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Different Moisture Contents of Tempered Hull Barley and Hull-Less Barley Grains Prior to Milling
2. Effect on Physical and Sensory Properties of Bread Baked from these Barley Flours.

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ABSTRACT

The purpose of this work was to study the effect of different moisture contents (12, 14, 16 and 18%) of conditioned hull barley and hull-less barley grains prior to milling on physical and sensory properties of bread baked from these barley flours. The results indicated that the specific volume of breads baked from barley flours and wheat-barley composite flours were enhanced with increasing conditioning moisture of barley grains prior to milling; therefore baking loss values decrease. On the other hand, increase the moisture content of barley grains prior to milling lead to improve all the tested parameters of sensory evaluation and retarded the staling rate of barley pan bread and wheat-barley breads.

Keywords: hulled, hull-less, barley, tempering, milling, flour, bread, baking characteristics, sensory evaluation

INTRODUCTION

Barley *(Hordeum vulgare L.)* is grown as a commercial crop in some hundred countries world-wide and is one of the most important cereal crops in the world. Barley assumes the fourth position in total cereal production in the world after wheat, rice and maize, each of which covers nearly 30% of the world's total cereal production (Reddy *et al*., 2014). Barley was first used as human food, but later evolved to be primarily grown for feed, malt and brewing purposes (Rødbotten *et al*., 2015). The interest in barley has increased due to its many beneficial constituents (Holtekjølen *et al*., 2008). Ullrich, (2011) reported that barley has been known for a long time to bring health beneficial properties when consumed. Actually, the non-starch polysaccharides (β-glucans and arabinoxylans) are the minor components of the barley grain (15 to 17%) (Cornejo, 2005). Once barley was consumed in a diet, there is an increase in bulk and that will reduces transit time of fecal matter, which is associated with a lower frequency of hemorrhoids and colon cancer (Tsai *et al*., 2004). Besides, soluble fiber β-glucan prevents heart diseases and lowering cholesterol levels (Wang *et al*., 2002; Brennan, 2005); moreover it decreases the rate of glucose absorption to the blood which gives a more stable blood sugar level (Jenkins *et al*., 1981). Today, many different types of barley are available with different chemical compositions and properties. The predominant type of barely cultivated is hulled having a tough fibrous husk and is used as a malting and brewing grain. The other type is the hull-less or naked barley in which the hull is easily removed during threshing similar to wheat (Sharma and Gujral, 2010). On the other hand, tempering barley grains before milling process can reduce the proportion of fines particles less than 1.0-mm (Hironaka et al., 1992). Swanson and Penfield (1988); Dhingra and Jood (2004) showed that addition of more than 20% barley flour to wheat flour caused a decrease in loaf volume and, dull brown color and hard crumb texture in resulted wheat-barley bread. Moreover, Kinner (2010) reported that the use of barley flour cause negative influence on bread volume and appearance. In fact using other cereals such as barley flour with wheat flour for bread production may overcome the great consumption of wheat grains in bread making and lead to decrease the amount of imported wheat. So the objective of the present work was to study the effect of different moisture contents of tempered hulled and hull-less barley grains prior to milling on physical and sensory properties of bread baked from these barley flours.

MATERIALS AND METHODS

Materials: Samples of hulled barley cultivars Giza 123 (six-row) and hull-less barley cultivars Giza 130 (six-row) were purchased from Agricultural Research Center of Giza. Wheat cultivar Mesr 1 was obtained from local farmer at Assiut Governorate.

Methods:

Milling: 50 kg of each hull and hull-less barley grains sample were cleaned thoroughly, and the foreign seeds and materials were removed by hand picking followed by sieving. The barley grains were then conditioned by wetting the grains using different amounts of tap water. The tempering process was completed by mixing and storing the moist grains for 15-24 hours to obtain different moisture contents of tempered grains at 12, 14, 16, and 18% prior to milling. Milling was carried out a local stone mill. The straight flours thus obtained was sieved through suitable sieves (350, 300 and 250 μm) to flour and other milling fractions. The obtained flour samples were cooled immediately and stored in air tight plastic containers at 4 ºC until analysis.

Bread making:

Code number of flour samples for pan bread from barley flour and wheat-barley composite flours: The names of samples were abbreviated. It gave the symbol "S" that means "sample" and followed by number which identified the sample. Pan bread was made using 100 g of flour. Control bread was made from 72% extraction rate wheat flour (*Mesr 1*), whereas the barley pan breads were baked from 100% barley flours of each barley varieties (*Giza 123 and Giza 130*). Four barley flours from each variety were prepared at different conditioning moisture contents of grains (12, 14, 16 and 18%) prior to milling (Table 1). Wheat-barley pan bread made from wheat-barley composite flours by replacing wheat flour with 50% of each barley flour prepared at different conditioning moisture prior to milling (Table 1).

Table 1. The samples code number of wheat, barley and wheat-barley composite flours.

Code of sample	Samples	Code of composite flours	Composite flours
S1	Wheat flour	S10	50% S1+50% S2
S2	Barley flour from hulled grains Giza 123 tempered to 12% moisture prior to milling	S11	50% S1+50% S3
S3	Barley flour from hulled grains Giza 123 tempered to 14% moisture prior to milling	S12	50% S1+50% S4
S4	Barley flour from hulled grains Giza 123 tempered to 16% moisture prior to milling	S13	50% S1+50% S5
S5	Barley flour from hulled grains Giza 123 tempered to 18% moisture prior to milling	S14	50% S1+50% S6
S6	Barley flour from hull-less grains Giza 130 tempered to 12% moisture prior to milling	S15	50% S1+50% S7
S7	Barley flour from hull-less grains Giza 130 tempered to 14% moisture prior to milling	S16	50% S1+50% S8
S8	Barley flour from hull-less grains Giza 130 tempered to 16% moisture prior to milling	S17	50% S1+50% S9
S9	Barley flour from hull-less grains Giza 130 tempered to 18% moisture prior to milling	-	-

Procedure of pan bread making: Breads were prepared using straight-dough method according to Causgrove, (2004).

Dough yield efficiency: Dough yield efficiency was achieved for all treatments as described by Movahed *et al*., 2012 and based on the following equation:

$$P = (W_1 / W_2) \times 100$$

In which P is dough yield efficiency, W_1 is dough weight (flour + all of additives) and W_2 is flour weight.

Physical properties of pan bread: Three loaves were selected basing on each treatment. After cooling for 2 h, the breads were weighed in order to calculate bread yield value according to the equation: $P_2 = (W_3 / W_2) \times 100$; in which P_2 is bread yield efficiency, W_3 is bread weight (flour + all of additives) and W_2 is flour weight (Movahed *et al*., 2012). The volume of breads baked from different flour samples were determined by rapeseed displacement method as described by A.A.C.C. (2000). Specific volumes of the bread samples were calculated by dividing volume of loaves (cm^3) by their weights (g) following the method of Keskin *et al*. (2004). While specific volume index and bread yield index calculations were expressed as percentage of the control bread.

Sensory evaluation of bread: The bread samples were evaluated by ten panelists from the food science and technology department staff. The bread samples were sliced, placed in trays and labeled with random codes. The judges were provided with water to rinse their mouths before evaluating and rating the next sample. The procedure involved in a manual evaluation of the crumb (compression and kneading) and oral evaluation of the crust (biting and chewing) is shown in procedure A; while procedure B included manual evaluation of a whole slice and oral evaluation (biting and chewing) of the crumb according to Stölman and Lundgren (1987).

Determination of bread moisture content: The moisture content of bread samples was measured according to A.O.A.C. (1995).

Determination of bread staling rate: Staling rate was determined in fresh bread (4 hrs after baking) and after 24, 48 and 72 hrs of storage at room temperature by alkaline water retention capacity (AWRC) method according to Kitterman and Rubentholar (1971).

Statistical analysis: Analysis of variance and significant differences among means were tested by one-way ANOVA using SPSS software (version 16.0 for Windows, SPSS Inc., Chicago, IL). Analysis of Variance (ANOVA) was completed using Duncan's multiple comparison for mean difference testing.

RESULTS AND DISCUSSION

Bread making from flours of barley grains milled at different conditioning moisture contents:

Dough evaluation and baking characteristics:

Table 2 showed effect of different conditioning moisture contents of barley grains prior to milling on the dough yield made from barley flours. The results indicated that there was an increase in dough yield with increment of moisture content of grains prior to milling in both barley varieties which may be due to the increase in water absorption by flour. In all cases, the dough yield of hulled barley flours were more than the corresponding hull-less barley flours which attributed to increase in water absorption by the former than the later variety. This increase in dough yield may be due to the increase in soluble non-starch polysaccharides content which bind more water after conditioning treatment (Abdel-Gawad *et al*., 2016). In this concept, it could be confirmed by the finding that the solubility of non-starch polysaccharides (pentosan and β-glucan) in hulled barley flours were higher than the hull-less barley flours (Abdel-Gawad *et al*., 2016) and therefore the dough yield of hulled-barley flours were higher than the corresponding of hull-less barley flours. Puhr and D'appolonia (1992) reported that when the amount of water or absorption rate of certain flour enhanced, the dough produced from a fixed amount of that flour increased. In the fact, the conditioning treatment caused an increase in soluble non-starch polysaccharides; which form a gel network and bind water (Gill, 2001). Moreover, Thebaudin *et al*., (1997) reported that soluble fibers had high water binding capacity (the quantity of water that remains bound to the hydrated fibers). Furthermore, Gajdošová *et al*., (2007) showed that the molecular weights of soluble β-glucans are higher than those of the insoluble β-glucans; and the high molecular weight β-glucan resulted in a greater increase in the water absorption capacity (Skendi *et al*., 2009). Table 2 indicated that there were no significant differences in final bread weights of barley bread samples, except of the bread samples of flours obtained from barley grains conditioned to 18% before milling, which had high significant differences in bread yield. On the other hand, it can be observed that volume, specific volume and yield of bread from hulled and hull-less barley flours were enhanced with increasing the conditioning moisture content of grains prior to milling. Gill *et al*., (2002) reported that (1,3 and 1,4)-β-D-glucan and starch contents in barley had an effect on loaf volume indirectly. So such increase in loaf volume may be reflect the improvement of the gas holding capacity of the barley and wheat-barley doughs which happened as a result of viscosity increase. Moreover, Gan *et al*., (1995) reported that the increase in dough viscosity results in an improvement of the gas-holding capacity of the wheat dough, which cause a higher volume.

