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EFFECT OF BARLEY FLOUR ON WHEAT BREAD QUALITY

[83]

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ABSTRACT

This study was carried out to investigate the possibility of utilization of barley flour in production of pan bread. wheat flour of (72% extract) was replaced by 10, 15 and 20% barley flour. The effect of such replacements on physical and chemical characteristics of produced pan bread were studied. The results indicated that barley flour had a higher contents of chemical composition than that in wheat flour except carbohydrate content was the highest in wheat flour (85.53%) than in barley flour (76.67%),whereas, protein, ash, dietary fiber, β-glucan and antioxidant were higher content in barley flour (13.63, 2.44, 19.00, 8.65, 97.34 respectively) as compared with its content in wheat flour (12.26, 0.49, 4.88, 0.34, 55.33 respctively),while, wet gluten and falling number were reduced by added barley in composite flour. The rheological properties of the five dough mixes were studied using farinograph and extensograph. The water absorption and dough weakening increased as the percentage of barley flour increased, while were decreased the extensibility and maximum resistance to extension . The results of sensory characteristies of prepared bread (containes10% barley flour) was not significants different from control for crust color, grain and texture.

The results revealed that it was possible to use barley flour at level of 10, 15% to produce bread that satisfied baker's and consumer's sensory expectation. This levels may be to increased the nutritional value from dietary fibers, β-glucan, minerals, vitamins and antioxidants.

INTRODUCTION

Wheat (*Triticum aestivum*) is the most important crop for baking due to its absolute baking performance in comparison to all other cereals **(Dewettinck et al 2008).** Several developing countries have encouraged the initiation of programs to evaluate the feasibility of alternative locally available flours as a substitute for wheat flour. Many efforts have been carried to promote the use of composite flours, in which a portion of wheat flour is replaced by locally growing crops, to be used in bread, thereby decreasing the cost associated with imported wheat **(Olaoya et al 2006) .** However, wheat flour proteins are deficient in some essential amino acids such as lysine lowering the quality and nutritional properties of cereal and their products **(Dhingra and Jood, 2001).**

Barley is well known as an excellent choice for diet fortification in deficient proteins areas **(Aludatt et al 2012) . Newman and Newman (2006)** have used barley in several food industries such as the brewing industry and even animal feeding. Recently several studies were recommended to use barley seed in the human diet compared to other seeds due to pharmaceutical and neutraceutical properties **(Manach et al 2004).** Many diseases were studied in relation to barley and its products such as cardiovascular disease and diabetes **(Lupton et al 1994).** Blending of barley with human diets is being intensively studied due to the presence of β-glucan and phenolic compounds which have the potential to lower cholesterol and glucose levels in blood **(Cavallero et al 2002). Miller (1994)** showed that the isolated β-glucan from barley reduced glucose and insulin response to carbohydrates loads in human. Barley proteins have been recognized as a rich source of the limiting essential amino acids (Lysine, threonine, methionine and tryptophan) **(Newman and Newman 2006).**

Bread is an important stable food in both developed and developing countries, wheat flour of both hard and soft wheat classes has been the major ingredient of leavened bread for many years

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because of its functional properties **(Abdelghafar et al 2011).**

Therefore, this work was aimed to study the proximate chemical composition of wheat and barley flour and the effect of the partial replacement of wheat flour by barley flour on physical properties of the resulted dough. Baking characteristics of pan bread prepared from the different suggested replaced flours were also evaluated.

MATERIALS AND METHODS

MATERIALS

Strong Wheat flour (72% extraction) was obtained from Ebnel-Khattab milling company in 6th October, Cairo, Egypt. Barley grains, hull less barely grains (*Hordium vulgare* L.) was obtained from Barley Research Section, Field Crops Research Institute, Agricultural Research Center, Giza, Cairo, Egypt.

All other ingredients (Instant active dry yeast, sucrose, salt, corn oil and bread improver) were obtained from the local market, Cairo, Egypt.

Methods

Preparation of barley flour

Hull less barley grains were moistened to 14% moisture content for 24h, then milled by perten laboratory mill 3100 to whole barley flour, then sieved through a 35-mesh screen sieve to produce flour 85% extraction rate . The flour was packed in polyethylene bags and stared at (-18°C) until used.

