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Changes in Flour Quality of Four Iraqi Wheat Varieties During Storage

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ABSTRACT

The issue related to suitable wheat age after harvesting for producing flour is raised regularly during a harvest season. Therefore, determining the suitable wheat storage for different wheat strength and with high extraction rate (80%) is necessary to produce a good quality flour. Four varieties of bread wheat (Adina, Aibaa99, Sham6, and Rasheed) were tested. Gluten amount, gluten index, amylase activity, dough rheological properties (farinograph parameters), and flour size were detected. Results showed that gluten index was stable for Adina variety (the strongest variety), but it was reduced significantly during week 11^{th} and 15^{th} for Sham6 and Aibaa99 (weak wheat varieties) respectively. The α-amylase activity of all varieties was reduced during storage periods. Dough stability increased during storage period for all four varieties. However, the increment was higher in Adina compared to others (lower strength wheat). Mixing tolerance index (MTI) of Adina was changed slightly during the storage period while for other varieties MTI increased sufficiently. In conclusion, wheat varieties behaved differently depending on wheat strength, and there was no specific time that all that dough properties improved during the study period.

Keywords: Dough quality, rheological properties, wheat storage

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INTRODUCTION

Cereal is an important crop all over the world because of its nutritional value and low price. Cereals provide high starch content, energy source, dietary fiber, protein, lipid that rich in essential fatty acids, and micronutrients (Dewettinck et al., 2008). Wheat is considered one of the most important crops in the world (Shewry et al., 2002). The quality of wheat flour for bread making is generally determined by content and type of its protein, starch conditioned (damage) and enzymes. These factors are controlled by wheat variety, time and conditions of wheat harvest, and milling technology (Hrušková & Machová, 2002) in addition to wheat and flours ages (Mense & Faubion, 2017). After wheat harvest and before milling, wheat moisture changes occur, which is considered the main factor affecting flour quality in term of wheat age (Posner & Deyoe, 1986).

Flour quality can be determined by analyzing chemical and rheological properties of its dough. Quality and quantity of gluten (wheat protein) are one of the most important properties of flour in producing bread because of dough extension (gas retention) that can be determined by the amount and type of gluten (Hadnađev et al., 2011). Gluten index is considered a quicker method to determine wheat quality (weak, normal, or strong) compared with other methods such as fariongraph or mixing graph (Oikonomou et al., 2015). Another important device to determine dough physical properties is farinograph that can determine water absorption, mixing tolerance index, stability, and development time. These properties are useful in term of optimizing baking quality (Yazar et al., 2016). Starch gelatinization can be determined indirectly by measuring falling number. Falling number (FN) indicates total α-amylase in the grain. The higher FN, the less α-amylase activity. High level of α-amylase reduces baking quality, which can be indicated by FN less than 250s (Ral et al., 2016).

The issue related to the suitable wheat age for flour production is raised regularly worldwide during harvested seasons. In Iraq, Grain Board of Iraq (GBI) imports raw wheat (usually stored for several months) continuously that is mixed with the demotic wheat, sometimes the imported wheat is not available because of some political or technical issues. In this situation, GBI entirely depends on the cultivated wheat in Iraq, especially during the harvest season (May to August). Therefore, the aim of the study is to determine the suitable wheat ages of different Iraqi wheat varieties (strong and weak wheat) to produce high quality flour with high extraction rate (80%), which is used in Iraq.