Table 2. Dough and baking characteristics of barley bread.

Variety	Bread of Flour samples	Baking characteristics					
		Dough yield (%)	Bread				
			Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)	Bread yield (%)	Baking loss (%)
Giza123 Hulled barley (100%)	S2	225.00d	150.00d	193h	1.28e	171.39e	23.82a
	S3	228.90c	165.00b	257g	1.56d	188.21c	17.81b
	S4	230.29b	165.00b	259f	1.57d	190.14b	17.44c
	S5	231.00a	170.00a	273d	1.61d	194.84a	15.65e
Giza130 Hull-less barley (100%)	S6	200.13h	150.00d	266e	1.77c	166.77g	16.66d
	S7	201.03g	150.00d	275c	1.83c	167.52f	16.66d
	S8	205.59f	150.00d	300b	2.00b	171.33e	16.66d
	S9	210.23e	159.75c	346a	2.31a	181.53d	13.65f

Different letters mean significant differences at ($p < 0.05$), whereas values with the same letter mean no significant differences

It can be observed from the results of Table 2 that there was decrease in baking loss values of bread baked from hulled barley flours with the increase in conditioning moisture content of grains prior to milling; and this decrease may be due to increase in solubility of β-glucan and pentosan, which bind water and keep the bread from losing its weight. Jacobs (2006) reported that the increase in bread weight with barley as fiber rich fraction enrichment indicating that much of the additional water was tightly bound and not lost during baking. On the other hand, Tiwari *et al*., (2011) showed that the baking time effect on the baking loss percentage. Indeed, hulled barley bread required more baking time than hull-less barley bread, which may be explain the high baking loss value of its bread. These results are in good agreement with that reported by Sharma and Gujral (2014), who reported that chapatti bread containing higher levels of barley flour required longer time to bake and had a higher baking loss (up to 20%). Moreover, Therdthai *et al*., (2002) reported that the weight loss during the bread baking process is mainly due to loss of moisture from the outmost layer of the bread; and the surface moisture is significantly reduced due to the formation of a relatively hard crust (Tiwari *et al*., 2011).

Sensory evaluation of barley bread:

The results of sensory evaluation of fresh pan breads baked from different flour samples were illustrated in Figures 1-11, which showed the both procedures A and B. The procedure A involved in a manual evaluation of the crumb (compression and kneading) and oral evaluation of the crust (biting and chewing). Figure 1 showed that spring back attribute recorded its highest score at zero time, then it decrease after 24 hours of storage as a result of moisture redistribution in the bread, after that the curve return to increase again. Also, Kihlberg *et al*. (2006) showed a correlation between highest juiciness and lowest springiness in bread samples. The curves showed that conditioning treatment increased the springback attribute values, as the samples S5 and S9, which prepared from barley grains conditioned at 18% moisture before milling, recorded the highest scores during the storage time. Furthermore, Figure 1 revealed that hull-less barley bread samples were better than that baked from hulled barley samples. Figure 2 and 3 illustrated the softness of the crumb center and the softness of the upper part of the crumb, which decreased with storage time in all samples due to the migration of the moisture with time from the crumb to the crust. Indeed, the softness of hulled and hull-less barley breads increased with the increase of condition moisture content of grains prior to milling. Also the figures showed that the softness of hull-less barley bread samples seems to be better than hulled barley bread. Moreover, Figure 4 indicated that the attribute ease to knead a ball from the crumb decreased with storage time. It can be observed that hulled barley bread samples were better than hull-less barley during the three days of storage. The crumbliness attribute increased with storage time as shown in Figure 5. Khatkar (2004) reported that when the bread crumb stale, it becomes drier, less elastic, crumbly and harsh textured. Indeed the conditioning treatment of barley grains prior to milling, especially at the level 18% in both varieties (samples S5 and S9) had the lowest score of crumbliness after three days of storage, which reflect the positive effects of conditioning treatment. This decrease in crumbliness values happened as a result of soluble non-starch polysaccharide (Pentosan and β-glucan); which compete with native starch granules in the dough and restricted the swelling and solublization of starch during baking, and thereby reduced the firmness (Gill, 2001). On the other hand, the crust of bread samples was evaluated in the fresh bread and after storage time; and showed that the difficulty to bite attribute (Figure 6) indicated an increase after 24 hours of storage, then it decrease after that in all samples which attributed to the migration of the moisture from the crumb to the crust and makes the crust more leathery and softer (Khatkar, 2004). The Figure 6 indicated also that the conditioning treatments caused a decrease in the difficulty to bite through the crust. Although, the crust would be crisp, brittle and somewhat dry in fresh bread, the brittleness (Figure 7) and toughness (Figure 8) attributes decreased with increase of the storage time. The procedure B was conducted for manual evaluation of a whole slice and oral evaluation (biting and chewing) of the crumb. Figure 9 showed the positive effect of conditioning treatment of hulled and hull-less barley grains prior to milling on the whole slice softness of the bread samples. Meanwhile, the attributes of dryness (Figure 10) and stickiness to teeth (Figure 11) were increased with the storage time. However, the samples S5 and S9 had the lowest score of dryness. Figure 12 illustrated the effect of physical altering by conditioning the barley grains before milling to different levels of moisture on the bread crumb of barley bread. The crumb of hulled barley bread seems to be dryer and firmer consistency than that of hull-less barley bread. In addition, Figure 12 showed that the hull-less barley breads were better than hulled barley breads regarding crumb color because the hull-less barley flour had higher L^* value (white) than that of corresponding flour from hulled barley (Abdel-Gawad *et al*., 2016).

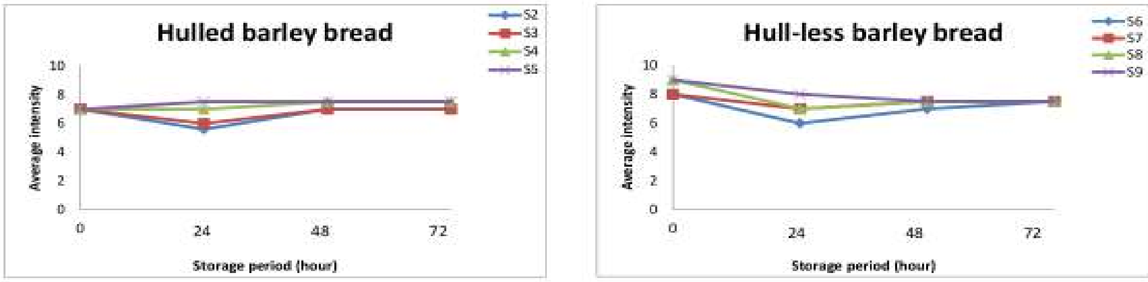

Fig. 1. The spring back attribute of barley bread crumb.

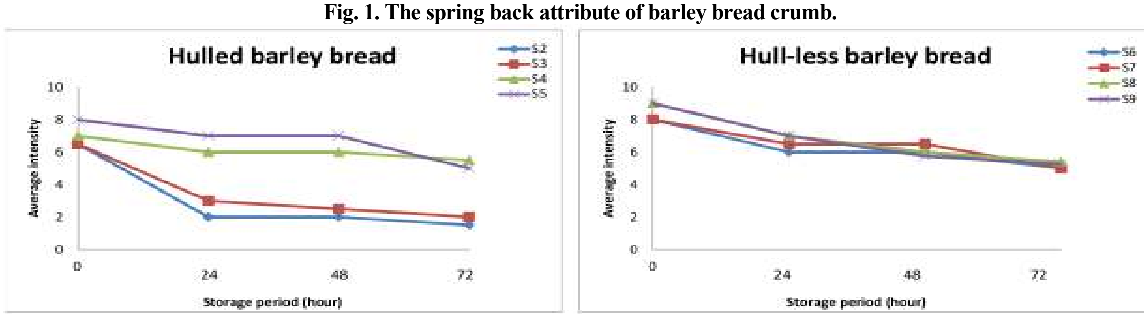

Fig. 2. Crumb softness evaluation of barley bread (in the center of the slice).

