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FUNCTIONAL PROPERTIES OF WHEAT GERM FLOUR AND ITS EFFECT ON BREAD QUALITY

BY

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ABSTRACT

Defatted wheat germ flour was prepared from raw and treated wheat germ with autoclaving and roasting. The effect of pH and heat processing on functional properties were studied. Functional properties of wheat germ flour (WGF) were recorded over a pH range of 3.0-9.0 in order to evaluate the potential use of WGF. All wheat germ flour showed a minimum solubility at pH 4.5, meanwhile, at pH values above and below the isoelectric region the solubility of raw and autoclaved wheat germ flour increased. Wheat germ flour registered the highest emulsion stability at pH 4.5, 7.5 and 9.0. Replacement of wheat flour with defatted wheat germ flour at levels of 0 to 5% was evaluated for its effect on pan bread baking characteristics. Up to 5% replacement, the dough closely resembled the 100% wheat flour inconsistency and handling characteristics and the dough would give good quality bread. Significant differences ($p<0.05$) in loaf volume were noticed for baked bread with different level of wheat germ flour. Replacement of wheat flour with wheat germ flour and packaging of bread samples reduced the penetration force and cutting energy of stored samples, compared with the all unpackaged bread samples. This means that both treatments were able to keep the freshness of pan bread for longer time. This point was considered very important because the major economic losses that stale bakery products many time. The sensory evaluation data demonstrated that, the addition of wheat germ flour up to 5% did not produce the adverse effect on pan bread. Finally the results of the research indicate that, the wheat germ flour can successfully replace wheat flour for pan bread up to 5% without the addition of surfactant (improvers).

Key words: wheat germ flour, functional properties, baking characteristics, mechanical characteristics, pan bread, sensory evaluation.

INTRODUCTION

In recent years there has been an increment benefit in the utilization of new protein sources in manufactured foods. The demand for new plant protein is increasing with the growing serious protein shortage in many parts of the world. The new proteins should exhibit a moderate cost with respect to the conformist foods and compliant functional properties to allow the preparation of high protein product for a wide range of markets (Canella, 1978). Wheat germ is a by-product of wheat milling industry that has the potential as a food ingredient, remarkable source of high quality protein, very high level of essential amino acids and is an excellent source of lysine, methionine and theronine, minerals and vitamins as well as, superiority over other milling products as a nutritive supplement (Miladi *et al.*, 1972&Jensen and Martens, 1983). Mild heat processing or toasting of wheat germ improved its flavor, nutritional value and functional properties (Shurpalekar and Rao, 1977 and Srivastava *et al.*, 2006). Use of wheat germ protein in bakery products, especially in breads, biscuits, macaroni and cookies are reported (Vitti *et al.*, 1979; Godunova *et al.*, 1986 and Abu-elmaati *et al.*, 1996, Pinarh *et al.*, 2004 and Arshad *et al.*, 2006). Bread is an ideal food for protein supplementation, especially for the young children suffering from protein-energy malnutrition. The high consumption of bread can be used as a vehicle for the distribution of supplementary quantities of protein to the population, hoping to improve the nutritional value of the diet. A number of changes occur in bread with aging. The crumb becomes firm and its water absorption capacity is reduced and a change in X-ray diffraction pattern is observed, due to the aggregation of amylase and amylopectin and that the process can be inhibited by complex formation of the starch polymers with lipids and protein.

Therefore, the scope of this work was to examine the functional properties, reheological and baking properties of heated treated wheat germ flour-wheat composite flour and to determine the staling and acceptability of the resulting bread.

MATERIALS AND METHODS

Materials:

Wheat germ was obtained from North Cairo Mills Comp. Samples of wheat germ were blended to provide a uniform samples and stored at -18 ^{0}C till further experimental treatments.

The wheat germ samples were divided into three portions, the first portion was without heat treatment (control), and the second for the roasted and the later for the autoclaving.

