5. The CF5 and the control showed the most red and the lightest color, respectively.

The samples' levels of yellowness were significantly reduced, with the control having the highest levels and the CF2 and CF4 having the lowest.

3.9 Sensory Evaluation of the cake

Figure 3 displays the mean results of the hedonic sensory evaluation of cake produced with MD and ZG gum. The findings revealed no significant difference ($p < 0.05$) between the cake made with MD, ZG, or a combination of the two and the control. The examined quality parameters had a score ranging from 7.11 to 8.00 for aroma, taste 7.56-8.33, texture 7.22-8.22, crumb color 7.00-8.22, porosity 7.00-8.33 and overall acceptability 7.11-8.22. The range was noticeably narrow, with the control receiving the top marks solely for the color of the crumb and overall acceptability, while blends 1.5% MD received the greatest marks for aroma, texture, and porosity.

Table 8. Effect of Maltodextrin and Ziziphus gums on the crumb color parameters of cake samples.

	L*	a*	b*
CF0	75.88 ± 1.95^{a}	-3.92 ± 0.33 ^{d}	26.56 ± 1.64 ^{a}
CF1	72.40 ± 0.96 ^{b}	-2.88 ± 0.25 ^{c}	25.61 ± 0.71 ^{ab}
CF2	71.00 ± 0.55 ^{b}	-1.73 ± 0.35 ^{a}	23.57 ± 0.43 ^{c}
CF3	73.29 ± 1.27 ^{b}	-3.06 ± 0.197 ^{c}	24.00 ± 2.91^{bc}
CF4	73.30 ± 1.49 ^{b}	-2.35 ± 0.26 ^{b}	22.97 ± 0.81^{c}
CF5	76.51 ± 1.51^{a}	-4.17 ± 0.27^{d}	24.51 ± 1.09 ^{bc}

CF0: control (100% cake wheat flour); CF1: 98% cake wheat flour + 2% maltodextrin; CF2: 98% cake wheat flour + 2% Ziziphus gum; CF3: 98% cake wheat flour + 0.5% maltodextrin + 1.5% Ziziphus gum; CF4: 98% cake wheat flour + 1% maltodextrin + 1% Ziziphus gum; CF5: 98% cake wheat flour + 1.5% maltodextrin + 0.5% Ziziphus gum. L* = lightness; a* = green/red; b* = blue/yellow; Values followed by different letters in columns are significantly different at $p \leq 0.05$.

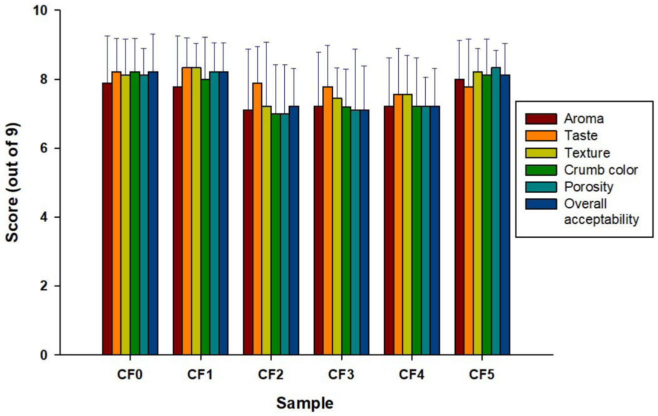

Figure 3. Effect of Maltodextrin and Ziziphus gums on the sensory evaluation score of cake samples. CF0: control (100% cake wheat flour); CF1: 98% cake wheat flour + 2% maltodextrin; CF2: 98% cake wheat flour + 2% Ziziphus gum; CF3: 98% cake wheat flour + 0.5% maltodextrin + 1.5% Ziziphus gum; CF4: 98% cake wheat flour + 1% maltodextrin + 1% Ziziphus gum; CF5: 98% cake wheat flour + 1.5% maltodextrin + 0.5% Ziziphus gum.

4 Conclusions

The control flour utilized in this study is ideal for cake baking based on the dough stability, dough development time, and MTI measurements because these parameters are very different for bread flour. The dough mixing properties in the presence of ziziphus gum were improved, with good dough stability and low MTI being observed. Both MD and ZG, as well as its combination, decreased the doughLab's water absorption. The control had the highest MTI and the second-lowest dough stability. In addition to the high setback caused by ZG, the RVA data demonstrated a considerable reduction in the peak and final viscosity of the flour. ZG reduced the starch's pasting temperature, which is crucial for cake volume and shows a negative impact on the final cake volume. The final Cake volume reflected this. After starch gelatinization, ziziphus gum did not appear to interact with amylose, but it did disrupt the amylose network by softening the gel. The testing conditions, where setback was measured at 50 °C and gel hardness at room temperature, can be used to explain this discrepancy. However, in the data reported here, a high density batter due to MD produced a high cake volume, which is attributable to the various cake formulations utilized here (high eggs content) and the literature (more water and less egg). All blends exhibited cake volume higher than the control. After storage for few hours, the blend's cake firmness increased, but after 3 days the control was firmer. Unlike ZG, when MD was added to the formulation, the cake color was lighter. The overall cake acceptability of the control and the blends was not different but samples with MD scored higher.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

The authors extend their sincere appreciation to the Deanship of Scientific Research project at King Saud University for supporting the work through College of Food and Agricultural Sciences Research Center.

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