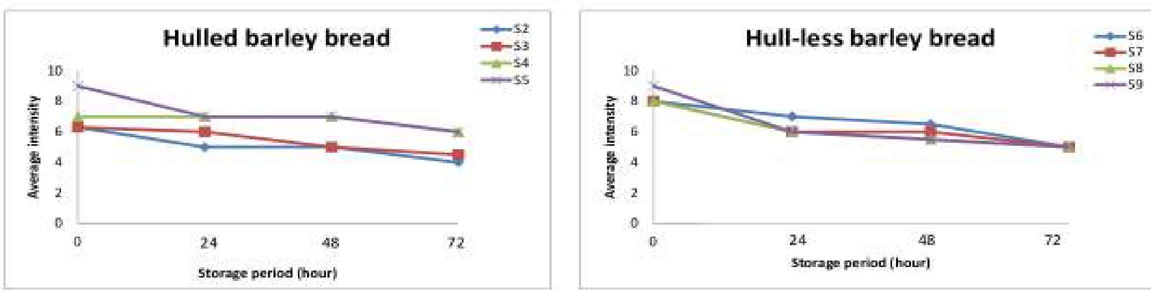

Fig. 3. The crumb softness evaluation of barely bread (at the upper part of the slice)

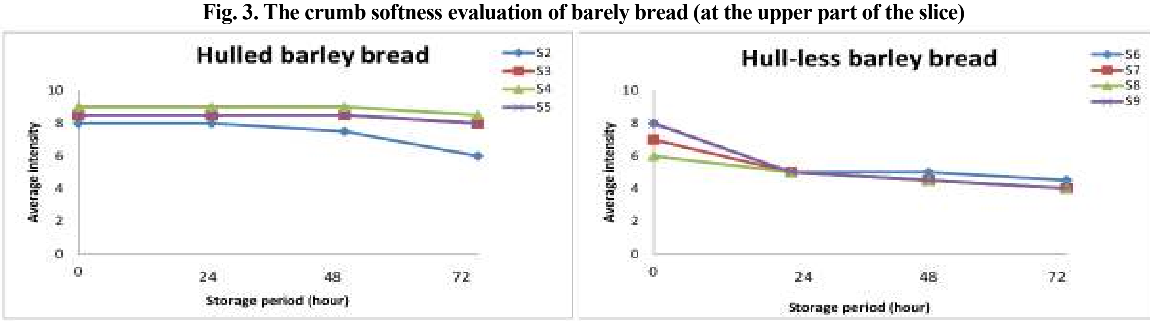

Fig. 4. The ability to knead a ball for barley bread crumb.

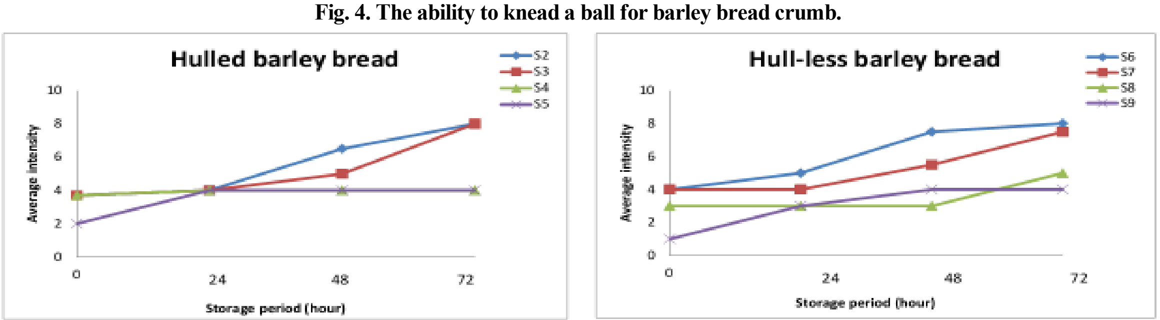

Fig. 5. The crumbliness attribute evaluation of barley bread crumb.

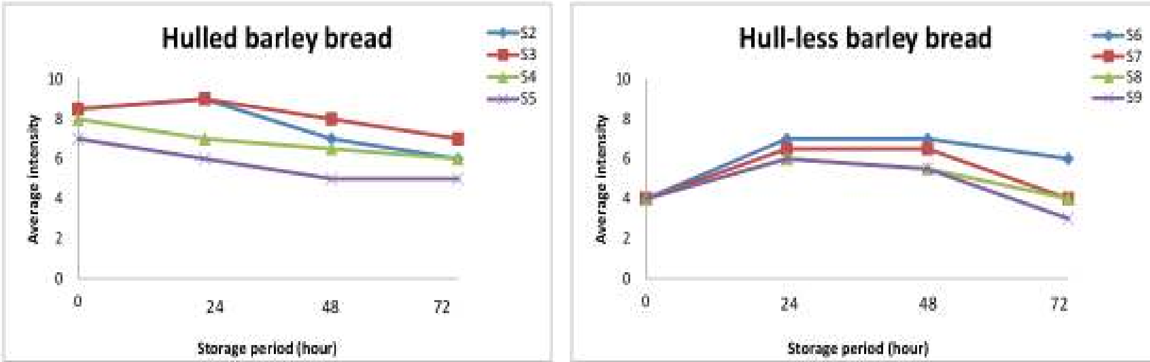

Fig. 6. The difficulty to bite through the crust of barley bread.

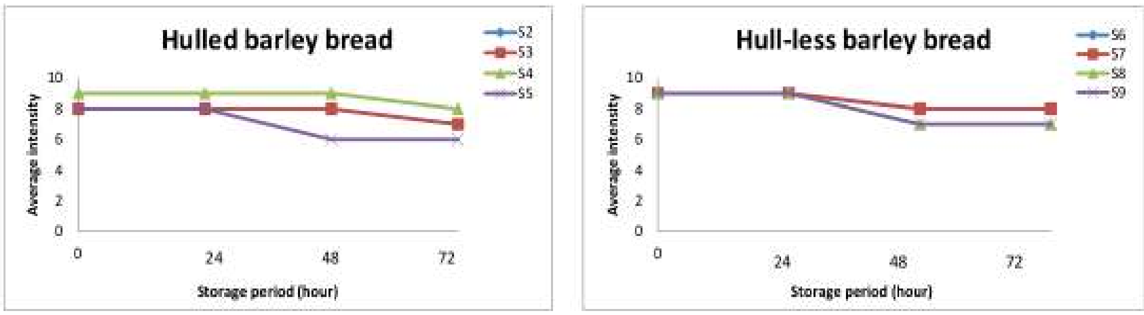

Fig. 7. The brittleness of barley bread crust.

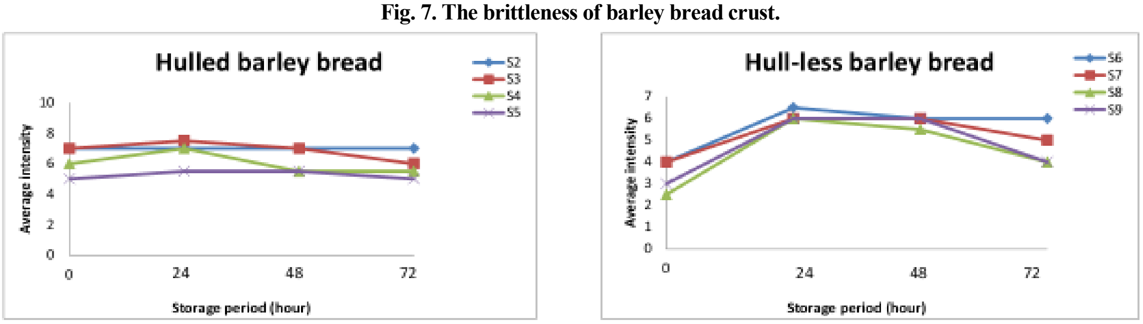

Fig. 8. The oral evaluation of the crust toughness attribute of barley bread.

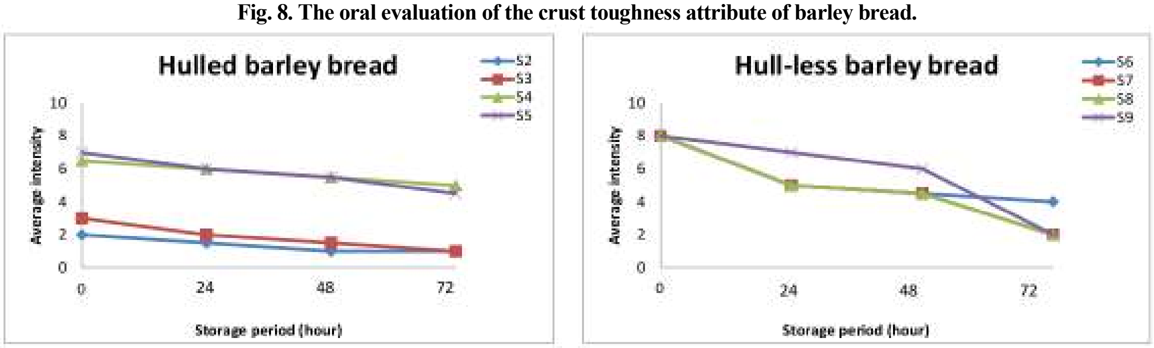

Fig. 9. Whole slice softness of barley bread crumb.

