Enhancing arabic bread quality and shelf life stability using bread improvers

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Abstract Arabic breads is produced mainly from hard red winter wheat (HRWW) and have relatively little crumb, dense texture, form pocket and are often round with golden brown crust color. The objectives of this research were to investigate the effect of different bread improvers combinations addition in enhancing the quality parameters of Arabic bread. Therefore, the ability of Arabic bread for rolling, folding and overall quality were evaluated during the Arabic bread storage period for 2 days. It was found that there was significant effect of bread improvers combinations (Arabic gum “AG” * Mongglycerides “MG” *alpha-amylase) addition on the ability of Arabic bread for rolling and folding on the second day ($P \leq 0.1$). The highest white Arabic bread quality was obtained significantly from addition of low AG, high of MG and high alpha-amylase combination and high AG, low of MG and high alpha-amylase combination. While, low of AG, high of MG and low alpha-amylase combination and high of AG, high of MG and low alpha-amylase combination significantly exhibited the highest overall quality for the Arabic bread made from whole flour.

Keywords Arabic bread quality · Shelf life · Improvers · Arabic gum · Mono glyceride · Alpha amylase

Introduction

Arabic bread is flat with round shape, forms pocket during baking, and has a golden brown crust color (Qarooni 1990). Flat (Arabic) breads are made mainly from hard red winter wheat (HRWW) and have relatively little crumb, dense texture and are often round (Faridi 1988). Different additives, different extraction rates and different proteins content were used in the Arabic bread production (Rubenthaler and Faridi 1981; Qarooni 1987a, 1988a, 1990; Quail et al. 1991; Williams and El-Harmein 1989). It is known that Arabic bread stales fast. Staling could cause moisture transfer from crumb to crust causing crumb drying (Shaikh et al. 2007). Also, staling could be due to the starch re-crystallization (Retrogradation) or other bread components (e.g. gluten, protein and pentosans) but the extent and the nature of their contribution to staling is still unknown (Stauffer 1990). However, various additives can be used to improve the dough properties and bread quality in the bakery industry (Benejam et al. 2009).

During baking, different emulsifiers and surfactants can be used to retain the moisture in heat coagulated gluten to give initial crumb softening (Waldt 1968; Kamel and Ponte 1993). Surfactants can be used to reduce or replace shortening (Rogers and Hoseney 1983) and retard firming in bread (Morad and D’Appolonia 1980; Dziezak 1988). Also, the emulsifier interacts with the starch molecules and granules to slow the rate of the recrystallization which may lead to increase the crumb softness retention (Junge et al. 1981). Emulsifiers which are obtained from the fatty acids can be added to the dough with up to 0.5 % on a flour basis (Bloksma and Bushuk 1988). Monoglycerides are the primary anti-staling additives it accounts for about one-third of the emulsifiers used in the baking industry (Stauffer 2000).

Currently enzymes also play an important role in baking technology (Guilbot and Godn 1984; Shah et al. 2006;

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Grausgruber et al. 2008; Almeida and Chang 2012). Showed the amount of enzyme required depends on the quality of the flour and on the bread making process as well as on the desired softness. The rate of development of firmness was decreased in the presence of the enzyme (Dragsdorf and Varrino-Marston 1980). The amylases have the ability hydrolyze the damaged starch. These damaged granules are susceptible to amylase in dough prior to baking (Kulp and Ponte 1981).

Hydrocolloids gums such as methylcellulose and carboxymethyl cellulose (CMC) are able to retard the migration of moisture to the bread surface and thus retard its staling process during storage (Fennema 1996; Rosel et al. 2001; Gray and Bemiller 2003). According to, the hydroxyl groups in the hydrocolloid structure allow more water interactions through hydrogen bonding in wheat dough. Furthermore, the addition of CMC, hydroxyl-propylmethyl cellulose (HPMC), enzymes and emulsifiers to bread dough improves its water absorption, mainly because of the high binding capacity of hydrocolloids (Armero and Collar 1996; Davidou et al. 1996; Sidhu and Bawa 2002; Azizi and Rao 2003; Asghar et al. 2005). The low viscosity gum Arabic is an excellent water binder (Anderson and Andon 1988).

Farvili et al. (1995) investigated the effect of emulsifiers on the Arabic bread quality. It was found that a higher quality Pita bread can be produced by using low concentration (0.25 %) of sodium stearyl-2-lactylate compared to the control and the other treatments which contain glycerol mono-stearate and di-acetyl tartaric acid esters of monoglycerides. Al-Eid, (2000) investigated the effects of monoglycerides and alpha amylase with ascorbic acid on the final quality of Arabic bread. It was found that Arabic bread supplemented with MG had significantly higher evenness of layers, grain appearance and grain uniformity which increased significantly the overall score compared with other treatments. All of the supplemented pita breads did significantly varied from the control in their ability for rolling, folding and tearing. However, these properties decreased upon storage. The penetrometer reading (penetrated distance) was significantly lower for the second than the first day of storage as a result of staling of pita bread for all treatments. Abu-Ghoush et al. (2008a, 2008b) found that the texture analysis, near-infrared spectroscopy and sensory evaluation results indicated that the improver combination (HPMC, High fructose corn syrup “HFCS”) addition significantly can improve the quality attributes and extend the shelf life Arabic bread quality.

Arabic bread is produced from formulas and processing techniques that are different from those used in the production of white pan bread and has large surface area and is baked at higher temperatures and short time than white pan bread. The differences in baking for Arabic bread, as compared with pan bread, result in substantial changes in the bread characteristics. It is wrong to recommend the same types of bread improvers for both pan bread produce and Arabic bread to produce

similar quality (Aleid Al-Eid 2000). Thus the objective of this study was to investigate the effects of Arabic gum (AG), Monoglycerides (MG) and alpha-amylase on the quality properties for Arabic breads made from white flour (80 % extraction) and whole wheat flour (95 % extraction) to minimize staling adverse consequences and improve quality parameters as well as prolonging shelf life of the Arabic bread.

