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PROTEIN FRACTION – FUNCTIONALLTY of SOME NEW WHEAT CULTIVARS AND ITS RELATIONSHIP TO FLOUR AND PAN BREAD QUALITY.

Mobarak, El. A.
Food Technology Research Inst. ARC. Giza- Egypt

ABSTRACT

The present investigation was carried out to study the protein fraction and its relationship to flour quality and pan bread product of new bread wheat (sids – 12 , Gemmiza – 7, Giza – 168, Sakha – 93) and two durum wheat (Beni – Sweif – 3 and Beni – Sweif – 5) produced from wheat research section , Agricultural Research Center, Giza , Egypt. The physico-chemical, rheological properties, protein fractions, glutenin/ gliadin ratio and electrophortic pattern of the protein were determined. Results indicated that, the quality of physico – chemical and rheological properties were increased by increasing ratio of both, high molecular weight glutenin and of glutenin / gliadin ratio of flour protein. Moreover, the organoleptic and technological (baking properties) quality increased by increasing high molecular weight gultenin and glutenin / gliadin ratio. Also orgonoleptic and baking properties for each one were evaluated. It was found that, pan bread produced from sakha-93 resulted in organoleptic and technological quality values higher than that produced from durum wheat despite, Skha-93 had the lowest protein and wet gluten than all other wheat flour. Therefore the ratios of high molecular glutenin and glutenin/gliadin ratios are important parameters for determination wheat flour quality, not only protein or/and wheat gluten. Finally it could be recommended that, sids-12, Gemmiza -7, sakha-93, Beni-sweif-3 and Beni-sweif-5 were considered a suitable cultivars for pan bread meanwhile Giza-168 was unsuitable.

INTRODUCTION

The unique functional properties of wheat dough are due to the storage proteins of the indosperm (Pomeranz 1988). After flour is mixed with water, storage proteins form a rubbery mass (the gluten) that can be fractionated with aqueous alcohols into the soluble, predominantly monomeric gliadins and the insoluble, aggregated glutenin, both fractions are cohesive, but their contribution to other functional properties of dough is different .Gliadin determine viscosity, while glutenin regulate strength and elasticity. The glutenin fraction consists of two main protein subgroups: high molecular weight (HMW) and low molecular weight (LMW) subunits .which occur in flour in proportions ranged from ≈1:2 to 1:3 on a weight basis depending on the cultivar.

The amount of both HMW and LMW subunits showed good correlation with the maximum resistance of dough and gluten, but twice as many LMW subunits were necessary to get the same effects or resistance as from HMW subunits. The extensibility of dough and gluten was mainly dependent on the ratio of gliadin to both HMW and LMW subunits (Wieser *et al*, 1994b). Antes and Wieser (2001) studied the effect of gluten fractions after addition to flour on rheological properties of gluten. The results demonstrated that the extensibility of gluten was increased by monomeric subunits. The maximum resistance of gluten was increased by HMW subunits. Wellner *et al*. (2003) found that, with exceptions of the ω.gliadins all the prolamin contain cystein residue, the disulfide bonds in α-β and -γ gliadin are mainly intramolecular but the LMW subunits and in particular HMW subunits of glutenin are linked by intermolecular disulfide bonds into large macromolecular aggregates. The gliadins, which comprise ≈ 50% of the gluten, are alcohol. soluble monomeric proteins and interact by hydrogen bonding and hydrophopic interaction. Gliadin can be classified into α, β, γ and ω fractions based on mobiltity on acid – polyacrylamide gel (pH3.1). Each of gliadin fraction was consistent in molecular range and hydrophobicity. The approximate average, molecular masses of the gliadin have been reported as 31,000D for α – and β – gliadin , 35,000 D for γ- gliadin and 40,000-70,000D for ω gliadin, the negative effect of the gliadin fractions on loaf height followed this sequence. (Fido *et al*., 1997). They also found that gliadin fraction have negative effect on mixing time and resistance to extension and positive effect on extensibility. The order of glidain hydrophobicity is ω < α and β < γ fraction (weegels *et al*., 1994). Antes and Wieser (2001) found that as hydrophobicity increased, mixing time, maximum resistance to extension decreased ,while extensibility increased. Fido *et al*., (1997) found that γ- gliadians were responsible for greatly reducing maximum resistance to extension and increasing extensibility. The measurement of molecular weight and structure of HMW glutenin polymers still remains to be explored. It is widely accepted that molecular weight and structure of polymers are intimately linked to their rheological behavior and ultimately to thier end-use performance. Thus measurement of flour protein molecular weight may be used as a rapid methods of discriminating variations in molecular weight distribution (MWD) between cultivars that vary in baking quality and end –use application.