Preparation of composite flour blends

Wheat flour (72% ext.) was partially replacement with different ratio by 10, 15, 20, 25 and 30% of barley flour. The flour mixtures were individually blended, homogenized, then packed in polyethelene bags which tightly closed and stored at (-18°C) until used.

Pan bread processing

The conventional straight-dough method for pan bread was performed according to the procedure developed by **A.A.C.C. (2000)** with some modification. The following formulation: flour 100g, sugar 0.5 g, yeast (Active dry yeast) 2.0 g, salt (sodium chloride) 2.0 g, corn oil 0.5 g and specific amount of water according to the water absorption revealed by Brabander Farinograph.

Analytical methods

Chemical analysis

Moisture content, crude protein (N x 5.7), lipids, ash and crude fiber contents were determined according to **A.O.A.C. (2000).** Nitrogen free extract (NFE) was calculated by difference. Also, vitamins and minerals content were determined according to **A.O.A.C. (2000).**

Amino acids analysis for both, essential and non-essential amino acids were estimated using automatic high performance amino acid analyzer at Regional center for food&feed, Cairo,Egypt. According to the method described by **Baxter (1996).** A 0.1g of sample was hydrolyzed using 1 ml of 6 N HCl, then the sample was placed in distillation refluxing unit (100 Ċ/24h) under vacuum. The supernatant was filtered with cheese cloth followed by lyophilization and stored at -18Ċ for further amino acid analysis.

Protein quality of the various flours and flour blends.

The protein quality was evaluated using the following parameters:

Chemical score of essential amino acid (EAA) relative to FAO / WHO scoring pattern (1973) using the following equation:

Chemical score % (CS)

$$= \frac{EAA\%\ in\ crude\ protein\ x\ 100}{EAA\%\ of\ FAO/\ WHO\ scoring\ pattern}$$

The lowest percentage had been taken as the chemical score, and the corresponding amino acid had been taken as the limiting amino acid.

Essential amino acid index (EAAI)

EAAI had been calculated according to **Oser (1959)** as the geometric mean of the ratios of essential amino acids in the crude protein relative to their respective amount in FAO / WHO scoring pattern (1973) as percentage

Biological value (BV): was calculated according to **Oser (1959)** using the following equation:

BV = 1.09 (EAAI) – 11.73

Calculated protein efficiency ratio (C.PER): was calculated according to **Al-Smyer et al (1974)** using the following equation:

PER=-1.816+0.435 (Methionine)+0.78 (Leucine)+ 0.211 (Histidine) – 0.944 (Tryosine).

Total phenolic and flavonoid contents were determined according to methods described by **Zilic et al (2012).** But free radical scavenging activity were determined using the stable diphenyl picryl hydrzyl (DPPH) according to **Hwang and Dothi (2014).**

Total dietary fiber were measured according to the method described by **A.O.A.C. (2000).** Soluble and insoluble dietary fibers were determined according to the method described by **Prosky et al (1998).** Β-glucan was determined to the method described by **Carr et al (1990).**

Wet gluten and falling No. of wheat flour sample (72% ext.) and wheat flour samples replacement with different ratio by barley flour were determined according to the method described in **A.A.C.C. (2000).**

Rheological properties

Dough rheological properties of the various flour and flour dough blends were determined by Brabender farinograph and extensograph instruments according to **A.A.C.C. (2000).**

Physical characteristics and organoleptic evaluation of pan bread

The weight and pan bread volume was measured by rape seed displacement method as described by **A.A.C.C. (2000)** specific volume were calculated by dividing the volume (cm^3) by their weight (g). Organoleptic evaluation (crust color, summitry of form, grain, crumb color and texture) was determined according to the method described by **Maiya et al (2013).**

Texture properties of bread crumb

Texture parameters (hardness, springiness, cohesiveness, gumminess and chewiness) of bread sample were measured by using a texture analyzer TA-CT3 (Brookfield, USA) as adopted by the standard method by A.A.C.C., method 74-09 **A.A.C.C. (2000).**