Material and methods

Materials

Hard wheat flour from Yecora Rojo variety was obtained from (Grain Silos & Flour Mills Organization; Dammam, Saudi Arabia). Two types of flour were extracted, the white flour with 80 % extraction rate and whole flour with 95 % extraction. Commercial Safe-instant dry compressed yeast was used in the study. Three types of bread improvers were used. First, Arabic gum (E-414 from Sigma Company) was added at two different concentrations (0.5 % and 1.0 %) based on flour dry weight. Second, a blend of distilled monoglycerides “GMS-90” double strength kosher (American Ingredients company, USA) containing not less than 90.0 % monoglycerides was added at three different concentrations (0.5 %, 1.0 % and 2.0 %) based on flour dry weight. Third, alpha-amylases “Alphamelt V.C 5000” (Mühlenchemie GmbH Company, Germany) was added at three different concentrations (0.00625 %, 0.0125 % and 0.0250 %) based on flour dry weight. Those additives are generally recognized as safe. The three examined bread improvers were randomized in eighteen baking trials for flour with 80 % extraction (Table 1), and in eight baking trials for flour with 95 % extraction (Table 2).

Moisture, ash, wet gluten and protein, were determined using (AACC 2000) standard methods 44–16 A, 08–03, 56–81B and 46–13, respectively. Water absorption of the flours was determined using (AACC 2000) Farinograph test 54–21 (C.W Brabender Instruments, Inc., South Hackensack, N.J.). Gluten index test was determined using (AACC 2000) Glutomatic test 56–81B (Perten Instrument AB, Stockholm, Sweden). Falling Number was determined using (AACC 2000) Perten instrument (model 1700, Hagberg, Sweden).

Experimental design and statistical analysis

An experiment involving two flour types with three replications were used. The emulsifier, Arabic gum and enzyme as well as flour combinations selected for each day were completely randomized. A randomized complete block design was used in order to investigate the relative contributions of emulsifier, Arabic gum and enzyme on Arabic bread quality. A multiple comparison statistical procedure, using Fisher's least significant difference (LSD) procedure, and General

Table 1 Improvers types and concentrations used in white Arabic bread production (80 % Extraction)

Improver ^a	Arabic Gum (g)		MonoGlyceride (g)			α -Amylase (g)		
	Low (0.5 %)	High (1.0 %)	Low (0.5 %)	Medium (1.0 %)	High (2.0 %)	Low (0.00625 %)	Medium (0.0125 %)	High (0.0250 %)
T1	3.5	–	3.5	–	–	0.042	–	–
T2	3.5	–	3.5	–	–	–	0.084	–
T3	3.5	–	3.5	–	–	–	–	0.168
T4	3.5	–	–	7.0	–	0.042	–	–
T5	3.5	–	–	7.0	–	–	0.084	–
T6	3.5	–	–	7.0	–	–	–	0.168
T7	3.5	–	–	–	14	0.042	–	–
T8	3.5	–	–	–	14	–	0.084	–
T9	3.5	–	–	–	14	–	–	0.168
T10	–	7.0	3.5	–	–	0.042	–	–
T11	–	7.0	3.5	–	–	–	0.084	–
T12	–	7.0	3.5	–	–	–	–	0.168
T13	–	7.0	–	7.0	–	0.042	–	–
T14	–	7.0	–	7.0	–	–	0.084	–
T15	–	7.0	–	7.0	–	–	–	0.168
T16	–	7.0	–	–	14	0.042	–	–
T17	–	7.0	–	–	14	–	0.084	–
T18	–	7.0	–	–	14	–	–	0.168

^a Weight of improver based on (700 g) flour

Linear Model (GLM) to determine the interaction effect among independent variables using (SAS software ver.6.11. SAS Institute, Cary, NC, USA) were performed (Petersen 1985). All reported data are on the average of three replicates. Separation of means among all external and internal quality parameters were analyzed using least significant parameters, Fisher's (LSD) test (Petersen 1985).

Arabic bread baking

Arabic Bread was made according to Qarooni et al. (1987). Dry ingredients [flour 700 g, salt 7 g 1.0 % and instant active

dry yeast 7 g 1 %] were mixed at low speed for 1 min using Hobart mixer Model A-120 (The Hobart Manufacturing Company, Tory, Ohio). Water was added at 30 °C and mixed for 2.0 min at low speed. Then, the mixing speed was changed to medium for 4.0 min. After one hour of bulk fermentation at 30 °C and 85 % relative humidity (R.H), the dough was divided into pieces of 60 g, rounded by hand, covered with plastic sheet and allowed to relax for 15 min in the same fermentation cabinet. Dough pieces were flattened by hand and cross sheeted (0.8 mm thickness). All sheeted doughs were put in a wooden boards and transferred into proofing cabinet for 30 min at 30 °C and 85 % R.H. The proofed dough

Table 2 Improvers type and concentrations used in whole wheat Arabic bread production (95 % Extraction)

Improver ^a	Arabic Gum (g)		MonoGlyceride (g)		α - Amylase (g)	
	Low (0.5 %)	High (1.0 %)	Low (0.5 %)	High (2.0 %)	Low (0.00625 %)	High (0.0250 %)
T1	3.5	–	3.5	–	0.042	–
T2	3.5	–	3.5	–	–	0.168
T3	3.5	–	–	14.0	0.042	–
T4	3.5	–	–	14.0	–	0.168
T5	–	7.0	3.5	–	0.042	–
T6	–	7.0	3.5	–	–	0.168
T7	–	7.0	–	14.0	0.042	–
T8	–	7.0	–	14.0	–	0.168

^a Weight of improvers based on (700 g flour)

pieces were put on a pre-heated solid aluminum tray and baked at 425 °C for 100 s. The baked loaves were cooled for 15 min and wrapped in plastic bags, Qarooni et al. (1989). The scoring system used for evaluating Arabic bread quality was based on a numerical scale reported by Qarooni et al. (1987). In all cases, the better quality of the Arabic breads has the higher loaf's score.