MATERIALS AND METHODS

Four varieties of Iraqi wheat named Adina, Aibaa99, Sham6, and Rasheed (commonly varieties in Iraq) were harvested from farms of Kirkuk (north Iraq) on 20th and 21st of June 2017 and stored at ambient temperature until 26th of November (about five months). The varieties identity confirmed by the Ministry of Agriculture members that they had provided seeds to the farmers. Flour was produced and analyzed for the first week, third, fifth, seventh, 11th, 15th, 19th, and 23rd week of storage. Flour was produced after wheat was cleaned from impurities, moisturized to 16% moisture for 20-24 h, and milled by using Quadermet miller (Brabender® OHG, Brabender GmbH Co. KG, Duisburg, Germany) to 80% extraction rate (rate used in Iraq mills). The produced flour was analyzed within two days from its production to avoid flour age interferences for ash (AACC Method 08-01), moisture (AACC Method 44-10), wet gluten and gluten index (AACC Method 38-12), farinograph (AACC Method 54-21), particle size by using Buhler Laboratory Siftermin 300 (Bühler Group Company, Uzwil, Switzerland) for five minutes, protein (AACC Method 39-01), and falling number (56-81B) (American Association of Cereal Chemists [AACC], 2000). Farinograph analysis of week five was not detected because of some technical issues, and the analyzed had not been detected a week after because of flour storage issue that would interfere with the result.

Statistical Analysis

One-way analysis of variance (ANOVA) was performed for statistical analysis of data. Least Significant Difference (LSD) of means was implemented by using SAS version 9.0 (Cary, NC, USA). Significant differences were considered at $\alpha = 0.05$ level. All treatments were conducted in duplicate.

RESULTS AND DISCUSSION

In this study, the effect of wheat storage on the produced flour of the four wheat varieties cultivated in Iraqi was examined in terms of chemical and quality properties of dough. There were differences in wheat varieties used in this study in term of protein content, gluten quality and quantity, and rheological properties (farinograph) of dough produced from the wheat varieties. Using different wheat varieties (different quality) were important to know how each variety changed during the storage time. Table 1 indicates protein, ash, and moisture content of whole flour (100% wheat flour) and produced flour (first week) of the four varieties of wheat. For whole wheat flour, Aibaa99 variety had the highest protein content (12.1% at 14% mb), while Sham6 varieties had the lowest amount of protein (9.9% at 14% mb). The quantity and quality of gluten of the first week were shown in Table 2. While Aibaa 99 still had the highest amount of gluten (31.6%) for the first week compared with all other types, the quality of gluten determined by gluten index (76.5%) refers to the lowest quality compared with the other varieties for the first week. Increasing gluten index refers to the gluten strength (Hadnađev et al., 2011). All four tested wheat varieties had low amylase activity for the first week, and the highest activity was noticed in Sham6 varieties, which had falling number 399s (Table 2). The best falling number range occurs between 250-300s (Ral et al., 2016).

Table 2 indicates wet gluten (%), gluten index (%), and falling number (s) of flour produced from the four varieties of wheat for the first week to the 23rd-week ages. Increasing gluten amount and high gluten index (Meerts et al., 2017) are a good indication of high-quality dough. While the variables fluctuated during the storage period, it is necessary to highlight some significant differences during the storage to explain the results in a useful way. Wet

Table 1

Whole wheat flour and produced flour characteristics (1st week) of the four wheat varieties

Characteristic	Wheat Types			
	Adina	Aibaa99	Sham6	Rasheed
Whole wheat Flour*				
Protein (14%mb)**	11.1 ± 0.1	12.1 ± 0.1	9.9 ± 0.1	11.3 ± 0.0
Ash (14%mb)	1.41 ± 0.01	1.57 ± 0.01	1.43 ± 0.01	1.69 ± 0.00
Moisture%	7.6 ± 0.6	7.6 ± 0.4	7.4 ± 0.4	7.6 ± 0.3
Produced Flour***				
Protein (14%mb)	10.6 ± 0.3	11.5 ± 0.4	9.4 ± 0.6	11.0 ± 0.4
Ash (14%mb)	0.81 ± 0.01	0.89 ± 0.03	0.82 ± 0.02	0.93 ± 0.02
Moisture%	14.6 ± 0.3	14.7 ± 0.3	14.4 ± 0.5	14.7 ±0.1