Wheat flour (72% extraction, 12.5% moisture, 11.84% protein, 1.15% lipid, 0.57% ash and 74.30% total carbohydrates) was obtained from the North Cairo Flour Mill Comp. All other ingredients for preparing the bread (e.g. sugar, salt, shortening, instant dry yeast) were purchased from local super market.

Methods:

Heat treatment of wheat germ:

The wheat germ was autoclaved and roasted at 121 ^{0}C and 150 ^{0}C for 10 min and 3 hr, respectively. After that, the samples were dried in oven at 100 ^{0}C for 2-3 hr and allowed to cool to room temperature (20 ^{0}C ± 2) before lipid extraction.

Preparation of defatted wheat germ flour:

Untreated and treated wheat germ samples were milled by using a coffee mill at high speed till a fine wheat germ mill obtained. The obtained samples were defatted at room temperature by soaking the samples in hexane for six times (each one, 12 hr). The resultant defatted samples were dried at room temperature for 72 hr and reground to obtain fine defatted wheat germ flour.

Functional properties:

Solubility:

Nitrogen solubility index was determined according to the method mentioned by Were *et al.*, 1997 & Bera and Murkherjee, 1989.

Emulsifying properties:

Emulsifying properties of untreated and treated wheat germ samples were determined as mentioned by the methods of Pearce and Kinsella, 1978.

Foaming properties:

Foaming capacity and stability of samples were measured according to Wilde and Clark, 1996.

Water and oil absorption:

Water and oil absorption were determined according to Liu and Hung, 1998.

Rheological properties:

The physical dough properties of the various blends were examined by farinograph with 300 mixing bowel according to A.A.C.C. (1983).

Bread making:

The pan bread was prepared by the straight dough procedure according to A.A.C.C. (1983). After baking, the bread was removed from the pan and left to be cooled at room temperature for 2 hr. Volume and weight of three loaves were recorded. Loaf volume was determined by rape seed displacement, specific volume (cm^3/g) was calculated.

Structograph test:

Brabender Structograph (Brabender, Duisbay, Germany) was used to measure the compressibility as a test for bread staling. Bread slices were tested by measuring the force necessary to push a cylindrical plunger of 15 mm diameter through the slice center placed on a plastic plate hole of 17 mm diameter according to the method mentioned by Mohamed, 1988. The obtained diagrams were evaluated for:

Compressibility of the bread slices, the length of the compression curve (in mm) from the start until the top curve.

- Hardness: the force in Brabender Units (BU) recorded at the highest point of the structogram.
- Cutting energy: (in mm^2) as the area under the structogram.

Sensory quality evaluation:

The baked loaves were allowed to cool for 2 hr at room temp. Before sensory evaluation by the staff members of the Food Sci. Dept., Fac. Agric., Ain Shams Univ. The panelists were familiar with the evaluation and quality of bread. The whole and sliced bread samples were coded and served on a plastic tray with plain water. Sufficient water was provided for mouth rinsing between the samples. General appearance, crust color, (crumb color, distribution and texture), pocket formation, taste, odor and overall acceptability were scored 20, 10, (5, 15 and 10), 20, 10 and 10, respectively.

Statistical analysis:

Data of physical measurements and sensory quality were statistically analyzed using analysis of variance and the statistical analysis system (SAS, 1988). Difference among means was compared using Duncan' s Multiple Range test at level of significance of 0.05.

RESULTS AND DISCUSSION

Solubility profiles over a wide range of pH values are frequently used as an index to select suitable proteins for a desired application (Sekule *et al.*, 1978). Solubility of wheat germ flour dispersed in water over a range of pH 3.0 to 9.0 is illustrated in Table (1). As indicated nitrogen solubility response to changing levels of pH in water.