Sensory evaluation of arabic bread

Arabic Bread quality evaluation was performed by sensory assessment. The panelists were 13 volunteers, consumers of Arabic bread, nonsmokers, aged 19–38 years. The Panelists were selected from undergraduate students, laboratory technician's members of the College of Agriculture and Food Science, King Faisal University. The Panelists were trained about the evaluation procedures prior to the Arabic bread evaluation in both written and verbal formats (Qarooni et al. 1987). Panelists evaluated the required Arabic bread loafs after one hr of baking and on the next day. Bread staling was evaluated by sensory analysis after 1 h of baking and 24 h for Arabic breads stored at room temperature (25 °C). Each attribute of the Arabic bread was scored from 1 to 10 from poor to excellent, respectively.

Results and discussion

Chemical and physical characteristics of flour

The two types of the wheat flours were analyzed for protein, moisture and ash (Table 3). The average protein content was 13.4 % and 15.0 % for 80 % and 95 % extraction rate flour, respectively. Quail (1990) reported that the high extraction flours may have protein with higher content than the low extraction rate flour. Qarooni et al. (Qarooni et al. 1988) found the optimum flour protein content for Arabic bread was 10–12 % while Quail et al. (1991) found flour with protein content of 9–12 % was suitable.

Table 3 Chemical and physical characteristics of flours

Parameter	80 % Extraction	95 % Extraction
Protein (%) ^a	12.9 %±0.27	14.3 %±0.35
Moisture (%)	10.9 %±0.30	9.7 %±0.40
Ash (%)	0.65 %±0.03	1.75 %±0.04
Falling Number (sec)	447±4.5	492±2.5
Farinograph Water-absorption% (corrected to 14 % moisture)	66.6 %±1.07	65.7 %±5.03

^a The average results of triplicate (± SD) based on 14 % moisture

The Farinograph water absorption for 80 % and 95 % extraction flours was 66.6 % and 65.7 % (corrected to 14 %), respectively. Dough development time for 80 % and 95 % extraction flours was 7.5 and 8.7 min. respectively. Stability time for 80 % and 95 % extraction flours was 10.5 and 11.8 min. respectively. Quail et al. (1991) reported that water absorption should be high enough for flours which are used for the Arabic bread production with expected Farinograph values ranging from 58 % to 65 %. Although, Qarooni (Qarooni et al. 1988) found that the preferred water absorption should be about 60 % . The falling number for flours with 80 % and 95 % extraction was 447 and 492 s respectively (Table 3). Brain (2005) indicated that a falling number value of 350 s or longer refers for low enzyme activity and very sound wheat. Also, it was found that as the amount of enzymes activity increase, the falling numbers decrease. Values below 200 s indicate high level of enzyme activity.

Flour with 95 % extraction exhibited high wet gluten weight (31.8 g) compared to flour with 80 % extraction (29.71 g) (Table 4). Similar observations were noticed for the passed thru results. On the other hand, the gluten index value and dry gluten for flour with 80 % extraction were 99.36 and 11.85 respectively while the gluten index value and dry gluten for flour with 95 % extraction were 98.01 and 10.5 respectively.

Arabic Bread Features Baked from White Flour (80 % Extraction)

Effect of the selected bread improvers (Arabic gum, mono-glyceride, and alpha-amylase) and their interactions on quality of Arabic bread made from white flour and whole wheat flour can be shown in the following (Tables 5, 6, 7, 8, 9 and 10).

Size, shape and smoothness

The F-factors (GLM) analysis shows the interaction effect of bread improvers on the Arabic bread from white flour which can be seen in Table 5. There was no interaction (AG*MG*alpha-amylase) effect on size values of Arabic bread.

Arabic bread with high level of AG, low level of MG and low level alpha amylase (Treatment #10) exhibited a significant reduction in the Arabic bread size compared to the other treatments. However, there was strong (AG*MG*alpha-amylase) interaction effect ($P \leq 0.05$) on the shape values of Arabic bread. The results indicated significant variations in the Arabic bread shape among all the treatments (Table 6). Treatments 1 and 12 exhibited the highest shape values compared to all other treatments. There were no significant differences in the smoothness values of white Arabic breads among different combinations of bread improvers (AG*MG*alpha-amylase). However, the interaction effect of (MG*alpha-

Table 4 Gluten test of flours

Flour type	Wet gluten weight (g)	Passed thru G.I Sieve (g)	Gluten index %	Dry gluten (g)
80 % extraction ^a	29.71	0.0206	99.36±0.09	11.85
95 % extraction ^a	31.8	0.053	98.01±0.02	10.5

^a The average results of triplicate and calculation based on 14 % moisture basis

amylase) on the white bread smoothness was significant ($P \leq 0.01$) as can be seen in Table 5. As can be seen, treatments 2, 15, 16, and 18 exhibited the highest smoothness values compared to the other treatments. Al-Eid (2000) reported that Arabic bread containing alpha-amylase was significantly low in crust smoothness, shape and evenness of layers than Arabic bread loaves without improvers.

Crust color, blisters and pocketing

It was found that there was a high significant ($P \leq 0.05$) effect of the Arabic gum addition alone on the crust color on Arabic bread as can be seen in Table 5. However, two treatments out of 18 exhibited the significantly highest crust color value compared to all other treatments. The first treatment was the Arabic bread with high level of AG (1.0 %), medium level of MG (1.0 %) and low level of alpha-amylase (0.00625 %) combination (treatment 13, Table 6). The second treatment was the Arabic bread with low level of AG (0.5 %), high level of MG (2.0 %) and high level of alpha-amylase (0.0250 %) combination (treatment 9, Table 6). Also, it was found that the effect of alpha-amylase alone was significantly high ($P \leq 0.05$)

on the blisters of the Arabic white bread (Table 5). However, three treatments out of 18 exhibited the significantly highest blisters score (Table 6). The first treatment was the Arabic bread with high level of AG (1.0 %), high level of MG (2.0 %) and high level of alpha-amylase (0.025 %) combination (treatment 18). The second treatment was the Arabic bread with high level of AG (1.0 %), low level of MG (0.5 %) and low level of alpha-amylase (0.00625) combination (treatment 12). The third treatment was the Arabic bread with low level of AG (0.5 %), high level of MG (2.0 %) and high level of alpha-amylase (0.025 %) combination (treatment 9).