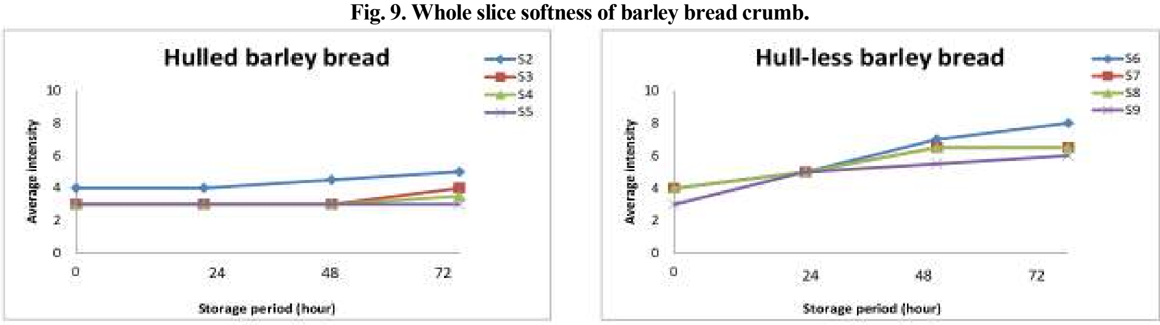

Fig. 10. Crumb dryness of barley bread.

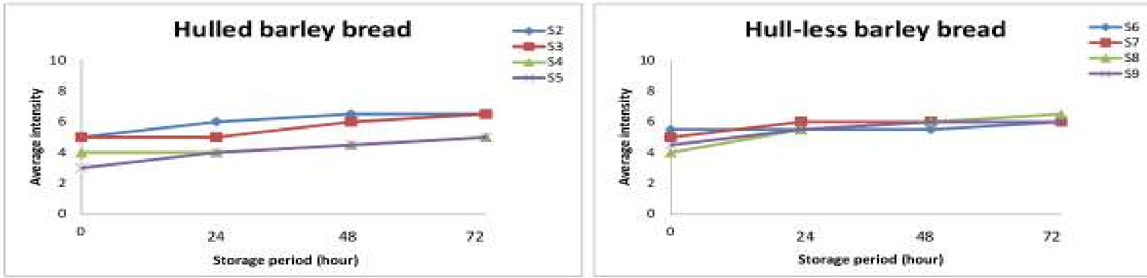

Fig. 11. The stickiness to teeth attribute of barley bread.

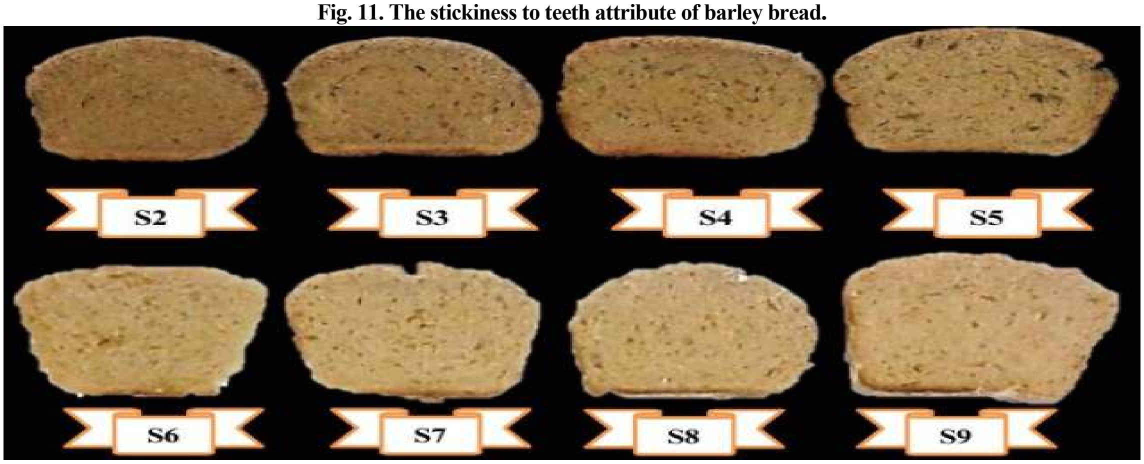

Fig.12. Hulled and hull-less barley bread samples baked from flours of grains tempered at different levels of moisture prior to milling.

Moisture content of barley bread:

The moisture contents of bread baked from hulled and hull-less barley flours are shown in Figure 13. In general, there was an increase in bread moisture content with increasing the moisture level of conditioning treatment of barley grains prior to milling which may be due to increase in soluble dietary fiber (pentosans and β-glucan) which bind more water. Also, Figure 13 showed that there was a decrease over time in the bread moisture content during 24, 48 and 72 hrs of storage periods because the migration of moisture from crumb to crust of bread and finally to atmospheric air. Such observation was reported previous by Puhr and D'appolonia, (1992). It could be concluded from Figure 13 that hull-less barley bread samples had higher moisture content than corresponding hulled barley bread which may be due to the low values of baking loss in hull-less barley breads comparing with hulled barley bread.

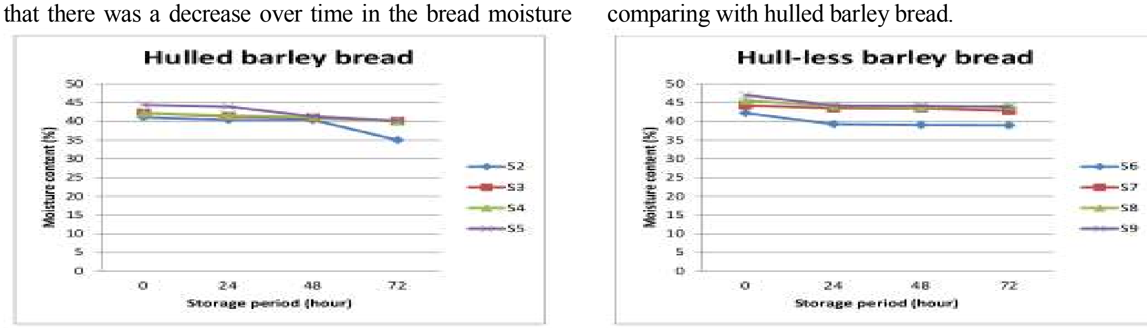

Fig. 13. Moisture content of barley breads after storage period of zero time, 24, 48 and 72 hrs.

Staling rate of barley bread:

Bread staling was determined by the alkaline water retention capacity (AWRC) as a simple and quick test to follow staling of pan bread, where there are reverse relationship between alkaline retention capacity and the rate of bread staling. High values of AWRC mean high freshness of bread. Data presented in Figure 14 showed the values of the determined AWRC as indicator for bread staling. The effect of increase in moisture content of barley grains by tempering process prior to milling on staling rate of baked barley pan bread at zero time (after 4 hrs) and after 24, 48 and 72 hrs of storage at room temperature showed decreases in AWRC values indicating the increase in staling rate of bread from flours of both barley varieties. The high retrograded starch has less AWRC. In addition, the bread samples which had higher moisture content had less staling rate. In fact, bread moisture content influenced the firming rate and starch retrogradation and there was a negative relationship between moisture content and firming rate in the bread samples (Rogers *et al*., 1988). In addition, Rasmussen and Hansen (2001) referred to the influence of moisture content on bread staling. Moreover, Figure 14 indicated that the AWRC values of hulled barley bread samples were higher than hull-less barley samples indicating that the staling rate in the former were lesser than the latter. However the sample S9 of hull-less barley recorded the highest AWRC value after 72 hours of storage indicating the lesser staling rate. The anti-staling property of barley β-glucan prevents the retrogradation of amylopectin due to its high water retention capacity (Sharma and Gujral, 2014) which may explain the differences in AWRC values between varieties. In addition, Hoseney and Miller (1998) mentioned the relationship between the reduction observed in starch solubility in the bread crumb during storage and the increase of starch re-crystallization. Furthermore, Abdel-Gawad *et al*., (2016) showed that hulled barley flour had a higher soluble starch content than hull-less barley flour; which imply lower starch re-crystallization especially the bread sample S8 and S9 after 72 hrs of storage. Indeed the high content of non-starch polysaccharides of hulled barley may explain the differences between varieties in AWRC values of fresh and 24hrs-stored bread. In addition, Khatkar (2004); Beaver (2008); Gill *et al*., (2002) showed the role of pentosans and β-glucans in slowing down the firming of starch gels by restricting the amount of water available for starch gelatinization. Also, Kurek *et al*., (2017) studied the effect of beta-glucan and moisture content on the quality parameters of the fresh and stored bread on different levels, and found that the bread fortified with optimized beta glucan could prevent staling of bread, even up to 7 days of storage. Figure 15 showed the loss of freshness (%) which calculated from the differences between AWRC at zero time and after 24, 48 and 72 hrs. The results of the this Figure showed the positive effect of the increase of moisture content of barley grains prior to milling on retarding staling of the baked pan bread. Also it showed that the loss in freshness % of hull-less barley bread was lower than that determined for hulled barley bread may be due to the loss of bread moisture during storage for 48 and 72 hrs was lesser in the former than that observed for the latter.

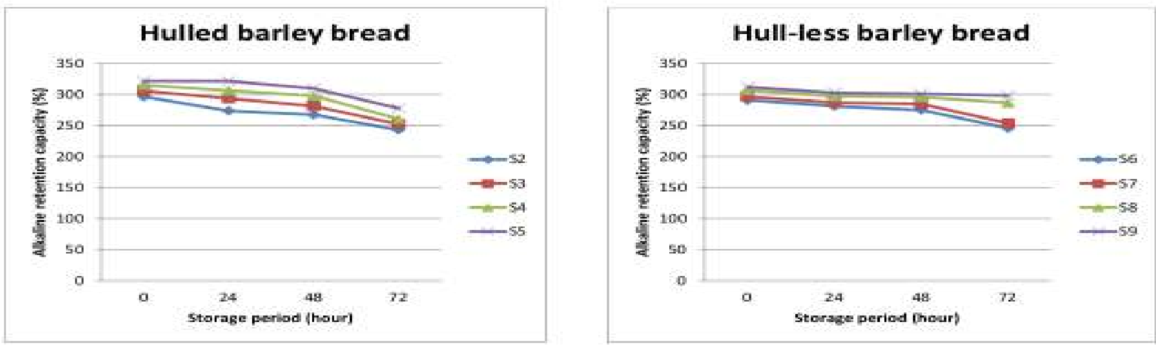

Fig. 14. AWRC of fresh barley breads and after storage for 24, 48, and 72 hrs.