*Whole flour is produced from milling whole wheat (100%) without removing the bran
**mb (Moisture basis)
***Produced flour is flour with 80% extraction rate

gluten of Adina was reduced during the storage period. It was reduced significantly from 27% for the first week to 23.7% for week 23rd and this result agreed with the Posner and Deyoe (1986) study that wet gluten was reduced from 27.4 to 24.8%. In their study, they moisturized wheat to 16% before milling and used freshly harvested hard red winter. Wet gluten percentage for Aibaa99 was reduced significantly during week 11th and 15th compared to week 19th and 23rd, while there were no significant differences of wet gluten content for Sham6 and Rasheed varieties during the storage period. Gluten index percentage of Adina was almost stable during storage period except during week 19th was reduced significantly (Table 2). Gluten index of Aibaa99 variety (the lowest gluten index in the first week) had been improved from 76.5% to the highest value (98.4%) during week 19th, which indicated that storage time had a positive effect on gluten index of a weak wheat variety. For Sham6 variety, gluten index reduced significantly only during week 11th to 71.5% compared to 93% of the first week. Gluten index of Rasheed variety was reduced during 5th to 11th week storage, however, the reduction was not significant. The fluctuation in gluten index for all varieties during the storage period probably refers to some protein chemical bonds changes during storage. Further study is required to determine what protein bonds are formed or broken to cause these changes and to determine what the reason behind the fluctuated results was. Variation of protein and gluten of the produced flour during storage time is probably because of using the high extraction rate flour (80%) that have some bran, which led to producing different particle size during the storage period

Table 2
Produced flour properties during storage time of the four varieties (Adina, Aibaa99, Sham6, and Rasheed)

	Adina				Aibaa99			
Time after Harvest (W)	Protein% (14%mb)	Wet Gluten% (14%mb)	Gluten Index%	Falling Number (S)	Protein% (14%mb)	Wet Gluten% (14%mb)	Gluten Index %	Falling Number (s)
1	10.6	27.04 ± 0.78a	99.00 ± 0.85a	431 ± 2d	11.5	31.61 ± 2.50a	76.50 ± 0.71b	441 ± 41d
3	9.9	26.75 ± 1.37a	100.00 ± 0.00a	451 ± 8d	11.0	30.65 ± 2.66ab	75.00 ± 0.00b	494 ± 13bc
5	10.2	24.73 ± 0.71ab	99.15 ± 1.20a	434 ± 1d	10.8	29.22 ± 0.35ab	74.00 ± 14.14b	529 ± 9b
7	10.1	26.45 ± 0.65a	99.25 ± 1.10a	445 ± 6d	11.0	30.7 ± 1.44ab	68.00 ± 7.07b	532 ± 4b
11	10.0	26.36 ± 0.29a	100.00 ± 0.00a	625 ± 1a	10.9	26.28 ± 0.79b	82.50 ± 2.12ab	621 ± 2a
15	10.0	25.12 ± 0.57ab	100.00 ± 0.00a	524 ± 0bc	10.8	28.24 ± 24b	77.50 ± 0.71b	432 ± 2d
19	9.9	25.02 ± 0.00ab	94.90 ± 0.28b	547 ± 6b	10.8	33.16 ± 0.0a	98.35 ± 0.00a	459 ± 39cd
23	9.8	23.67 ± 0.73b	99.35 ± 0.92a	504 ± 7c	10.8	29.06 ± 0.80a	90.60 ± 1.56ab	494 ± 6bc
Sham6					Rasheed			
1	9.0	23.21 ± 1.85a	93.00 ± 5.70a	399 ± 1cd	11.0	29.29 ± 0.07a	96.00 ± 0.00ab	474 ± 6c
3	9.1	24.44 ± 2.44a	95.50 ± 3.50a	397 ± 26cd	10.5	28.9 ± 0.43a	90.00 ± 0.00ab	511 ± 23bc
5	9.1	22.71 ± 0.14a	89.50 ± 3.50a	414 ± 60bc	10.7	29.09 ± 1.36a	86.50 ± 4.95b	471 ±6c
7	9.1	22.39 ± 0.50a	91.50 ± 5.00a	399 ± 2cd	10.7	29.14 ± 1.29a	87.50 ± 6.36b	535 ±11b
11	9.2	23.43 ± 0.36a	71.50 ±9.20b	318 ± 1d	10.6	27.77 ± 3.52a	88.00 ± 4.24b	796 ±45a
15	9.1	23.95 ± 1.00a	87.50 ± 5.00a	491 ± 1ab	10.6	28.06 ± 0.29a	98.50 ± 0.71a	489 ± 1bc
19	9.1	26.95 ± 0.07a	97.30 ± 0.60a	518 ± 40ab	11.0	30.88 ± 0.22a	95.85 ± 1.20ab	498 ± 0bc
23	9.2	22.78 ± 0.00a	97.50 ± 0.30a	492 ± 7a	11.0	29.29 ± 0.07a	96.00 ± 0.00ab	474 ± 6c