Ability for rolling and folding on day one, day two and pocketing

The ability of Arabic bread for rolling and folding were evaluated for the first and the second day. There was no significant effect due to the (AG*MG*alpha-amylase) on the rolling and folding features of Arabic bread on the first day, while the same combination showed a significant effect on the rolling and folding on the second day ($P \leq 0.1$) (Table 5). However, the interaction of (AG*alpha-amylase) showed

Table 5 F- factors (general linear model) of white bread (80 % Extraction)

Dependent variable	AG	MG	α	AG ^a α	MG ^a α	AG ^a MG	AG ^a MG ^a α
Size	N/S	N/S	N/S	N/S	N/S	N/S	N/S
Shape	N/S	12.9 ^b	N/S	N/S	3.28 ^b	N/S	3.14 ^b
Smoothness	N/S	N/S	6.94	N/S	5.03 ^c	N/S	N/S
Crust color	19.84 ^b	N/S	N/S	N/S	N/S	N/S	N/S
Blisters	N/S	N/S	3.65 ^b	N/S	N/S	N/S	N/S
Rolling & folding day (1)	N/S	N/S	N/S	2.45 ^a	N/S	N/S	N/S
Pocketing	N/S	N/S	N/S	N/S	N/S	N/S	N/S
Crumb texture	N/S	N/S	2.67 ^a	N/S	N/S	N/S	2.09 ^a
Crumb appearance	N/S	N/S	N/S	N/S	N/S	N/S	2.07 ^a
Evenness of layers	N/S	N/S	N/S	N/S	N/S	N/S	N/S
Tearing day (1)	N/S	N/S	N/S	N/S	2.55 ^a	N/S	N/S
Rolling & folding day (2)	N/S	N/S	N/S	N/S	N/S	6.11 ^a	2.03 ^a
Tearing day (2)	N/S	N/S	4.36 ^b	N/S	5.59 ^c	6.11 ^a	2.47 ^a
Total Score	N/S	N/S	N/S	N/S	N/S	N/S	2.91 ^b

^a Significant at $p \leq 0.1$ MG monoglycerides

^b Significant at $p \leq 0.05$ AG arabic gum

^c Significant at $p \leq 0.01$ α alpha amylase

Table 6 Effect of different treatments on the external properties of white bread (80 % Extractions)

Treatments	AG	MG	α	Size	Shape	Smoothness	Crust color	Blisters	Rolling day (1)	Pocketing
TC	—	—	—	5 ^a	4.6 ^{cadbe}	4.1 ^{cde}	3.6 ^{cb}	4.6 ^b	6.2 ^{de}	8.7 ^{cab}
T1	3.5 g	3.5 g	0.042 g	5 ^a	4.9 ^a	4.8 ^{cab}	4.1 ^{cab}	4.6 ^a	7.8 ^{cadbe}	8.1 ^{cab}
T2	3.5 g	3.5 g	0.084 g	5 ^a	4.8 ^{ab}	5 ^a	4.5 ^{ab}	4.6 ^a	7.4 ^{cadbe}	8.7 ^{cab}
T3	3.5 g	3.5 g	0.168 g	5 ^a	4.3 ^c	4.4 ^{cadbe}	4.0 ^{cab}	4.2 ^{ab}	7.1 ^{cdbe}	8.7 ^{cab}
T4	3.5 g	7.0 g	0.042 g	5 ^a	4.6 ^{cadbe}	4.6 ^{cadb}	4.0 ^{cab}	4.0 ^{ab}	8.1 ^{cadb}	9.4 ^{ab}
T5	3.5 g	7.0 g	0.084 g	5 ^a	4.2 ^c	4.4 ^{cadbe}	4.1 ^{cab}	4.4 ^{ab}	7.7 ^{cadbe}	9.0 ^{cab}
T6	3.5 g	7.0 g	0.168 g	5 ^a	4.7 ^{cadb}	4.9 ^a	4.4 ^{ab}	4.6 ^a	7.0 ^{cdbe}	7.7 ^{cab}
T7	3.5 g	14 g	0.042 g	5 ^a	4.2 ^c	4.2 ^{cdbe}	4.4 ^{cab}	4.4 ^{ab}	8.9 ^{ab}	9.6 ^{ab}
T8	3.5 g	14 g	0.084 g	5 ^a	4.6 ^{cadbe}	3.8 ^c	3.7 ^{cb}	4.3 ^{ab}	6.5 ^{de}	6.7 ^c
T9	3.5 g	14 g	0.168 g	5 ^a	4.8 ^{cab}	4.9 ^{ab}	4.8 ^a	4.9 ^a	8.9 ^{cab}	9.8 ^{ab}
T10	7.0 g	3.5 g	0.042 g	4.7 ^b	4.7 ^{cadb}	4.7 ^{cadb}	4.0 ^{cab}	4.1 ^{ab}	7.0 ^{cdbe}	7.8 ^{cab}
T11	7.0 g	3.5 g	0.084 g	5 ^a	4.8 ^{ab}	4.7 ^{cadb}	3.5 ^c	4.2 ^{ab}	7.0 ^{cdbe}	8.8 ^{cab}
T12	7.0 g	3.5 g	0.168 g	5 ^a	4.9 ^a	4.9 ^{ab}	4.3 ^{cab}	4.7 ^a	9.3 ^a	10.0 ^a
T13	7.0 g	7.0 g	0.042 g	5 ^a	4.4 ^{cde}	4.0 ^{de}	4.9 ^{cab}	4.0 ^{ab}	7.2 ^{cadbe}	9.0 ^{cab}
T14	7.0 g	7.0 g	0.084 g	5 ^a	4.4 ^{cdbe}	4.4 ^{cadbe}	3.9 ^{cab}	4.6 ^a	7.8 ^{cadbe}	9.1 ^{cab}
T15	7.0 g	7.0 g	0.168 g	5 ^a	4.6 ^{cadbe}	5 ^a	4.1 ^{cab}	4.5 ^a	6.9 ^{cdbe}	7.3 ^{cb}
T16	7.0 g	14 g	0.042 g	5 ^a	4.6 ^{cadbe}	5 ^a	3.7 ^{cb}	4.0 ^{ab}	5.8 ^c	9.0 ^{cab}
T17	7.0 g	14 g	0.084 g	5 ^a	4.3 ^{be}	4.0 ^{de}	3.9 ^{cab}	4.1 ^{ab}	7.2 ^{cadbe}	10.0 ^a
T18	7.0 g	14 g	0.168 g	5 ^a	4.8 ^{cab}	5 ^a	4.4 ^{cab}	4.7 ^a	6.8 ^{cde}	7.6 ^{cab}