Table (1): Protein solubility index of different treated wheat germ flour

Wheat germ flour	pH value				
	3.0	4.5	6.0	7.5	9.0
Untreated	30.92	22.33	25.77	39.51	41.23
Autoclaved	27.10	16.94	28.79	30.41	33.71
Roasted	13.48	15.16	17.85	21.91	28.64

In order to find a possible explanation for the results observed above, the degree of solubility of a protein in a given aqueous system is the net result of both electrostatic and hydrophobic interactions between the protein molecules. Conditions under which the electrostatic repulsions between the molecules are greater than the hydrophobic interactions between the no polar patches on the surface favor increased solubility. Conversely, conditions under which the hydrophobic interactions are greater than the electrostatic repulsions will result in intermolecular aggregation and decreased solubility. Physiochemical changes during commercial preparation which results in irreversible changes in the oligomeric state of the protein, would alter the delicate balance of the above two forces and thereby affect the solubility (Kinsella *et al.*, 1985).

All wheat germ flour protein should a minimum solubility in the region of pH 4.5. At pH values above and below the isoelectric region, the solubility of raw and cooked wheat germ flour increased.

As shown in Table (1), nitrogen solubility levels of wheat germ flour were reduced by the application of heat treatment (cooking and roasting). Denaturation and solubility are not always correlated, high solubility data are sometimes obtained from completely denatured proteins. However, low solubility is not always a disadvantage and many proteins of limited solubility find uses in the production of foods (Hermansson, 1979).

A sharp minimum solubility at the isoelectric point was not observed with roasted wheat germ flour, instead a broad range of minimum solubility between pH 3 and 4.5 was found. Wheat germ flour showed good solubility at alkaline pH. Roasted wheat germ flour exhibited lower protein solubility than the raw and cooked wheat germ flour over the pH range examined.

The ability of proteins to aid the formation and stabilization of emulsions is critical for many food applications. The emulsifying capacity of proteins depends on the suitable balance between the hydrophobic and lipophilic characteristics rather than merely on the high values for each one (Dekanterewicz *et al.*, 1987). The stability of emulsion has also been related to the spreading coefficients of the internal phase liquid on the surface of a solution of the emulsifier in the continuous phase (Petrowski, 1976).

Effects of pH on emulsion capacity (EC) and stability (ES) of wheat germ protein suspended in water are reported in Table (2). Emulsion Capacity was pH dependent. It is interesting to note that untreated wheat germ protein was more efficient in emulsifying the oil than cooked or roasted wheat germ proteins at all PH values. Emulsion Capacity of cooked or roasted wheat germ protein was the poorest at pH 4.5, a level which is near the isoelectric point (PI) of the predominate native wheat germ protein. Shifting the pH a way from the PI apparently improved EC of wheat germ protein by giving the protein an electrical charge and possibly by increasing the protein's solubility.

Results of emulsion stability (ES) of wheat germ protein are showed in Table (2). Wheat germ protein registered the highest ES at pH 4.5, 7.5 and 9.0, respectively, since the emulsion did not separate into aqueous phase within 2 hr standing at room temperature after preparation. At the PI where electrostatic repulsions between molecules are minimal, proteins are packed in their most compact state and form rigid protein films, this rigidity, by opposing deformation of the surface and desorption, stabilizing the emulsions (Halling, 1981).

The cooked wheat germ protein has a poor ES within 2 hr standing at room temperature at all pH values ranged from 3.0 to 9.0. It is interesting to note that the raw wheat germ flour was more efficient in emulsifying the oil, followed by cooked and roasted wheat germ proteins. Meanwhile, the untreated wheat germ protein had the highest ES followed by roasted and cooked wheat germ proteins.

Foaming capacity is an important protein functional property for several food formulations. Foam stability is important since the usefulness of whipping agents depends on their ability to maintain the whip as long as possible (Lin *et al.*, 1974).