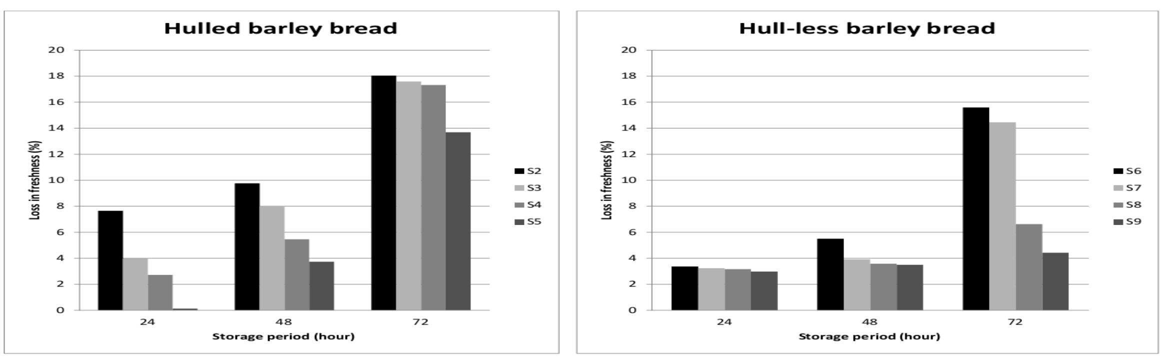

Fig. 15. The loss of freshness (%) in hulled and hull-less barley breads during the storage at room temperature.

Bread making from wheat-barley composite flours:

Dough evaluation and baking characteristics:

Table 3 showed the effect of different conditioning treatments of barley grains prior to milling on the dough and baking characteristics of bread from wheat-barley composite flours. Dough of wheat showed lower yield compared to all doughs from wheat-barley composite flours. Such differences between wheat and wheat-barley doughs may due to the high content of fibers in barley flours. Furthermore, the dough yield of wheat-hulled barley was higher than the corresponding dough yield of wheat-hull less barley composite flour which may be due to the increase in flour water absorption by soluble non-starch polysaccharides in the former than the later. The bread weight of bread samples (Table 3) indicated that there were no significant differences between hulled and hull-less barley samples, whereas the wheat bread had the lowest weight because wheat flour required less water amount for dough development. It can be observed from Table 3 that the loaf volume of wheat bread recorded the highest volume (644 cm^3), whereas the sample S10 had the lowest volume, as it contain the highest amount of insoluble fibers. Škrbic *et al*. (2009) found that the addition of barley flour to wheat flour caused a decrease in bread volume due to the gluten dilution and less retention of CO_2 gas which lead to a decrease in baking quality. On the other hand, the loaf volume of breads baked from wheat-barley composite flours (Table 3) increased significantly with the increase of moisture content of barley grains prior to milling in both barley varieties. The decrease of ash and fiber contents of flour with increasing the conditioning moisture of grains prior to milling improved the bread volume. In addition, the increase in loaf volume of bread from wheat-barley composite flours with increment of conditioning moisture of barley grains prior to milling may be reflect the improvement of the gas holding capacity of the wheat-barley doughs as a result of viscosity increase (Gill *et al*., 2002). Concerning the specific volume (Table 3), the results indicated that wheat bread had the highest specific volume, followed by bread from wheat-hull-less barley composite flour (S17), whereas the bread from wheat-hulled barley composite flour (S10) had the lowest specific volume. All yield of bread from wheat-barley composite flours was increased when the moisture content of barley grains prior to milling increased (Table 3). Wheat-hulled barley bread (S13) had the highest bread yield, whereas the wheat bread had the lowest bread yield. In addition, the baking loss values were decreased in all wheat-barley bread with the increase in conditioning moisture of barley grains prior to milling; and this decrease may due to the increase in the solubility of β-glucan and pentosan, which bind water and keep the bread from losing its weight. Jacobs (2006) found that the increase in bread weight with barley as fiber rich fraction enrichment, indicating that much of the additional water was tightly bound and not lost during baking. The data in Table 3 revealed that wheat-hulled barley bread samples were higher in baking loss values than the corresponding samples of wheat-hull-less barley breads which may be due to the differences between them in the water binding capacity by pentosans and β-glucan as well as the baking time. Such observations were noticed by Sharma and Gujral (2014). Furthermore, the specific volume index, bread yield index and baking loss index of wheat-barley breads were expressed as percentage of the wheat bread as control (Fig. 16). The figure illustrated the positive effects of the increase in conditioning moisture of barley grains before milling on the specific volume index, bread yield index, and decrease in the baking loss index.

Table 3. Baking characteristics of bread from wheat and wheat-barley composite flours.

Variety	Bread samples	Baking characteristics					
		Dough yield (%)	Bread				
			Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)	Bread yield (%)	Baking loss (%)
100% (wheat)	S1	186.9d	142.7d	644a	4.51a	164.04f	12.23b
50% *Giza130* Hulled barley	S10	199.87b	153.16a	265i	1.73f	173.55d	13.17a
	S11	200.36ab	152.21b	272h	1.78f	174.43c	12.94a
	S12	200.40ab	152b	300g	1.97e	174.45c	12.95a
	S13	201.15a	153.38a	350d	2.28cd	176.29a	12.35b
50%*Giza130* Hull-less barley	S14	188.9c	151.7bc	340f	2.24d	172.68e	8.61c
	S15	189c	151.47bc	344e	2.27cd	173.51d	8.20d
	S16	189c	152.14b	358c	2.35c	174.27c	7.79e
	S17	189.84c	150.98c	377b	2.49b	175.56b	7.52f

Different letters mean significant differences at ($p < 0.05$), whereas values with the same letter mean no significant differences.

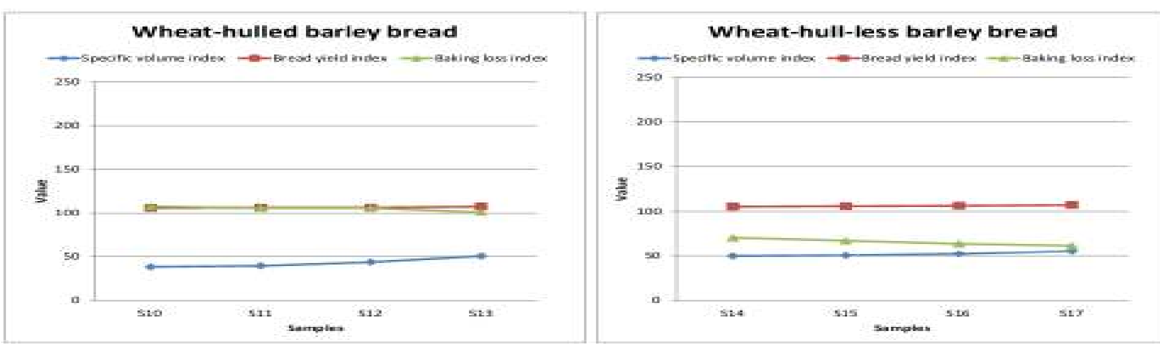

Fig. 16. Specific volume, bread yield and baking loss index of bread from wheat-barley composite flours.

Sensory evaluation of bread from wheat-barley composite flours:

Sensory evaluation was carried out for bread samples from wheat-barley composite flours to evaluate different parameters of bread. Figures 17-27 showed the both procedures A and B. The procedure A involved in a manual evaluation of the crumb (compression and kneading) and oral evaluation of the crust (biting and chewing). Figure 17 showed that springback attribute recorded its highest score at zero time, then it decrease after 24 hours of storage as a result of moisture redistribution in the bread, after that the curve return to increase again. The curves showed that conditioning treatment improved springback attribute. Furthermore, the figure illustrated that hull-less barley samples were better than hulled barley samples. Figure 18 and 19 illustrated the softness of the crumb center and the softness at the upper part of the crumb, which decreased with storage time in all samples due to the migration of the moisture with time from the crumb to the crust; while wheat bread recorded the highest softness. This parameter measured for wheat-hulled and wheat-hull-less barley breads showed improving with increment of conditioning moisture content of barley grains prior to milling. Furthermore, the softness score of the sample S17 was better than wheat bread after 72 hrs of storage and this reflect the positive effect of physical altering of barley grains by conditioning treatment on the softness of the crumb which considered a sign of freshness for consumers according to Stölman and Lundgren (1987). Moreover, Purhagen *et al*. (2011) reported that the high water-holding capacity and water absorption of the barley flours improve the crumb softness. Moreover, Figure 20 indicated that the attribute ease to knead a ball from the crumb was decreased with storage time. It can be observed that wheat-hulled and wheat-hull-less barley bread samples were better than wheat bread as control and recorded the highest scores, even after 72 hrs of storage due to the high moisture content of these breads.