Within each column means with same letter(s) are not significantly different at $P < 0.05$

MG Monoglycerides; AG arabic gum; α alpha amylase

significant effect on the ability of Arabic bread for rolling and folding ($P \leq 0.1$) on the first day. Arabic bread with high of AG (1.0 %), low of MG (0.5 %) and high alpha-amylase (0.025 %) combination (treatment # 12) value exhibited the highest value on the ability for rolling and folding in both the first and the second day (Table 7). Reported that alpha-amylase tends to improve shelf life by producing low molecular weight dextrin.

Also, there was no significant combined effect on the quality of pocketing formation of the Arabic bread due to the (AG*MG*alpha-amylase) (Table 5). Al-Eid (2000) investigated the effect of MG alone on Arabic bread quality, and found that breads supplemented with MG alone had significantly higher evenness of layers, grain appearance and grain uniformity, leading to significantly increased overall score.

Crumb texture and crumb appearance

There was a significant interaction effect (AG*MG*alpha-amylase) on the crumb texture as well as on the crumb appearance of the Arabic bread ($P \leq 0.1$) (Table 5). Arabic bread made from white flour in the presence of high level of AG (1.0 %), high level of MG (2.0 %) and medium level of alpha-amylase (0.0125) combination (treatment 17) significantly exhibited the highest crumb texture and crumb appearance values compared to all treatments (Table 7). Kulp and

Ponte (1981) reported that alpha-amylase is known to improve bread texture.

Evenness of layers, tearing day one and tearing day two

Arabic breads showed a marked significant variation in evenness of layers among all treatments (Table 7). Arabic bread made from white flour in the presence of high level of AG (1.0 %), high level of MG (2.0 %) and low level alpha-amylase (0.0625) combination (treatment 16) significantly exhibited the highest value of evenness of layers among all treatments (Table 7).

The ability of Arabic bread for tearing in an acceptable manner was evaluated for the first and the second days. It was found that there was no significant interaction effect due to (AG*MG*alpha-amylase) on the tearing feature of Arabic white bread in the first day. However, there was strong interaction effect of (MG*alpha-amylase) on the ability of Arabic white bread to be torn in a good manner ($P \leq 0.1$) on the first day (Table 5).

Arabic bread made from white flour in the presence of high level of AG (1.0 %), low level of MG (0.5 %) and low level of alpha-amylase (0.00625) combination (treatment 12) significantly exhibited the highest evenness of layers value among all treatments (Table 7). On the other hand, the interaction effect of (AG*MG*alpha-amylase) showed a significant effect on the tearing on the second day ($P \leq 0.1$) (Table 5). In addition, the interaction of (AG*MG) showed a significant effect on the ability of Arabic white bread to be torn in a good manner ($P \leq$

Table 7 Effect of treatments internal characteristic of white bread (80 % Extraction)

Treatment	AG	MG	α	Crumb texture	Crumb appearance	Evenness of layer	Tearing #1	Rolling day (2)	Tearing #2	Total score
Tc	—	—	—	4.1 ^{cadb}	4.3 ^{cab}	4.6 ^{cab}	9.7 ^{cab}	15.2 ^{ab}	9.0 ^a	46.9 ^{cab}
T1	3.5 g	3.5 g	0.042 g	4.4 ^{cadb}	4.4 ^{cab}	4.2 ^{cab}	8.7 ^{cadb}	13.2 ^b	6.6 ^c	41.5 ^{cab}
T2	3.5 g	3.5 g	0.084 g	4.5 ^{cadb}	4.4 ^{cab}	4.4 ^{cab}	9.8 ^{ab}	14.4 ^{ab}	6.6 ^c	44.1 ^{cab}
T3	3.5 g	3.5 g	0.168 g	3.7 ^{cdb}	3.8 ^{cb}	3.9 ^{cb}	8.4 ^{cdbe}	14.4 ^{ab}	7.4 ^{cb}	41.6 ^{cab}
T4	3.5 g	7.0 g	0.042 g	4.4 ^{cadb}	4.3 ^{cab}	4.4 ^{cab}	9.3 ^{cadb}	12.8 ^b	8.2 ^c	43.4 ^{cab}
T5	3.5 g	7.0 g	0.084 g	4.2 ^{cadb}	4.2 ^{cab}	4.1 ^{cab}	9.0 ^{cadb}	12.8 ^b	6.6 ^c	40.9 ^{cb}
T6	3.5 g	7.0 g	0.168 g	3.6 ^d	3.6 ^c	3.6 ^{cb}	8.9 ^{cadb}	14.0 ^{ab}	6.6 ^c	40.3 ^{cb}
T7	3.5 g	14 g	0.042 g	4.7 ^a	4.7 ^a	4.2 ^{cab}	8.8 ^{cadb}	14.8 ^{ab}	7.0 ^c	44.2 ^{cab}
T8	3.5 g	14 g	0.084 g	4.0 ^{cadb}	4.0 ^{cab}	4.2 ^{cab}	7.2 ^c	14.4 ^{ab}	7.0 ^c	40.8 ^{cb}
T9	3.5 g	14 g	0.168 g	4.6 ^{ab}	4.6 ^{ab}	4.7 ^{ab}	9.7 ^{cab}	16.4 ^a	8.6 ^{ab}	48.6 ^{ab}
T10	7.0 g	3.5 g	0.042 g	4.1 ^{cadb}	3.9 ^{cab}	3.9 ^{cb}	9.2 ^{cadb}	14.4 ^{ab}	7.2 ^{cb}	42.7 ^{cab}
T11	7.0 g	3.5 g	0.084 g	4.2 ^{cadb}	4.2 ^{cab}	4.3 ^{cab}	9.3 ^{cadb}	12.4 ^b	6.2 ^c	40.6 ^{cb}
T12	7.0 g	3.5 g	0.168 g	4.5 ^{cadb}	4.6 ^{ab}	4.7 ^{ab}	9.9 ^a	17.2 ^a	8.4 ^{ab}	49.3 ^a
T13	7.0 g	7.0 g	0.042 g	4.1 ^{cadb}	4.4 ^{cab}	4.1 ^{cab}	8.1 ^{de}	15.2 ^{ab}	6.8 ^c	42.7 ^{cab}
T14	7.0 g	7.0 g	0.084 g	4.1 ^{cadb}	4.1 ^{cab}	4.1 ^{cab}	8.3 ^{cde}	15.2 ^{ab}	8.6 ^a	44.4 ^{cab}
T15	7.0 g	7.0 g	0.168 g	4.6 ^{cd}	3.6 ^c	3.6 ^c	8.7 ^{cadb}	14.0 ^{ab}	6.6 ^c	41.1 ^{cb}
T16	7.0 g	14 g	0.042 g	4.6 ^{cab}	4.7 ^{ab7}	5.0 ^a	8.5 ^{cadbe}	14.4 ^{ab}	6.6 ^c	43.8 ^{cab}
T17	7.0 g	14 g	0.084 g	4.9 ^a	4.8 ^a	4.6 ^{cab}	8.1 ^{de}	14.4 ^{ab}	6.6 ^c	43.4 ^{cab}
T18	7.0 g	14 g	0.168 g	4.0 ^{cadb}	4.1 ^{cab}	3.9 ^{cb}	9.1 ^{cadb}	14.4 ^{ab}	7.0 ^c	42.5 ^{cab}