Statistical analysis

The results were statistically analyzed by SPSS computer software **(SPPS, 2000).** The stataistical was performed by analysis of variance (ANOVA) and significant differences among the means established was contented using Duncan's multiple test at (P<0.05) according to **Waller and Duncan (1969)**

RESULTS AND DISCUSSION

Chemical properties of wheat and barley flour

Proximate chemical composition of wheat flour (72% ext.) and barley flour are presented in **Table (1).** Barley flour was significantly higher protein, lipids, ash and crude fiber being 13.63%, 3.18%, 2.77% and 4.53, respectively.Meanwhile, wheat flour significantly contained the higher percentage of nitrogen free extract. These results are in agreement with **Salem (2005) and El-Yamlahi and Quhssine (2013)**. Also, from the results presented in **Table (1),** it could be noticed that, barley flour significantly contained higher vitamins (Thiamine, Riboflavin and Tocopherols) by 500, 184 and 350 % more than wheat flour, respectively for these vitamins. Also, it could be noticed that barley flour recorded the higher content of Na, K, Fe, P, Zn, Mn and Mg compared to wheat flour. These results agreed with those obtained by **Mekhael (2005).**

The investigated wheat and barley flour were analyzed for total dietary fiber (TDF), soluble dietary fiber (SDF), insoluble dietary fiber (IDF) and β-glucan. Results are show in Table (1). Barley flour contained the higher percentage of TDF, SDF, IDF and β-glucan compared with wheat flour (72% ext.) by 130, 480, 390 and 8.65% more than wheat flour, respectively. Those results are in accordance with those obtained by **Mekhael (2005) and Mann et al (2005).** Also, data in **Table (1)** showed that, total phenolic contents were higher significantly in barley flour compared to wheat flour (12,58 ver 1.13mg gallic/g). On the other hand, no significantly differences between their flavonoid contents. These results are in agreement with **Quinde-Axtell and Baik (2006).**

The results of antioxidant activity as shown in **Table (1)** revealed that barley flour had significantly high antioxidant activity (97.34 mg trolox/g) compared with wheat flour (55.33 mg trolox/g). These results are in harmony with those obtained by **Aludatt et al (2012) and Zhao et al (2008).**

Table 1. Chemical properties (chemical composition, vitamins, minerals, dietary fiber, β-glucan, phytochemical and antioxidant activity of wheat and barley flour (% on dry weight basis).

Parameters	Wheat flour (72% ext.)	Barley flour
Chemical composition* (%)		
Moisture	12.40[a]	12.88[a]
Crude protein	12.26[c]	13.63[b]
Lipids	1.21[c]	2.77[b]
Ash	0.49[c]	2.44[b]
Crude fiber	0.59[b]	4.53[a]
nitrogen free extract	85.53[a]	76.67[b]
Vitamins* (mg/100g)		
Thiamine (vit. B_1)	1.40[b]	7.00[a]
Riboflavin (vit. B_2)	0.83[b]	1.53[a]
Tocopherol (vit. E)	0.33[b]	1.16[a]
Minerals (mg/100g)		
Sodium (Na)	36.76	61.19
Potassium (K)	126.70	537.00
Iron (Fe)	2.10	4.27
Cupper (Cu)	0.88	0.25
Phosphorus (P)	117.50	360.00
Zinc (Zn)	1.89	3.26
Manganese (Mn)	1.09	2.39
Calcium (Ca)	38.10	36.60
Magnesium (Mg)	16.80	107.00
Dietary fiber (%)		
Total dietary fiber	4.88	19.00
Soluble dietary	1.78	2.30
Insoluble dietary fiber	3.10	16.70
β-glucan	0.34	8.65
Phytochemicals*		
Total phenols (mg gallic acid/g)	1.13[c]	12.58[a]
Total flavonoids (mg catchin/g)	0.36[a]	0.36[a]
Antioxidant activity (DPPH)		
(mg trolox./g)	55.33[c]	97.34[a]

* Means followed by different letters in the same column are significant different by Duncan's multiple test ($p<0.05$)