The crumbliness attribute was increased with storage time as shown in Figure 21. Indeed the conditioning treatment of barley grains prior to milling, especially at the level of 18% moisture (samples S13and S17) had the lowest score of crumbliness after 72 hrs of storage, which reflect the positive effects of conditioning treatment at high level of moisture. The decrease in crumbliness values happened as a result of soluble non-starch polysaccharide (Pentosan and β-glucan). On the other hand, the crust of bread samples was evaluated in the fresh bread and after storage time; and the result of difficulty to bite attribute (Figure 22) showed an increase after 24 hours of storage, then it decrease after that in all samples due to the migration of the moisture from the crumb to the crust. Figure 22 indicated also that the conditioning treatments of barley grains at high moisture content caused a decrease in the difficulty to bite through the crust. Although, the crust would be crisp, brittle and somewhat dry in fresh bread, the brittleness (Fig. 23) and toughness attributes (Fig. 24) decreased with increase of the storage time. The procedure B was conducted for manual evaluation of a whole slice and oral evaluation (biting and chewing) of the crumb. The conditioning treatments improve the whole slice softness as shown in Figure 25. The whole slice softness of the fresh wheat bread (S1) recorded the best score among all other fresh breads. However, the bread samples (S13 and S17) were better than S1 after 48 and 72hrs of storage. Meanwhile, dryness (Fig. 26) and stickiness to teeth attributes (Fig. 27) were increased with the storage time, the samples S13 and S17 had a lower score of dryness than wheat bread. Figure 30 showed the effect of physical altering by conditioning barley grains at different moisture contents before milling on the volume and crumb characteristics of wheat and wheat-barley bread samples

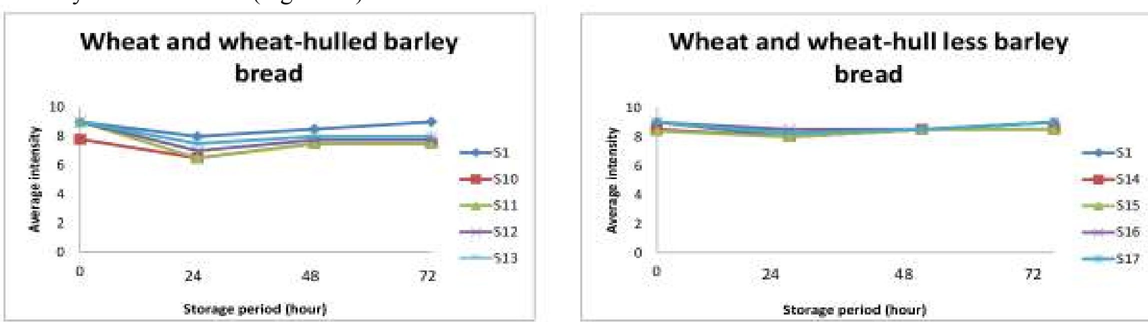

Fig. 17. Spring back attribute evaluation of the bread crumb.

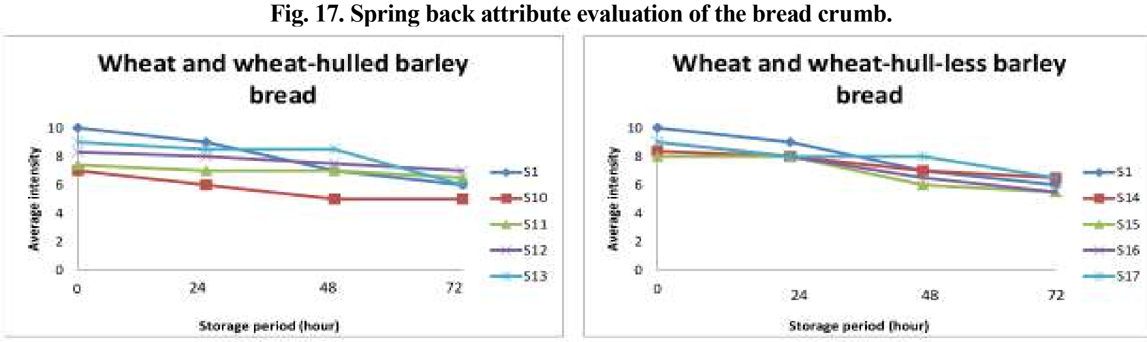

Fig. 18. Crumb softness evaluation (in the center of the slice).

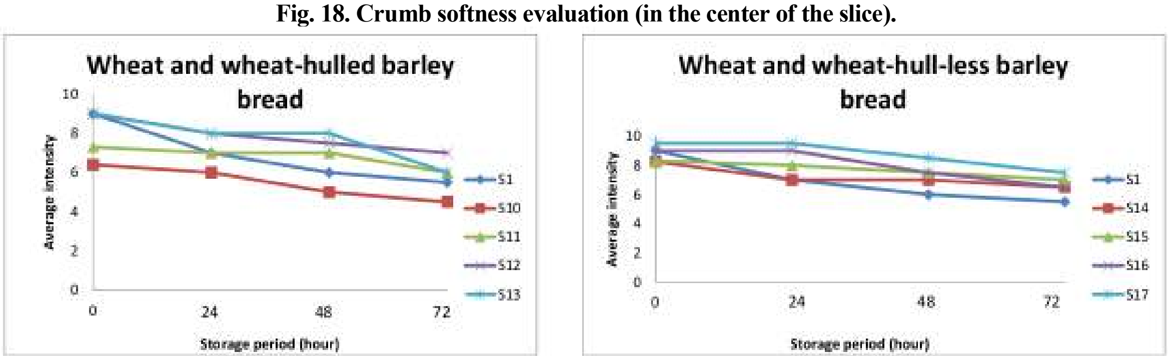

Fig. 19. Crumb softness evaluation (at the upper part of the slice).

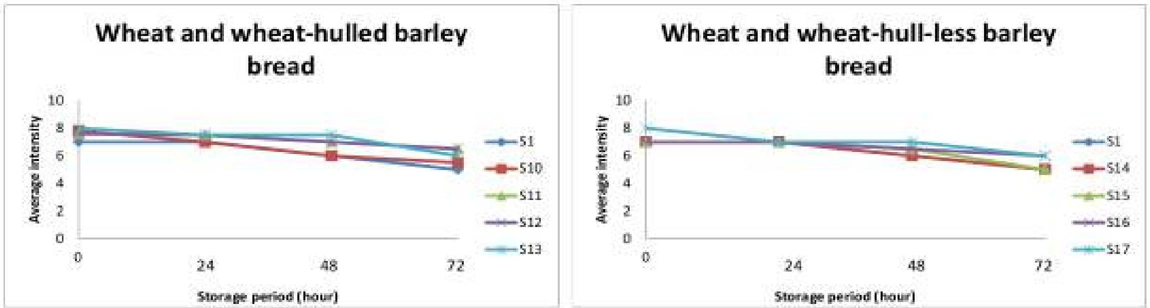

Fig. 20. The ability to knead a ball for bread crumb.

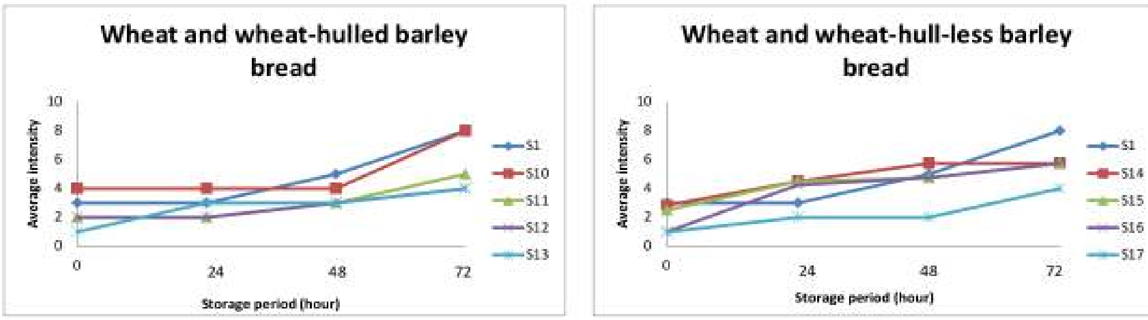

Fig. 21. The crumbliness attribute evaluation of the bread crumb.

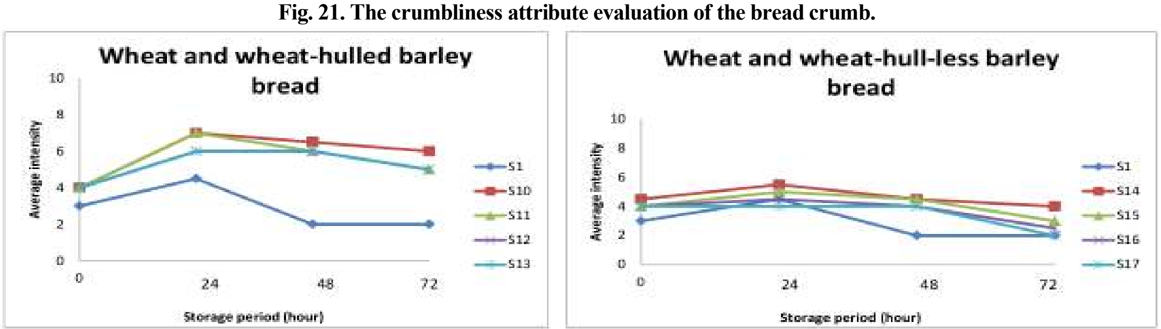

Fig. 22. The difficulty to bite through the crust.