Table (2): Emulsion Capacity (EC) and Emulsion Stability (ES) of wheat germ as a function of pH

Wheat germ flour	pH values	Vol. of emulsion (ml oil/g sample) EC	% aqueous phase separated at room temperature after time (min)- ES			
			15	30	60	120
Untreated	3.0	220	0	40	60	85
	4.5	194	0	0	0	0
	6.0	196	0	0	42	42
	7.5	200	0	0	0	0
	9.0	206	0	0	0	0
Autoclaved	3.0	188	76	93	100	100
	4.5	152	72	72	84	98
	6.0	166	100	100	100	100
	7.5	190	100	100	100	100
	9.0	192	100	100	100	100
Roasted	3.0	176	42	78	100	100
	4.5	158	20	20	34	54
	6.0	168	12	12	26	26
	7.5	176	0	18	30	42
	9.0	196	0	15	15	26

The foaming capacity or volume (FC, FV) and foam stability (FS) of foams produced by wheat germ meal protein suspensions are presented in Table (3). Adjusting the pH of suspensions prior to whipping markedly affected foam formation and stability of raw and roasted wheat germ flour protein. The FC of the untreated wheat germ flour protein was highest at pH 3.0 and 9.0, whereas the volume increase was 430 and 420%, respectively. While that of the cooked wheat germ flour protein was the lowest among the samples studied. After 4 hr standing at room temperature, the foam stability (FS) for untreated or roasted wheat germ flour protein did not collapse completely, unlike cooked wheat germ flour protein at all pH values under research which collapsed completely Table (3).

Dough characteristics:

Farinograph results of wheat flour and wheat germ flour blends are presented in Table (4). Water absorption (WA) of untreated wheat germ protein was higher than that of roasted or cooked wheat germ protein (1.65, 1.33 and 1.29 g water/g sample), respectively (untabulated data). Water absorption could be affected by water physically entrapped within unfolded proteins and by different degree of denaturation (Fiora *et al.*, 1990).

Water absorption of wheat flour (100% control sample) recorded 59.2%, remained with ± 0.2 variation, except the samples which containing 2 and 3% wheat germ flour which absorbed 59.6 and 59.85%, respectively. The dough development time slightly increased as the level of wheat germ increased up to 3%. Meanwhile the blends containing 4 and 5% wheat germ flour showed a decrease in dough development time. Dough development time was not used as the optimum mixing time because the bread loaves had inferior crust texture and overall bread quality than those produced with shorter mixing times (Serna-Saldivar *et al.*, 1988). Incorporation of wheat germ flour influenced the farinograph characteristics to varying extents (Sivastava *et al.*, 2006). Dough stability and time to breakdown of samples containing wheat germ flour remained within 6.5 ± 0.5, except dough stability for the samples containing 5% wheat germ flour which recorded slight decreased being 5.5 min.

Table (3): Foam Capacity (FC) and Foam Stability (FS) as a function of pH of 1% dispersion of wheat germ protein

pH value	Wheat germ protein							
	Untreated							
	FC*	FS**						
		0	15	30	60	120	180	240
3.0	430	0	16	16	16	16	16	16
4.5	408	7	18	18	18	18	18	18
6.0	406	10	18	18	18	18	18	18
7.5	360	0	27	27	27	27	27	27
9.0	420	8	19	19	19	19	19	19
Autoclaved								
3.0	200	100	100	100	100	100	100	100
4.5	200	100	100	100	100	100	100	100
6.0	200	100	100	100	100	100	100	100
7.5	200	100	100	100	100	100	100	100
9.0	200	100	100	100	100	100	100	100
Roasted								
3.0	342	14	28	28	28	28	28	28
4.5	312	14	24	24	24	24	24	24
6.0	318	16	23	23	23	23	23	23
7.5	330	10	10	28	28	28	28	28
9.0	316	13	13	30	30	30	30	30

FC*: volume increase cm^3

FS**: foam volume (cm^3) at room temperature after time (min)

The mixing tolerance index (MTI), in general, was increased with the increasing levels of wheat germ flour up to 5 %. Degree of softening (weakening, B.U.) was slightly improved with the addition of wheat germ flour up to 5 %. From these data, it could be concluded that, up to 5 % replacement, the dough closely resembled the 100 % wheat flour in consistency and handling characteristics and the dough would give good quality bread.