Amino acids content

Data presented in **Table (2)** showed the essential amino acid composition (g AA/100 g protein).Barley flour Contained higher amino acid contants compare to wheat flour as could be seen in Table(2) . On the other hand, the wheat flour recorded the highest of some essential amino acids such as, isoleucine tyrosine and phenyl alanine than that in barley flour. Also, concerning of non-essential amino acid (NAA), glutamic acid recorded the highest values of amino acids content for wheat or barley flour (25.21 or 22.27 g AA/100 g protein), respectively. An addition it was found that wheat and barley flour contained the relatively highest concentration of methionine+ cysteine and phenylalnine + tyrosin than FAO/WHO scoring pattern being (3.92 and 8.13 g / 100 g protein) for wheat flour and (4.19 and 6.79 g/ 100 g protein) for barley flour. Amino acid scores can be used generally to predict protein nutritional value for human.

Table 2. Amino acid composition (g AA/100g protein) and calculated protein biological values of wheat and barley flour

Amino acids	AASP	Wheat flour (72% ext)	Barley flour	FAW/WHO Child	FAW/WHO adult
Exssential amino acids (EAA)					
Valine	4.96	4.00	4.18	3.5	1.3
Isoleucine	4.00	3.75	2.94	2.8	1.3
Leucin	7.04	5.90	5.64	6.6	1.9
Cystine		2.17	2.45		
Methionine		1.75	1.74	2.5	1.7
Tyrosin	4.00	3.13	2.34	6.3	1.9
Phenylanine		5.00	4.45	5.6	1.6
Lysine	5.44	1.80	4.05	3.4	0.9
Thronine		2.30	2.91	1.9	1.6
Histidin		2.30	2.38		
Meth + Cyst	3.52	3.92	4.19		
Phen+ Tyrosin	6.08	8.13	6.79		
Non-essential amino acids (NAA)					
Aspartic acid		3.75	6.09		
Serine		3.58	3.18		
Glutamic acid		25.21	22.27		
Glycine		3.50	3.64		
Alanine		2.70	3.64		
Argenine		3.60	4.67		
Proline		11.90	9.54		
C-PER		1.08	1.63		
CS		33.10	54.44		
EAAI		60.39	66.89		
BV		54.10	61.18		
LAA		Lysine	Isoleucine		

C-PER = Calculated protein efficiency ratio

CS = Chemical score

EAAI = Essential amino acid index

BV = Biological value

LAA = Limiting amino acid

AASP = Amino acid scoring pattern **FAO / WHO (1985)**

The amino acid scores demonstrated that wheat flour were deficient in lysine, while barley flour were deficient in isoleucine.

From the results, it could be noticed that the quality of protein parameters (PER, CS, EAAI, BV and LAA) were indicated that barley flour can be utilized as a good protein source. Therefore, mixing the wheat flour with barley flour under study could give a product with high quality protein. These results were found to be agreed with those obtained by **Alu-Datt et al (2012) and Biel and Jacon (2013)**

Gluten content and falling number

Wet gluten and gluten index of wheat flour (72% ext.) and its blends with 10, 15, 20, 25 and 30% of barley flour used in the current study were determined and the obtained results were presented in **Table (3)**. The replacement of wheat flour with barley flour caused significantly decreased of wet gluten as the level of replacement increased. The percentage of wet gluten decreased about 8.5, 10.4, 13.6, 37.5 and 48% for wheat flour replacement with 10, 15, 20, 25 and 30% of barley flour, respectively compared with control wheat flour. This finding is in harmony with the obtained by **Dhingra and Jood (2004).** On the other hand, the replacement of wheat flour with 10 and 15% of barley flour caused slightly decreased of gluten index.