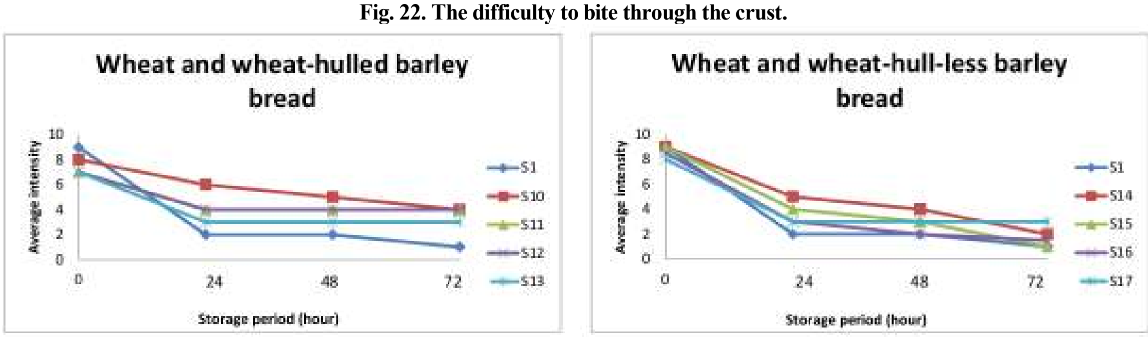

Fig. 23. The brittleness of the bread crust.

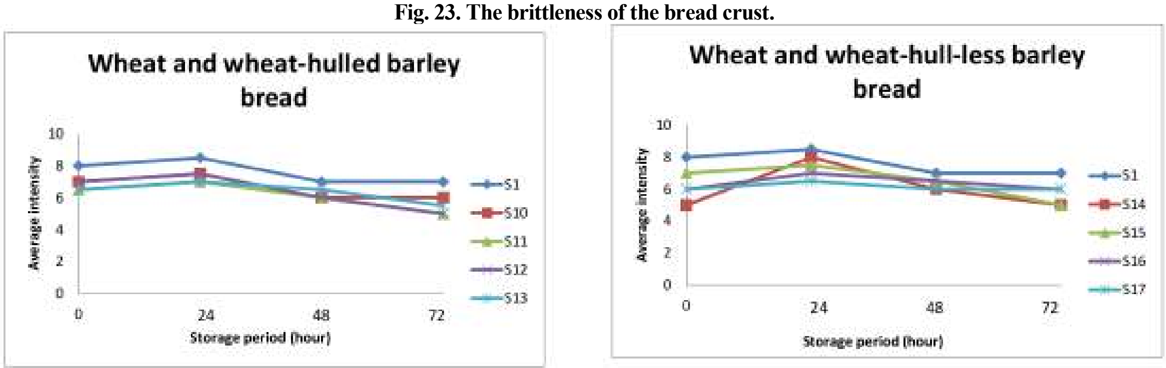

Fig. 24. The oral evaluation of the crust toughness attribute

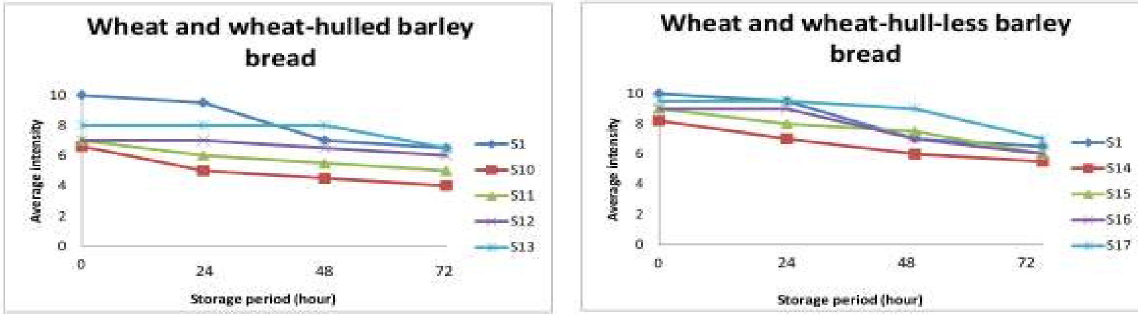

Fig. 25. Whole slice softness of the crumb.

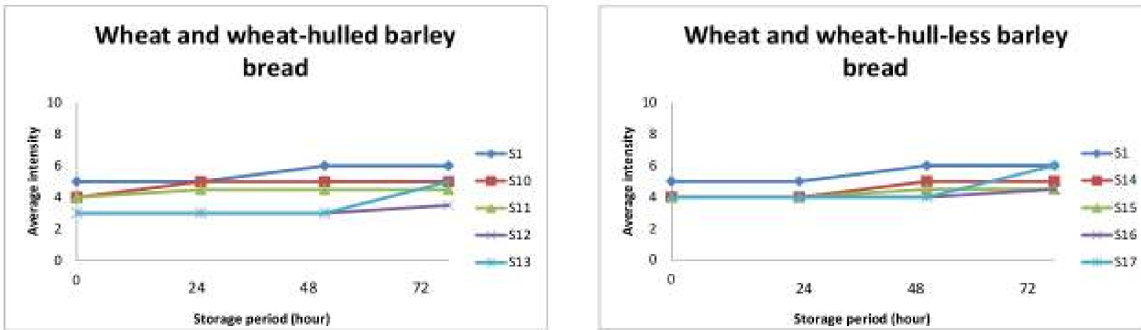

Fig. 26. The oral evaluation of the crumb dryness.

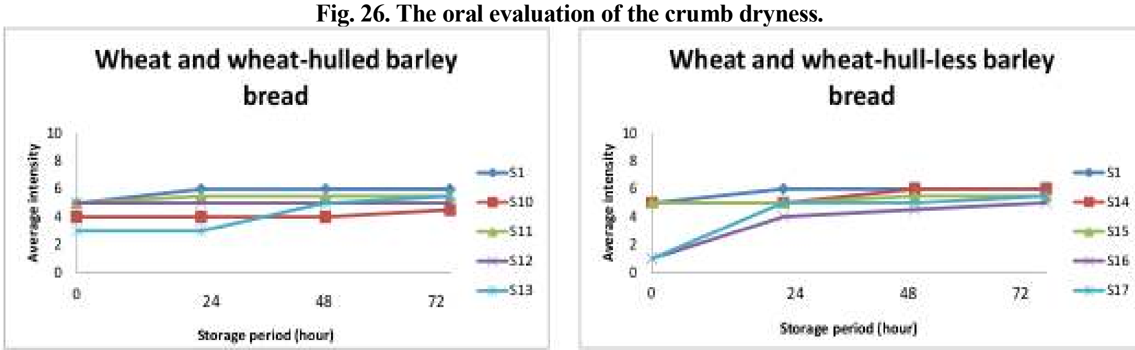

Fig. 27. The oral evaluation of the stickiness to teeth attribute.

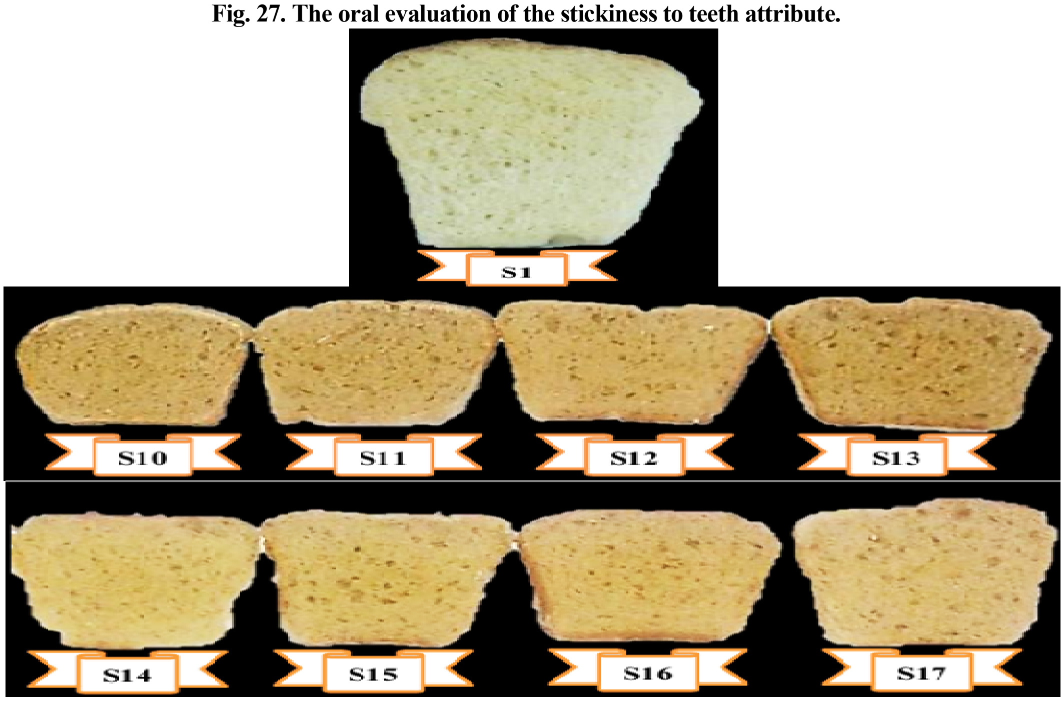

Fig. 28. Wheat and wheat-barley bread samples.