Bread baking characteristics:

The mean volume for the control loaves was 420.0 cm^3 and this value decreased with increasing level of wheat germ flour. Generally, significant differences ($p < 0.05$) in loaf volume were noticed for baked bread with different level of wheat germ flour (Table,5). Meanwhile, no significant observation for loaf weight and specific volume were recorded (Table, 5).

Table (4): Farinograph characteristics of dough with different levels of wheat germ flour

Dough samples with wheat germ flour %	Farinograph data						
	Absorption %	Arrival time (min)	Dough development time (min)	Stability time (min)	Mixing tolerance index (BU)	Time to breakdown (min)	Weakening (B.U.)
Control	59.2	1.0	4.0	7.0	70.0	7.0	100.0
1%	59.0	1.5	5.5	7.0	75.0	6.0	100.0
2%	59.6	1.5	4.5	7.0	90.0	7.0	80.0
3%	59.8	1.0	4.5	6.5	90.0	6.5	80.0
4%	59.2	1.0	2.0	6.0	95.0	6.5	80.0
5%	59.0	1.0	2.0	5.5	95.0	6.5	80.0

Table (5): Baking performance of pan bread prepared by using wheat flour with replacement with wheat germ flour

Wheat germ flour %	Loaf volume Cm^3	Loaf weight G	Specific volume Cm^3/g
Control	420.0^a	147.86^b	2.84^a
1	345.0^d	147.28^b	2.34^a
2	350.0^d	147.95^b	2.37^a
3	350.0^d	149.70^b	2.34^a
4	375.0^c	153.85^a	2.44^a
5	390.0^b	149.0^b	2.62^a

A, b… Means, for the same attribute with the same letters are not significantly different ($p>0.05$)

Effect of wheat germ flour substitution and packaging on retrogradotion of pan bread:

Figure (1) shows some structograms of bread samples tested in this investigation. Three parameters could be obtained from the structograms, namely, elasticity (in mm) of the bread samples, the force of deformation (in Brabender Units) and the energy required for cutting, as described before. Table (6) gives the values of the three rhleological (mechanical) characteristics for fresh and stored bread samples.

Deformation (Elasticity):

The unpackaged control bread samples showed a value of 40 mm deformation. Substitution of wheat flour by 1 to 5% of wheat germ flour resulted in higher deformation values at zero time. After 2 days of storage period at room temperature, the deformation value of the control sample was slightly decreased to 39 mm, while those of bread samples with wheat germ substitution were stable, except that of 1% wheat germ substitution. Packaging of bread samples in different plastic films did not alter the deformation value (the elasticity) of the bread samples. However, some increase in the elasticity was observed in packaged bread samples with wheat germ substitution. Such enhancement in the elasticity could be referred to the interaction between wheat germ (as a source protein) and the starch content of the bread samples. Some variation and non-consistency of the compression (elasticity) values of the tested samples has been observed, may be due to the non uniformity of the crumb in different parts of the loaf. To overcome such problems, De Man *et al.*, 1976, suggested a method based on the compression of the whole loaf instead of single slices.

Table (6): Structogram parameters of pan bread samples substituted with wheat germ flour and packaged in different plastic films.