Values are expressed as a mean ± SD from two independent experiments. Means with different letters within the same column are significantly different at $p<0.05$

(Figure 1). Noort et al. (2010) mentioned that adding bran to a bread flour had a negative effect on the bread quality because of fiber-gluten interaction. In addition to increasing extraction rate of flour which lead to increase bran and germ, leading to increase in protein, fat, minerals, vitamin B, and fiber. However, baking quality decreases (Mense & Faubion, 2017).

Falling number values of flour produced from wheat stored for different times generally increased during storage (reduce amylase activity). For Adina, Aibaa99, and Rasheed, the highest falling number was at 11th week, while for Sham 6 variety was increased maximally during week 19th, however, there were no significant differences between week 19th and weeks 5th, 15th, and 23rd. Increasing falling number refers to reduced α-amylase activity. The best falling number for bread flour occurs between 250-300s (Polat & Yagdi, 2017). Mense and Faubion (2017) reported that falling number of a wheat variety increased

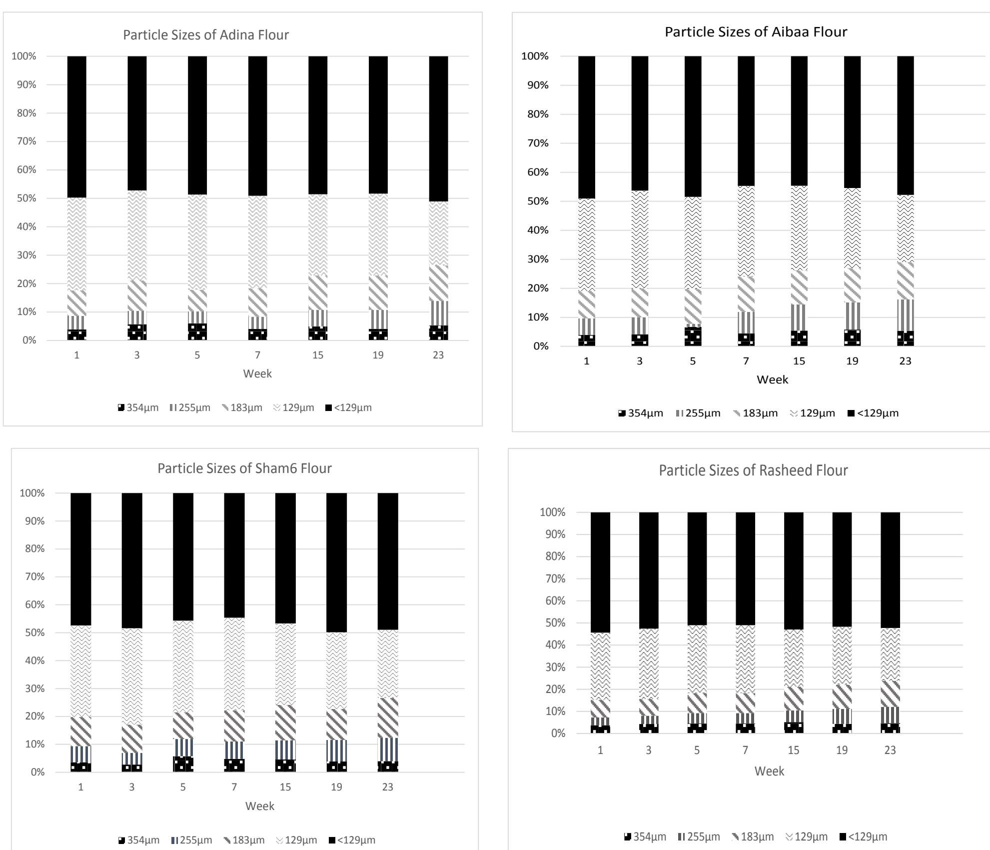

Figure 1. Particles sizes of produced flour of the four varieties during storage time. The mentioned particles were above the sieves except for <129, which was under the sieve

to 439s after 13 weeks storage time compared to 418s at the first week, while the other tested variety in the same study was almost stable during the same storage period. However, the increment was higher in our study compared with the Mense and Faubion (2017) study. The α-Amylase activity of the tested varieties at the first week was less than the optimum range. During storage, α-amylase was further reduced, therefore α-amylase was affected negatively by increasing storage time.

Table 3 demonstrates farinograph data of flour produced from the four wheat varieties during 23 weeks of storage period. Increasing stability, development time, water absorption, and reducing MTI are a good indication of high-quality dough for bread production (Wahyono et al., 2016). Water absorption of flour produced from Adina, Aibaa99, and Sham6 varieties were changed during the storage period, but mostly they were little higher than the first week. For Rasheed variety, water absorption was almost stable during the first eleven weeks, but it was reduced during week 15th and increased again during last week. Water absorption value is considered