Table 3. Gluten content and falling number of wheat flour and composite flour replacement with barley flour

Wheat flours with additives	Wet gluten* content (%)	Gluten index* (%)	Falling number* (sec.)	Liquefaction number
Control sample (wheat flour)	31.7a	95a	449a	15.04b
Barley flour	ND	ND	408 a	16.76a
Percentage of barley flour				
10%	29.0ab	91.1ab	445a	15.19b
15%	28.4ab	85.5b	449a	15.04b
20%	23.4b	80.8bc	448a	15.08b
25%	19.8c	75.9c	445a	15.19b
30%	16.5d	69.1d	445a	15.19b

* Means followed by different letters in the same column are significant different by Duncan's multiple test ($P<0.05$). ND= not determined

Data in the above mentioned Table revealed that, falling number not affected by the addition of barley flour, there were no significant differences ($P>0.05$) between wheat flour sample and wheat flour replacement with 10, 15, 20, 25 and 30% barley flour. The falling number values was ranged from 445 to 449 sec. for all samples. Also, the liquefaction number was not affected by the addition of barley flour (ranged from 15.04 to 15.19) for all wheat flour samples replacement with barley flour. **(Dornez et al 2007).**

Rheological properties of dough

From results presented in **Table (4),** it could be observed that the replacement levels in the blends of barley flour was increased, the water absorption was increased as compared with control sample (wheat flour 72% ext.). The increased in water absorption is probably due to the increase in the total protein, fiber and β-glucan contents of barley flour than wheat flour. These results are in agreement with **Skendi et al (2010).** On the other hand, it could be noticed that the stability of dough was not affected with the increasing of replacement of barley flour. The dough stability for all sample ranged from 9.0 to 9.5 min. **Rieder et al (2012)** reported that, the substitution of white wheat flour with barley flour did not lead to any significant differences from the same **Table (4)** revealed that the degree of weakening values (BU) increased gradually by the increasing levels of barley flour.

The increased in the weakness of the dough may be due to using barley flour which reduced the wheat gluten content (dilution effect) in the blends **(Mekhael, 2004)**

It could be noticed that from the data presented in **Table (4),** the resistance to extension of the dough showed not effected by added barley flour to wheat flour. Moreover, the blends contained 15 and 20% barley flour had higher resistance to extension value (535 and 525 BU), respectively, than that (500 BU) found in control dough.

On the other hand, it could be observed that the dough extensibility showed a pronounced decrease as the amount of barley flour increase. The percentage of extensibility were decreased about (140 and 120 mm) for wheat flour replacement with 10 and 15% barley flour, respectively. Concerning the dough energy (cm^2), these values decreased gradually by the increasing of barley flour.

These results are in agreement with **mann et al (2005).** These observation probably due to β-glucan which increase the elastic modules of wheat flour dough **(Izydorezkyk et al (2001)**

Table 4. Farinograph and extensograph parameters of wheat flour dough replacement with different levels of barley flour

Blends Parameters	Control sample (100% wheat flour)	90% WF+ 10BF	85% WF+ 15% BF	80% WF+ 20% BF	75% WF+ 25% BF	70%WF+ 30% BF
			Farinograph parameters			
Water absorption (%)	62.0	64.0	64.7	65.8	67.1	68.0
Arrival time (min.)	1.5	1.5	1.5	1.5	1.5	1.5
Dough development time (min.)	3.0	5.5	4.8	3.0	3.7	3.2
Dough stability (min.)	9.5	9.5	9.0	9.0	9.2	9.5
Mixing tolerance index (Bu)	35.0	25.0	23.0	23.0	26.0	20.0
Dough weakening (Bu)	55.0	73.0	90.0	93.0	93.0	93.0
			Extensograph parameters			
resistance to extension "R" (Bu)	500	500	535	525	495	505
Extensu\ibility "E" (mm)	150	140	120	105	105	90
O\Proportional number (R/E)	3.33	3.57	4.46	5.00	4.71	5.61
Strength of dough (energy) (cm^2)	100	97	87	76	70	60