Within each column, means with same letter(s) are not significantly different at $P < 0.05$

MG monoglycerides; AG arabic gum; α alpha amylase

0.1) on the second day as can be seen on the Table 5. Farvili et al. (1995) reported the addition of low concentrations of emulsifiers improved the softness and tearing quality of Arabic bread.

Total score

There was significant interaction effect due to (AG*MG*alpha-amylase) combination on total score of Arabic white bread ($P \leq 0.05$) (Table 5). Two treatments out of 18 exhibited significantly the highest overall total quality Arabic bread score 9 (Table 6). The first treatment was Arabic bread produced in the presence of high level of AG (1.0), high level of MG (2.0 %) and high level of alpha-amylase (0.025 %) combination (treatment 9). The second treatment was Arabic bread produced in the presence of high level of AG (1.0 %), low level of MG (0.5 %) and high level alpha-amylase (0.025 %) combination (treatment 12). It can be concluded that these two formulas can be used to improve the quality and of Arabic white bread.

Arabic bread features of whole wheat flour (95 % Extraction)

Size, shape and smoothness

Effect of bread improvers on the size, shape and smoothness of brown Arabic bread can be seen in Table 9. Brown Arabic

bread with low level of AG, high level of MG and low level of alpha-amylase combination (treatment 3) exhibited a significant decrease in its size compared to the other treatments. The GLM analysis showed the effect of bread improvers on size of brown Arabic bread (Table 8). There was no significant combination effect of (AG*MG* alpha-amylase) on the size values of the Arabic brown bread. However, there was strong MG, alpha-amylase interaction effect ($P \leq 0.05$) on the size values of brown Arabic bread.

Arabic Brown bread with low level of AG (0.5 %), low level of MG (0.5 %) and low level of alpha-amylase (0.00625 %) combination (treatment 1) exhibited significant improvement in brown Arabic bread shape compared with other treatments (Table 9). There was no significant interaction of (AG*MG*alpha-amylase) effect on the shape values of brown Arabic bread. However, there was significant MG, alpha-amylase interaction effect ($P \leq 0.1$) on the shape values of Arabic brown bread (Table 8).

Treatment with high Arabic gum (1.0 %), high M.G (2.0 %) and high alpha-amylase (0.025 %) (treatment 8) exhibited significant improvement on the Arabic bread smoothness values compared to the other treatments. The GLM analysis showed no significant interaction effect (AG*M.G*alpha-amylase) on the smoothness values of brown Arabic bread. However, there was a strong Arabic

Table 8 F- factors (General linear model) of brown bread (95 % Extraction)

Dependent variable	AG	α - MG	α	AG ^a α	MG ^a α	AG ^a MG	AG ^a MG ^a α
Size	N/S	12.79 ^b	8.5 ^b	N/S	8.5 ^b	N/S	N/S
Shape	N/S	N/S	N/S	N/S	2.91 ^a	N/S	N/S
Smoothness	11.42 ^c	N/S	10.51 ^b	N/S	N/S	N/S	N/S
Crust color	4.27 ^b	N/S	10.61 ^c	N/S	N/S	N/S	N/S
Blisters	4.4 ^b	N/S	N/S	N/S	4.79 ^a	N/S	10.77 ^c
Roll & fold day (1)	6.78 ^b	N/S	N/S	N/S	N/S	8.16 ^b	N/S
Pocketing	N/S	N/S	N/S	N/S	N/S	N/S	N/S
Crumb texture	6.67 ^b	N/S	8.72 ^b	7.21 ^b	N/S	N/S	4.61 ^a
Crumb appearance	13.71 ^c	7.28 ^b	5.75 ^b	N/S	N/S	5.75 ^b	N/S
Evenness of layers	N/S	N/S	N/S	N/S	N/S	3.72 ^a	N/S
Tearing day (1)	N/S	N/S	N/S	N/S	N/S	4.5 ^a	N/S
Roll & fold day (2)	7.57 ^c	22.83 ^c	N/S	5.44 ^b	42.98 ^c	N/S	N/S
Tearing day (2)	N/S	N/S	N/S	6.87 ^b	3.97 ^a	N/S	3.18 ^a
Total scoring	16.59 ^c	N/S	4.14 ^a	N/S	6.36 ^b	15.58 ^c	N/S

^a Significant at $p \leq 0.1$ MG - α - monoglycerides^b Significant at $p \leq 0.05$ AG arabic gum^c Significant at $p \leq 0.01$ α alpha amylase

gum ($P \leq 0.01$) and alpha-amylase ($P \leq 0.05$) effect on the smoothness values of Arabic brown bread.