the most important value of the farinograph parameters, and it directly refers to finished bakery products volume (Hadnađev et al. 2011; Okuda et al., 2016). Diósi et al. (2015) mentioned a classification of flour depending on the fariongraph parameters, which were the A quality group should have a minimum 60.0% water absorption, and the B quality group should have a minimum 55.0% water absorption with a minimum 10.0 min and 6.0 min stability respectively. Vetrimani et al. (2005) reported that there was a positive correlation between the extraction rate and water absorption for vermicelli dough. Water absorption of all varieties increased little during storage time and that refered to little enhancing of dough quality in this term (Ahmed et al., 2017). Development time of four varieties either reduced or was stable during the storage period. Development time of Adina variety was stable during storage period except during week 7th and 11th reduced to 5.3 and 5min compared to 6min. In Aibaa99 variety, development time was different during the storage period, the minimum was in week 7th (3.3min) and the maximum was in the week 19th and 23rd (4min). Development time of Sham6 variety was reduced maximum during week 11th and increased again after that. In Rasheed variety, development time was reduced during and after week 15th. Reducing development time during storage period refers to decline dough properties. Dough stability of produced flour was generally increased during wheat storage. The highest increment of stability was in Adina, stability was increased from 6.8min during the first week to the maximum stability in the last week (10min) (Table 3). For Aibaa99 and Rasheed varieties, stability increased from 3.2min and 4 min in the first week to the highest stability (5.5 min and 6 min) in the week 11th respectively. Dough stability of Sham6 variety was increased during storage period to maximum (5min) at the last week compared to the minimum at the first week (3min) (Table 3). Mixing tolerance index

Table 3
Farinograph characteristics of the four varieties during storage period

Time after Harvest (W)	Water Absorption %				Development Time (min)			
	Adina	Aibaa99	Sham6	Rasheed	Adina	Aibaa99	Sham6	Rasheed
1	58.5	58.2	57.7	58.3	6.0	3.8	4.2	4.0
3	60.4	59.6	59.2	58.7	6.0	3.6	3.2	4.0
7	58.2	58.6	58.4	58.4	5.3	3.3	3.5	4.0
11	59.3	59.1	59.4	58.9	5.0	3.5	3.0	4.0
15	59.2	58.3	57.9	56.2	6.0	3.5	3.5	3.5
19	59.3	59.2	57.6	58.7	6.0	4.0	3.5	3.5
23	59.4	60.1	58.3	59.8	6.0	4.0	3.5	3.5