Substituted level % of Wheat germ	Compressibility (deformation) in mm for samples packaged in									
	Non packaged (control) and stored for (day)		Cellophane and stored for (day)		Polyethylene and stored for (day)		Polypropylene and stored for (day)		Paraffin coated paper and stored for (day)	
	0	2	2	4	2	4	2	4	2	4
Control	40	39	37	44	42	-	-	42	-	-
1	42	35	45	46	46	42	-	50	45	52
2	48	48	45	47	42	51	-	50	54	71
3	45	50	51	55	53	51	-	50	52	75
4	43	48	48	48	48	47	-	46	52	65
5	45	50	49	53	53	54	-	50	49	48
Penetration force (Brabender units) for samples packaged in										
Control	560	640	605	850	785	1000	-	780	-	-
1	430	700	570	808	795	990	-	906	850	1005
2	918	880	780	990	755	1000	-	996	920	1015
3	805	940	960	1005	985	1005	-	1000	1005	1020
4	802	980	902	990	942	1000	-	1010	990	1020
5	830	1000	900	995	992	1002	-	995	998	1015
Cutting energy in mm^2 for samples packaged in										
Control	2471	2907	2365	3838	3531	-	-	3475	-	-
1	1992	2088	2773	3845	4250	3961	-	4909	4169	5774
2	4585	4274	3842	4946	3341	5668	-	5469	3997	7492
3	3954	4850	5332	3799	5525	5737	-	5555	5824	7705
4	3753	5066	4052	5138	4434	5185	-	5515	5071	7565
5	3913	5329	4480	5885	5158	5722	-	4754	5219	5563

Hardness:

As seen in Table (6), the hardness value of the control bread sample was 560 BU, and this value was increased to level of 900 BU by substitution of wheat germ. After 2 days of storage, the hardness value of the control sample was increased by 15%, while the increase in hardness values of the wheat germ substituted samples was in the range of 16% to 22% after the same period of storage. The effect of packaging on keeping the freshness of bread was obvious for wheat germ substitution bread samples. The average increase in hardness values of unpackaged control samples was 24% and 65%, respectively after 2 and 4 days of storage. On contrary, the average increase in hardness values of packaged substituted bread samples was only 15.6% and 19.02%, respectively for the same storage periods.