Crust color, blisters and pocketing

Arabic Brown bread showed a marked significant variation in crust color and blisters as can be seen in Table 9. The GLM analysis (Table 8) showed that there was no significant interaction effect of (AG*MG* alpha-amylase) effect on the crust color values. However, there were significant Arabic gum effect ($P \leq 0.05$) and significant alpha-amylase effect ($P \leq 0.01$) on the crust color value. Treatment with low Arabic gum level, low of MG level and high alpha-amylase level combination (treatment 2) and treatment of high of Arabic gum level, low of MG level and high of alpha-amylase level

(treatment 6) exhibited significant improvement of crust color combination (Table 9).

There was significant interaction of (AG*MG*alpha-amylase) effect on the blisters values of brown Arabic bread ($P \leq 0.01$). However, there were significant AG effect ($P \leq 0.05$) and alpha-amylase effect ($P \leq 0.01$) on the blister values of brown Arabic bread. Treatment with high of AG, high of MG and high alpha-amylase combination (treatment 8) showed a significant effect on blisters compared to the other treatments.

Ability for rolling and folding on day one, day two and pocketing

In the first day, the interaction of (AG*MG) combinations exhibited significant effect on the ability of brown Arabic

Table 9 LSD external characteristic of brown bread (95 % Extraction)

Treatments	AG	MG	α	Size	Shape	Smoothness	Crust color	Blisters	Rolling Day (1)	Pocketing
TC	—	—	—	5 ^a	4.467 ^{ab}	3.93 ^d	3.967 ^{ab}	5 ^a	5.13 ^c	10.0 ^a
T1	3.5 g	3.5 g	0.042 g	5 ^a	4.83 ^a	4.7667 ^a	4.567 ^a	4.67 ^{cd}	7.23 ^{ab}	10.0 ^a
T2	3.5 g	3.5 g	0.166 g	5 ^a	4.47 ^{ab}	4.367 ^{cb}	4.167 ^{ab}	4.8 ^{cab}	8.13 ^a	10.0 ^a
T3	3.5 g	14.0 g	0.042 g	4.63 ^c	4.73 ^{ab}	4.6 ^{cab}	4.43 ^a	4.77 ^{cab}	6.67 ^{abc}	10.0 ^a
T4	3.5 g	14.0 g	0.166 g	5 ^a	4.3 ^b	4.23 ^{cd}	4.167 ^{ab}	4.76 ^{cab}	7.1 ^{ab}	10.0 ^a
T5	7.0 g	3.5 g	0.042 g	5 ^a	4.63 ^{ab}	4.83 ^a	4.567 ^a	4.83 ^{cab}	5.7 ^{bc}	10.0 ^a
T6	7.0 g	3.5 g	0.166 g	5 ^a	4.53 ^{ab}	4.4 ^{cb}	4.23 ^{ab}	4.47 ^d	5.7 ^{bc}	9.77 ^a
T7	7.0 g	14 g	0.042 g	4.73 ^{cb}	4.53 ^{ab}	4.53 ^{cab}	4.43 ^a	4.63 ^{cd}	7.53 ^a	10.0 ^a
T8	7.0 g	14 g	0.166 g	4.93 ^{ab}	4.53 ^{ab}	4.6 ^{cab}	4.277 ^{ab}	4.93 ^{ab}	6.7 ^{abc}	10.0 ^a

Within each column means with same letter(s) are not significantly different at $P < 0.05$

MG - α - monoglycerides; AG arabic gum; α alpha amylase

bread for rolling and folding on the first day ($P \leq 0.05$). Treatment with low of AG (0.5 %), low of MG (0.5 %) and high alpha-amylase (0.025 %) combination (treatment 2) showed significant effect on the ability of Arabic brown bread to roll and fold on the first day versus other treatments.

On the second day, effect of AG, and the interaction of (MG*alpha-amylase) showed significant effect ($P \leq 0.01$) on the ability of Arabic brown bread for rolling and folding. Moreover, the interaction of (AG*alpha-amylase) showed significant effect ($P \leq 0.05$) on ability of Arabic brown bread for rolling and folding on the second day (Table 8). The Arabic brown bread showed a marked significant variation of the its ability for rolling and folding. Treatment with low of AG (0.5 %), low of MG (0.5 %) and high alpha-amylase (0.025 %) (treatment 2) had significant effect on the ability of brown Arabic bread for rolling and folding on the second day compared to the other treatments.

There was no significant effect found due to the interaction of (AG*MG*alpha-amylase) on the pocketing quality of brown Arabic bread (Table 8). Treatment with high AG (1.0 %), low MG (0.5 %) and high 1 alpha-amylase (0.025 %) combination exhibited significant pocketing property (treatment 6).

Crumb texture and crumb appearance

Arabic Brown bread with high of AG, high of MG and high alpha-amylase (Treatment 8) showed significant reduction on crumb texture of Arabic brown bread compared to treatment 4 of low of AG, high of MG and high alpha-amylase which showed high value of crumb texture. However, there was significant effect merged due to the interaction of (AG*MG*alpha-amylase) $P \leq 0.1$ on the crumb texture (Table 8). However, significant interaction effect on crumb texture due to (AG*alpha-amylase) interaction ($P \leq 0.05$) was noticed.