Time after Harvest (W)	Stability (min)				MTI (BU)			
	Adina	Aibaa99	Sham6	Rasheed	Adina	Aibaa99	Sham6	Rasheed
1	6.8	3.2	3.0	4.0	40	40	61	63
3	8.2	4.1	3.0	4.2	34	67	88	61
7	9.0	4.2	3.5	4.5	33	56	78	44
11	9.0	5.5	4.0	6.0	44	44	89	44
15	8.5	5.0	4.5	4.5	44	77	67	67
19	7.0	5.0	4.0	5.0	45	89	89	89
23	10	5.0	5.0	5.0	33	56	56	55

(MTI) of flour produced from Adina variety was reduced to minimum Brabender Unit (BU) during week 7th and week 23rd. For Aibaa99 variety, the highest MTI was 89 BU during week 19th compared to 40 BU in the first week. Storage time had no reducing effect on MTI of the flour produced from Aibaa99 variety. For Sham6 variety, MTI increased to the highest value during 11th and 19th weeks, while reduced to lowest value during 23rd week. For Rasheed variety, MTI reduced during storage period except during week 15th and 19th. Adina variety was faster (7 weeks) than other varieties in term of increasing dough stability and little alterations of MTI. Hadnađev et al. (2011) mentioned that high stability and lower MTI refered to more dough tolerance to mixing. Stability of all other varieties was increased, but the increase was less than in Adina variety, which was the strongest one. This result probably indicates that storage period effect positively on the strong wheat more than on the weak wheat. Although, Adina is considered the strongest variety compared to the tested varieties depending on gluten index value (99%), water absorption (58.5%), stability (6.8 min), and MTI (40 BU) of the first week (Tables 2 and 3), it is a B quality group depending on the Diósi et al (2015) classification that was mentioned above. Adina variety was the only variety that reached 10 min stability after 23rd-week storage (Table 3). The other varieties had not met the B quality properties after 23rd storage period except for Rasheed variety during week 11th (Table 3). Wheat cultivated in Iraq depending on the varieties tested in this study needs quality improvement to meet quality A group or at least quality B.

Figure 1 shows particle sizes of produced flour of the four varieties, and it indicates that the particle sizes were different in different storage time of each variety. The main change in particle size during storage time was reducing of particle size between 129 and 183 μm. Water absorption has a correlation with extraction rate. Particle size of flour influences the rheological properties of dough. Bressiani et al. (2017) mentioned that particle size influenced the functionality of the gluten network and consequently the bread volume. Reduced particle size of flour leads to increase starch damage (break starch to small particle sizes) and increase surface area that causes more dough absorption and consequently more dough stickiness (Gaines, 1985). Further, increasing extraction rate of flour to 80% probably implies some bran layers in the producing flour (Mense & Faubion, 2017). The effect of adding different particle sizes of bran to flour was reported in literature contradictory (Noort et al., 2010). Bressiani et al. (2017) mentioned that reducing particle size of bran enhanced bread volume. While Noort et al. (2010) stated that reducing particle size of bran had negative effect on baking. However, in our study, the alteration of particles size occurred naturally during storage period although the producing method was same in all period intervals. This probably indicates that wheat storage has an effect on the milling process that leads to form different particle size of the producing flour.

CONCLUSION

The results emphasize that the tested wheat varieties were not strong enough either at the first week or after 23rd week storage. Iraqi wheat varieties need to be improved to meet A quality group of farinograph parameters. A wheat variety is considered an important factor in determining the suitable wheat age to produce flour. The stronger wheat variety, the faster changes occurred. Probably because all the tested wheat varieties were not strong enough, therefore, no clear improvement occurred. There was no specific storage period that all the dough enhanced at the same time. Some properties were improved, declined, or had no clear effect.

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