WF = Wheat flour

BF = Barley flour

Physical measurements of fresh pan bread

Results in **Table (5)** showed that, bread weight of pan bread prepared by added 20% barley flour (20% BB) was higher than 15% BB, 10% and WB (control samples for bread prepared with or without improver) . The increasing of bread weight may be to the increase fiber and β-glucan content in barley flour as presented in **Table (1)** which characterized by higher water holding capacity as mentioned by **Skendi et al (2010).** On the other hand, the volume of 10% BB and 15% BB was decreased about 5.6 and 9.8% or 5.3 and 16.1% in bread prepare with or without improver, respectively compared to control sample. This data confirmed the results of rheological dough properties **(Table 4)** and also are in agreement with **Izydorczk et al (2001).** Also, the reduction in loaves volume may be the dilution of wheat gluten as a result of addition of barley flour, plus the increased in fiber content specially β-glucan as presented in **Table (1)**. On the other hand, the volume of 10% BB and 15% BB prepared by added improver higher than WB without improver, these values were 1133 and 1082 cm^3 compared to WB 924 cm^3. Also, specific volume of 10% BB or 15% BB prepared by added improver higher than WB without improver (control sample).

Table 5. Physical properties of pan bread prepared by partial replacement of wheat flour (72% ext.) with barley flour

Bread	Loaf weight*(g)		Loaf volume* (cm^3)		Specific volume (cm^3/g)	
	A	B	A	B	A	B
Control sample (100% wheat flour (WF)	272^{ab}	271^{c}	924^{a}	1200^{a}	3.39^{a}	4.41^{a}
90% WF+10% BF (10% BB)	272^{ab}	273^{bc}	875^{b}	1133^{b}	3.22^{b}	4.15^{b}
85% WF + 15% BF (15% BB)	272^{ab}	273^{bc}	775^{d}	1082^{c}	2.84^{d}	3.96^{c}
80% WF+ 20% BF (20% BB)	275^{a}	279^{a}	700^{a}	725^{e}	2.53^{e}	2.59^{e}

WF = Wheat flour

A = Pan bread made without improver

B = Pan bread made by added bread improver

Sensory evaluation of pan bread samples

The results in **Table (6)** showed that there were no significant differences (P<0.05) in all the organoleptic properties of produced pan bread without improver between the control sample (WB1) and bread sample contained 10% barley flour (10% BB1) except the taste. On the other hand, the addition of bread improver, there were no significant differences (P<0.05) in all the organoleptic properties between the control sample (WB1) and bread sample contained 10 or 15% barley flour (10% BB2 or 15% BB2), except the grain. The total score of WB1 was 93.71, this value decrease about 4.3% for pan bread containing 10% barley flour (10% BB1) comparing to WB1. Also, the total score of WB2 was 94.10, this value only decreased about 1.5 or 4.0 for (10% BB2 or 15% BB2), respectively.

Table 6. Organoleptic evaluation of wheat fresh pan bread rise composite flour with and without bread improver .

Sensory properties samples	Crust color (20)	Summitry of form (15)	Grain (20)	Crumb color (15)	Texture (15)	Taste (15)	Total score (100)
Controlsample 100%wheat flour(WB1)	18.33^{a}	14.00^{a}	19.16^{a}	14.05a	14.41^{a}	13.76^{a}	93.71^{a}
90%WF+ 10%BF (10%BB1)	18.33^{a}	13.62^{ab}	18.33^{a}	13.28^{ab}	14.00^{ab}	12.13^{b}	89.69^{bc}
85% WF+ 15%BF (15%BB1)	16.97^{a}	12.60^{bcd}	17.30a	12.25^{bc}	13.55^{ab}	10.51c	83.18^{c}
80% WF+ 20%BF (20%BB1)	15.75^{cd}	12.25^{cde}	16.0^{c}	11.62^{cd}	12.29^{c}	8.65^{d}	76.56^{e}
WB2	18.55^{a}	14.00^{a}	19.20^{a}	14.05^{a}	14.30^{a}	14.00^{a}	94.10^{a}
10 %BB2	18.47^{a}	13.80^{ab}	18.33^{a}	14.02^{a}	14.07^{ab}	14.00^{a}	92.69^{b}
15% BB2	18.33^{a}	13.28^{abc}	17.30^{b}	103.79^{a}	13.90^{ab}	1374^{a}	90.34^{bc}
20% BB2	17.00^{b}	12.25^{cde}	16.02^{cde}	13.30^{ab}	13.28^{b}	12.30^{b}	84.18^{c}

WF = Wheat flour BF= Barley flour

BB1 = Pan bread made without improver

BB2 = Pan bread made by added bread improver

* Means followed by different letters in the same column are significant different by Duncan's multiple test ($p<0.05$).