The effect of the Arabic gum was significantly high ($P \leq 0.01$) on the appearance. Similarly, the effect of MG, and alpha-amylase, and the interaction of (AG*MG) showed significant effect ($P \leq 0.05$) on crumb appearance of brown Arabic bread (Table 10). The Arabic brown bread with high of AG (1.0 %), low of MG (0.5 %) and high alpha-amylase (0.025 %) combination (treatment 6) showed significant reduction on brown bread crumb appearance. Unlike, brown Arabic bread with low of AG (0.5 %), high of MG (2.0 %) and low alpha-amylase (0.00625) combination (treatment 3) exhibited the highest value of the Arabic brown bread crumb appearance.

Evenness of layers

The interaction of (AG*MG) showed significant interaction effect ($P \leq 0.05$) as this can be seen in Table 10. Arabic Brown

Table 10 Lsd internal characteristic of brown bread (95 % Extraction)

Treatments	AG (g)	MG (g)	α (g)	Crumb texture	Crumb appearance	Evenness of layer	Tearing day (1)	Rolling day (2)	Tearing day (2)	Total scores
TC	–	–	–	4.43 ^{de}	4.73 ^{bc}	4.43 ^a	8.57 ^{ab}	14.8 ^e	6.8 ^{ab}	66.5 ^d
T1	3.5	3.5	0.042	4.73 ^{ab}	4.73 ^{ab}	4.73 ^a	8.4 ^{ab}	17.6 ^{dc}	6.6 ^{abc}	71.37 ^a
T2	3.5	3.5	0.166	4.63 ^{ab}	4.73 ^{ab}	4.8 ^a	8.7 ^a	20.92 ^{ab}	6.6 ^{abc}	72.3 ^a
T3	3.5	14.0	0.042	4.73 ^{abc}	4.8 ^a	4.83 ^a	8.07 ^{ab}	19.6 ^{bc}	7.14 ^a	70.67 ^{ab}
T4	3.5	14.0	0.166	4.8 ^{ab}	4.7 ^{ab}	4.43 ^a	7.93 ^{ab}	14.8 ^e	5.92 ^c	68.23 ^{cd}
T5	7.0	3.5	0.042	4.57 ^{bed}	4.37 ^c	4.53 ^a	8.0 ^{ab}	17.2 ^{dce}	6.6 ^{abc}	68.57 ^{bed}
T6	7.0	3.5	0.166	4.4 ^c	4.27 ^c	4.37 ^a	7.73 ^b	23.1 ^a	6.86 ^{ab}	68.07 ^{ed}
T7	7.0	14	0.042	4.87 ^a	4.77 ^a	4.7 ^a	8.33 ^{ab}	17.48 ^{dce}	6.2 ^{bc}	70.67 ^{ab}
T8	7.0	14	0.166	4.3 ^d	4.43 ^c	4.73 ^a	8.0 ^{ab}	15.6 ^{de}	6.6 ^{abc}	68.73 ^{be}

Within each column means with same letter(s) are not significantly different at $P < 0.05$
 MG α -monoglycerides; AG arabic gum; α alpha-amylase

Fig. 1 Effect of different improvers combinations on the total score of Arabic white bread

bread with low of AG, high of MG and low alpha-amylase combination (treatment 3) exhibited the highest pocketing property.

Brown Arabic bread with low of AG (0.5 %), high of MG (2.0 %) and low alpha-amylase (0.00625) combination (treatment 3) exhibited the highest tearing quality (Table 10).

Tearing quality of day one and day two

The interaction of (AG*MG) showed a significant effect on the tearing quality ($P \leq 0.1$) in the first day (Table 8). Arabic Brown bread with high of AG (1.0 %), low MG (0.5 %) and high alpha-amylase (0.025 %) combination (treatment 6) showed significant reduction on the tearing quality. On the other hand, brown Arabic bread with low level of AG, low level of MG and low level alpha-amylase combination (treatment 1) exhibited the highest tearing quality (Table 10).

In addition, the interaction of (AG*alpha-amylase) and the interaction of (MG*alpha-amylase) showed a significant effect on the tearing quality ($P \leq 0.05$) in the first day (Table 10).

Total score

Two treatments out of eight exhibited the highest brown Arabic bread overall total quality ($P \leq 0.01$). The first treatment was Arabic brown bread with low of AG (0.5 %), high of MG (2.0) and low alpha-amylase (0.00625 %) combination (treatment 3) and the second treatment was (treatment 7) with high of AG (1.0 %), high of MG (2.0 %) and low alpha-amylase (0.00625 %) combination as can be seen in Table 10. Arabic Brown bread with low of AG (0.5 %), low of MG (0.5 %) and high alpha-amylase (0.025 %) combination (treatment 2) exhibited the highest total quality score value (Table 10).

Fig. 2 Effect of different improvers combinations on the total score of Arabic white bread

Conclusions

In this study, the highest overall total quality of Arabic white bread score were obtained significantly ($P \leq 0.01$) for two different treatments. These two treatments were Arabic white bread with low level of AG (0.5 %), high level of MG (2.0 %) and high level of alpha-amylase (0.0250 %). Also, the Arabic white bread with high level of AG (1.0 %), low level of MG (0.5 %) and high level of alpha-amylase (0.0250 %). Also, the highest overall total quality of Arabic brown bread score were obtained significantly ($P \leq 0.01$) for another different 2 treatments. These two treatments were Arabic brown bread with low level of AG (0.5 %), high level of MG (2 %) and low level of alpha-amylase (0.00625 %) and the Arabic brown bread with high level of AG (1.0 %), high level of MG (2 %) and low level of alpha-amylase (0.00625 %). Therefore, these different combinations can be used to improve the quality of Arabic bread either white or brown. It is recommended that more studies are needed to study and explore the mechanism and the mode of action of Arabic gum, monoglyceride and amylase enzymes in improving Arabic bread quality. The total effect of the different combinations on the Quality of the Arabic white bread can be seen in Fig. 1. Also, The total effect of the different combinations on the Quality of the Arabic brown bread can be seen in Fig. 2.

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