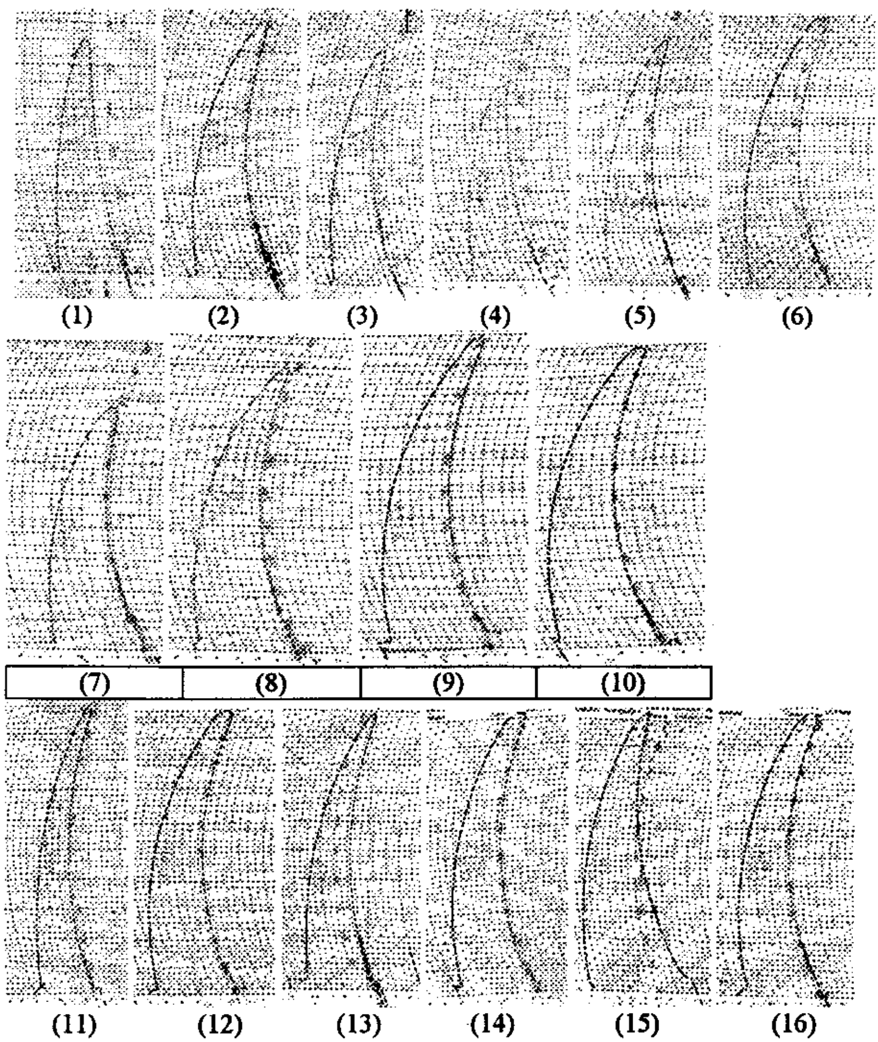

Figure (1): Some representative structograms of pan bread samples

1- All wheat unpackaged control sample (0 time)
2- Unpackaged with 2% WG substitution (0 time)
3- Unpackaged with 5% WG substitution (0 time)
4- Control sample after 2 d.
5- Unpackaged with 2% WG substitution after 2 d.
6- Unpackaged with 5% WG substitution after 2d.
7- Cellophane, 2% WG, 2d.
8- Cellophane, 5% WG, 2d.
9- Cellophane, 2% WG, 4d.
10- Cellophane, 5% WG, 4d.
11- Polyethylene, 2% WG, 4d.
12- Polyethylene, 5% WG, 4d.
13- Polypropylene, 2% WG, 4d.
14- Polypropylene, 5% WG, 4d.
15- Wax-paper 2% WG, 4d.
16- Wax-paper 4% WG, 4d.

Cutting energy:

As seen in Table (6), the cutting energy (in mm^2) for the fresh control sample was 2471 mm^2 and this value has reached the 4000 mm^2 level by increasing the substitution ratio of wheat germ. After 2 days of storage, the cutting energy was increased by 17.7% and 18.37%, respectively for the control and substituted bread samples. However, the packaged control sample showed an increase in cutting energy by 19.3% and 47.97%, respectively, after 2 and 4 days of storage. On other side, the increase in cutting energy for the substituted packaged samples was only 17.2% and 34.17%, respectively for the same storage period.

From these results it was obvious, that substitution of wheat germ and packaging of bead samples reduced the penetration force and cutting energy of stored samples, compared with the all wheat unpackaged control samples. This means that both treatments were able to keep the freshness of pan bread for longer time. The obtained results agree with those reported by Schneeweiss and Klose, 1981. They reported that protein resist the formation of hydrogen bonds between amylopectin molecules and packaging increase the water vapor pressure inside the package and reduce the rate of dehydration of the amorphous starch crystals in packed pan bread.

Sensory evaluation of pan bread:

Differences in sensory quality attributes of pan bread are shown in Table (7). Results of the sensory evaluation indicated that all baked pan breads had acceptable quality attributes. (Table, 7). In the same time there no significant differences ($p>0.05$), for these attributes except crumb distribution, between pan bread (100% wheat flour) and those containing 1 to 5% wheat germ flour. Meanwhile, significant differences ($p>0.05$) in crust color, pocket performance and overall acceptability could be observed for pan bread samples. Generally, the sensory evaluation data demonstrated that, the addition of wheat germ flour up to 5% level did not produce the adverse effect on the sensory quality attributes of the resulted baked pan bread. From comments received, the results of this research indicate that, the roasted wheat germ flour can successfully replace wheat flour for white pan bread up to 5 % without the addition of any surfactant or gluten.