These results are in agreement by **Bhatty (1986) and El-Yamlahi and Qussine (2013).** Generally, it could be concluded that the pan bread produced by replacement with 10% barley flour (89.69) or (92.69 and 90.34) gave bread loaves more sensory acceptable rather than the pan bread produced by added 20% barley flour.

Texture profile analysis of pan bread as affected by addition of barley flour to wheat flour (72% ext.)

Pan bread texture was determined as hardness, cohesiveness, gumminess, springiness, chewiness using a TPA texture profile analyzer. The results of texture profile analysis of pan bread samples are shown in **Table (7).** As can be seen , additional of barley flour at different ratios 10, 15, and 20% in the formulation of the bread samples affected the textural properties of the produced bread.

Hardness is an important factor in baking products since it is strongly correlated with consumer perception of bread freshness **(Olaoye et al 2006).** Hardness of bread were increased by increasing the level of addition of barley flour as compared to bread made from wheat flour (control sample). Lower values of hardness were recorded to bread sample made from wheat flour (501g), while this value was increased to 518, 770 and 1178 g for the fresh pan bread replacement with 10, 15 and 20% barley flour, respectively.

Also, from the data presented in **Table (7)** showed that the freshness of pan bread were decreased for all samples by increasing the storage period at room temperature.

The internal resistance of bread crumb is evaluated by cohesiveness which is a characteristic of mastication. The replacement of wheat flour with barley flour is not affecting of cohesiveness of bread at zero time after baking.

Gumminess of bread samples were increased by increasing the level of addition of barley flour compared to bread made from wheat flour (72% ext.) replacement with barley flour, the percentage of gumminess of bread samples was increases about 4.0% for the bread replacement with 10 or 15% barley flour by increasing storage period. Chewiness is one of the texture parameters easily correlated with sensory analysis (**Gallagher et al 2003)**. It is related to the work needed to chew a solid sample such as bread to a steady state of

Table 7. Texture profile parameters of pan bread as affected by addition of barley flour and storage of different times at room temperature (25°±5°C)

Parameters Storage period (hour)	Hardness (g)	Cohesiveness	Gumminess (g)	Chewiness (mg)	Springiness (mm)
pan bread made from 100% wheat flour (72% ext.)					
0	501	0.80	407	33.30	0.48
24	793	0.78	635	58.30	0.49
48	1314	0.62	863	74.30	0.27
72	1545	0.58	964	83.70	0.26
Pan bread made from wheat flour replacement with 10% barley flour					
0	518	0.80	s423	38.50	9.27
24	822	0.73	623	56.50	9.26
48	1078	0.67	758	68.50	9.21
72	1075	0.67	758	95.90	8.87
Pan bread made from wheat flour replacement with 15% barley flour					
0	770	0.80	423	38.50	9.28
24	1612	0.63	1055	84.20	8.62
48	2116	0.62	1370	107.40	7.99
72	2570	0.52	1426	116.80	8.35
Pan bread made from wheat flour replacement with 20% barley flour					
0	1178	0.02	646	59.60	9.41
24	1465	0.71	1092	101.60	9.49
48	1896	0.67	1336	197.10	8.94
72	1770	0.78	1450	134.90	9.49

swallowing, crumb chewiness is a product of crumb hardness, chewiness of bread samples were increased by increasing the level of addition of barley flour as compared to bread made from wheat flour (control sample). Lowering values of chewiness were recorded to bread samples made from wheat flour replacement with 15 and 20% barley flour. On the other hand, chewiness of all bread samples was increased gradually during storage of bread up to 72 hours at room temperature.

Springiness is a measurement of how much the bread crumb springs back after being compressed once and it can be defined as the elasticity of the bread crumb, it is also an important parameters to determine the staling of bread in **Table (7)** the results of springiness indicated that when the substitution level of barley flour increased, the bread required more time to recover its shape. Also, the springiness of bread was gradually decreased for all samples during storage of bread at room temperature.

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