Moisture content of wheat and wheat-barley bread:

The moisture contents of bread baked from wheat flour and wheat-barley composite flours are shown in Figure 29. In general, there was an increase in bread moisture content with the increment of conditioning moisture levels of barley grains prior to milling may be due to the increase of soluble dietary fiber (pentosans and β-glucan) which bind more water. In addition, the results showed also that there was a decrease over time in bread moisture content during 72 hrs of storage. Similar observation was reported also by Puhr and D'appolonia, (1992). It can be observed from Figure 29 that the bread sample S17 of wheat- hull-less barley had higher moisture contents after 72 hrs of storage than other tested bread sample. Moreover, the decrease rate in moisture content of bread during storage for 72 hrs was lesser in bread of wheat-hull-less barley than that of wheat-hulled barley bread and this confirms the low values of baking loss in hull-less barley breads comparing with that of hulled barley.

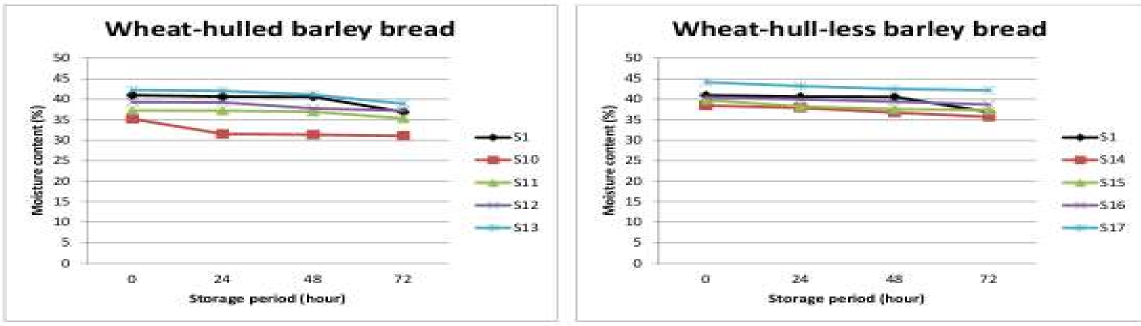

Fig. 29. Moisture content of fresh bread from wheat flour and wheat-barley composite flours and after storage period for 24, 48 and 72 hrs at room temperature.

Staling rate of wheat and wheat-barley bread:

Data presented in Figure 30 showed effect of the increase in moisture content of barley grains by the conditioning process prior to milling on alkaline retention capacity (AWRC) of fresh bread baked from wheat and wheat-barley composite flours and during the storage of bread for 24, 48 and 72 hrs at room temperature. The results indicated that the increase in AWRC of bread (more bread freshness) with increment of conditioning moisture of grains prior to milling. The increase in AWRC values may be due to the decrease in total setback values of starch (Abdel-Gawad *et al*., 2016); and increase of soluble dietary fiber (pentosans and β-glucan) which retard the staling rate. It could be seen from the Figure 30 that all wheat-barley bread samples (hulled and hull-less) had lower value of AWRC at zero time of storage (after 4 hours of baking) than the control sample (wheat bread), which had the highest value. Indeed the low value of total setback of wheat flour comparing with wheat-barley composite flours (Abdel-Gawad *et al*., 2016) reflects the decrease in starch retrogradation (high value of AWRC) of wheat bread. In this concept, (Sullivan *et al*., 2010) reported that the flour which had a high setback value, the bread baked from it would had a higher ability to starch retrogradation. Moreover, Figure 30 indicated that the wheat-hulled barley breads were staled lesser (higher values of AWRC) than wheat-hull-less barley bread. The bread sample S13, which made from 50%wheat-50% hulled barley flour from grains conditioned to 18% moisture content, had the highest value of AWRC after 72 hrs of storage and was better than wheat bread as control. Indeed the high content of non-starch polysaccharides of hulled barley may be explaining the differences between varieties in AWRC values. Gomez *et al.* (2003) stated that bread containing more fiber content show longer shelf life. Furthermore, Sharma and Gujral (2014) referred to the anti-staling properties of barley β-glucan, which prevent the retrogradation of amylopectin due to its high water retention capacity. The results of Figure 31 showed the staling rate (loss of freshness %) which calculated from the differences between AWRC at zero time and after 24, 48 and 72 hrs of storage at room temperature. The data indicated the positive effect of the increase of conditioning moisture content of barley grains prior to milling on retarding staling of the baked pan bread. Therefore, the incorporation of wheat flour with hulled barley flour decreased the staling rate of bread.

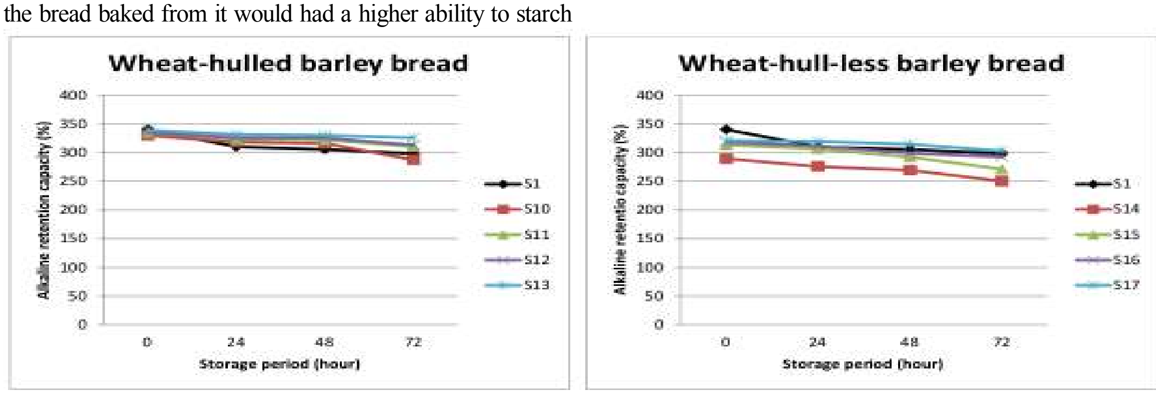

Fig. 30. Alkaline water retention capacity of wheat, and wheat-barley bread at zero time and after storage periods for 24, 48 and 72 hrs at room temperature

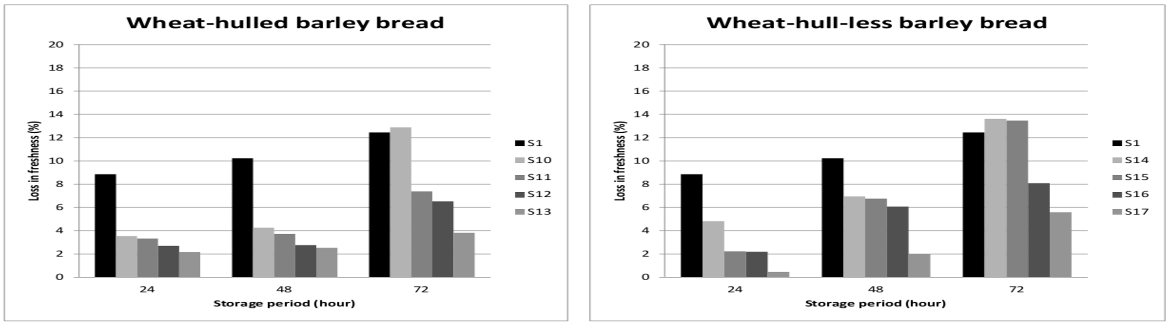

Fig. 31. The loss of freshness (%) in wheat and wheat-barley bread after storage for 24, 48 and 72 hrs of storage at room temperature.

CONCLUSION

The results indicated that the specific volume of breads baked from barley flours and wheat-barley composite flours were enhanced with increasing conditioning moisture of barley grains prior to milling; therefore baking loss values decrease. On the other hand, increase the moisture content of barley grains prior to milling lead to improve all the tested parameters of sensory evaluation and retarded the staling rate of barley pan bread and wheat-barley breads.

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محتوى رطوبي مختلف لتكييف حبوب الشعير المغطى والعاري قبل عملية الطحن . التأثير على الخصائص الفيزيائية والحسية للخبز المصنع من الدقيق الناتج

عبد الله صالح عبد الجواد ، محمد كمال السيد يوسف ، صلاح حسنين محمد ابوالهوي و أسماء محمد عبد الرحمن
قسم علوم و تكنولوجيا الأغذية – كلية الزراعة – جامعة أسيوط

أجرى هذا البحث لدراسة تأثير اختلاف المحتوى الرطوبي (18,16,14,12%) لحبوب الشعير المغطى والعاري قبل عملية الطحن على الخصائص الفيزيائية والحسية للخبز المصنع من الدقيق الناتج. ولقد استبان من نتائج الدراسة ان الحجم النوعى للخبزِ المصنع من دقيق الشعير الخالص وكذلك المصنع من مخلوط القمح والشعير قد تحسن بشكل ملحوظ بزيَاْدَة رطوبةِ تَكيّيف حبوب الشعير قبل الطَحْن فى صنفى الشعير محل الدراسة. بينما انخفضت قيمة الفقد في الوزن اثناء عملية الخبيز نتيجة لزيادةِ رطوبة التكييف قبل طَحْن حبوبِ الشعيرِ. من الناحية الأخرى، فان زيادة محتوى رطوبةَ حبوبِ الشعيرِ قبل الطَحْن قد ادت الى تَحسين كُلّ درجات التقييمِ الحسّي لخبزِ الشعيرِ الناتج، بالاضافة الى انخفاض معدل البيات بشكل واضح فى الخبز المصنع من دقيق الشعير الخالص وكذلك المصنع من مخلوط القمح والشعير.