Table (7): Average differences in sensory quality characteristics of pan bread substituted with defatted wheat germ flour

Replacement level with wheat germ flour %	Sensory attributes								
	Appearance	Color		Crumb		Pocket	Taste	Flavor	Overall acceptability
		Crust	Crumb	Distribution	Texture	Perfor-mance			
Control	19.6^a	9.6^a	4.6^a	12.0^b	9.6^a	14.6^c	9.6^a	8.6^b	88.2^c
1	17.6^c	7.4^c	4.6^a	13.4^a	9.4^a	19.6^a	10.0^a	10.0^a	92.0^b
2	18.4^b	7.0^c	5.0^a	13.6^a	10.0^a	17.0^b	10.0^a	10.0^a	91.0^b
3	19.4^a	9.4^a	4.6^a	13.0^a	9.6^a	19.6^a	9.6^a	9.6^a	94.8^a
4	18.6^b	8.6^b	4.6^a	13.6^a	9.6^a	19.6^a	9.6^a	9.6^a	93.8^a
5	16.8^d	8.6^b	4.6^a	13.6^a	9.6^a	16.6^b	9.6^a	9.6^a	90.8^b

Means within the same column have the same letters are not significantly different ($p>0.05$)

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الخصائص الوظيفية لدقيق جنين القمح وتأثيرة علي جودة الخبز

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تم في هذا البحث تجهيز دقيق جنين القمح منزوع الدهن من الجنين الخام والجنين المعامل بالبخار تحت ضغط (الأوتكلاف) والجنين المحمص وتم دراسة تأثير الاختلاف في درجة الأس الايدروجيني والمعاملة الحرارية علي الخصائص الوظيفية للعينات السابق الأشارة اليها. ولقد تم تسجيل للخصائص الوظيفية علي مدي من درجات الأس الايدروجيني من ٣ إلي ٩ لتقييم الاستخدمات المستقبلية لدقيق الجنين المجهز ولقد سجل بروتين دقيق الجنين أقل قدر من الذوبانية عند رقم أس ايدروجيني ٤,٥ في حين زادت درجة الذوبانية للبروتين عند رقم أس ايدروجيني أعلي أو أقل من نقطة التعادل الكهربي لكل من دقيق الجنين الخام والمعامل بالبخار تحت ضغط.

وقد سجل دقيق جنين القمح أعلي قدر من الثبات للمستحلب عند رقم أس ايدروجيني ٤,٥ و٧,٥ و٩,٠٠ علي الترتيب. ايضا تم في هذه الدراسة تقيم احلال دقيق جنين القمح المعامل بمستويات حتي ٥% محل دقيق القمح علي خصائص الخبز القوالب. ولقد كان قوام العجينة وخصائص التداول حتي مستوي ٥% مماثل تماما لعجينة دقيق القمح ١٠٠%. ايضا لوحظت فروق معنوية في حجم الرغيف لعينات

الخبز بمستويات الاحلال المختلفة من دقيق جنين القمح. كذلك أدي أحلال دقيق القمح بدقيق جنين القمح إلي خفض قوة الأختراق وطاقة القطع لعينات الخبز المخزنة والمغلفة بالاغشية البلاستيكية مقارنة بالعينات غير المغلفة وهذا يعني أن الأحلال بدقيق جنين القمح والتغليف كان له من الدور في احتفاظ الخبز لطزاجتة خلال فترة التخزين وتعد هذه النقطه علي درجة من الأهمية حيث أن معظم الفاقد من الخبز أنما بسبب هذه الظاهرة (قصر فترة طزاجة الخبز أو البيات). ولقد أوضحت نتائج التقيم الحسي أن استبدال دقيق القمح بدقيق جنين القمح حتي ٥% لم يكن له أي تأثير سيئ علي جبز القوالب. وفي النهاية تخلص الدراسة إلي أنه أحلال دقيق جنين القمح بنجاح محل دقيق القمح في صناعة خبز القوالب حتي مستوي أضافة ٥% بدون أضافة أي مواد ذات نشاط سطحي (محسنات).