The aim of this study is to characterize the flour protein molecular weight, and gulten protein fractions derived from some bread wheat and durum wheat (Egyptian cultivars) to get better understanding of the importance of structure and interactions of these proteins to the strength and quality of dough and gluten. In addition to determine the best end-use may be introduced for tested wheat cultivars.

MATERIALS AND METHODS

Materials:

Wheat grain samples of six wheat cultivars (4 Bread Wheat namely sids-12 Gemmiza-7, Giza -168, Sakha - 93 and durum wheat namely Beni–Sweif -3 and Beni–Swief -5) harvested at 2009 were obtained from wheat Research Section, Agriculture Research Center, Giza, Egypt. The seeds were cleaned and conditioned at 14 % and 16 % moisture content for bread and durum wheat respectively. Each cultivar were milled using Brabender Quadrumat Junior mill (brabender, Duisberg, Germany).The flour extraction rates were within a narrow range (70.0 -77.2 %) . All extracted flours were stored in air tight containers at 3-5 °C until uses.

Methods:

Chemical analysis of wheat flours:

Protein, oil and ash for each flour samples were determine according to methods of AOAC (1995)

Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophorsis (SDS – PAGE):

Flour protein fractions of all wheat cultivars were identified by sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS -PAGE) according to the method described by laemmli (1970).

physical properties:

Wet and dry gluten, albumim, globulin, gliadin and glutenin fractionations of wheat flour sample were determined according to the methods of AACC (1990).

Farinograph parameters:

Farinograph parameters determined according to method obtained in AACC (1990).

Pan bread making:

Baking test was performed according to the methods of AACC (1990).

A straight dough formula was as follows :

The formula consists of (based on flour weight): 100 gm. Flour, 3 gm. compressed yeast. 1 gm salt, 5 gm sugar. 3 gm. shortening and adequate amount of water . All the above mentioned ingredients were separately added and mixed. After 25 min. 140 gm. of the fermented dough was placed in baking pans (5×9×8). Then proofed at 30 °C till 55 min .and baked at 240 °C for 15 min. one hour after removing bread from the oven, loaves were tested for sensory evaluation, loaf volume and weight determination .

Sensory evaluation, loaf volume and specific loaf volume determination:

Sensory evaluation was carried out after one hour of baking for appearance (20), texture (20), crust color (10), crump color (10), crust character (10) taste (15) and odor (15) with total scores (100) using the method described by El. Hofi, *et al*., (2003) . Loaf volume of pan bread was determined by rapeseed displacement method (AACC 1990). Specific loaf volume was determined by dividing loaf volume by its weight (AACC 1990).

Statistical analysis :

The result were analyzed by analysis of variance (p‹ 0.05) and the means separated by Duncan's multiple range test the results were processed by Snedecor and Cochran (1980)

RESULTS AND DISCUSION

Physico – chemical properties of different wheat flours:

Table (1) presents the physico-chemical properties (on the dry weight) of bread and durum wheat cultivars. The data reveal that, the flour extraction ranged from 73.6-77.2% and 70-75% for bread wheat and durum wheat respectively. Ash and oil contents ranged from 0.67-0.77% and 1.50-1.96 % respectively for bread wheat. While these values ranged from 0.82-1.0% and 1.2-2.13% respectively for durum wheat. Wet gluten and dry gluten ranged from 28.0-34.6% and 9.5-11.71% respectively for bread wheat, while it ranged from 35.0-35.8 % and 12.2-12.6 % respectively for durum wheat.

Concerning gluten water holding capacity it showed values ranged from 174.5 - 195.5% and 184.1 – 186.9% for bread wheat and durum wheat respectively. From the above mentioned data it could be concluded that sids-12 and Gemmiza-7 characterized with high extraction rate followed by the other cultivars. On the other hand, gluten represent the high content regarding durum cultivars followed by bread ones. Ash and oil found in almost the same amounts for all cultivars. The obtained data are in agreement with those of Edward *et al*., (2003) who reported that protein and gluten generally used to asses the quality of durum wheat. They mentioned that increased protein is accompanied by increasing gluten strength. The strong gluten results in better quality durum, and plays a significant role in the end product.

Protein content and fractions of different wheat flours protein:

Table (2) show the protein content and its fractions of some new Egyption wheat cultivar. It is clear that the protein content ranged form 13.0 to 15.6%. Beni –sweif-3 (durum wheat) showed the highest percentage, while sakha-93 (bread wheat) resulted in the lowest one. Concerning protein fractions, it, could be noticed that, albumin and globulin showed the lowest percentages which ranged from 12.5-14.9 and 5.9-7.7% respectively compared with other protein fractions. On the other hand gliadin fraction ranged between 31.1 to 47.0%. Giza-168 resulted in the highest percentage, while Gemmiza-7 showed the lowest one. Regarding soluble glutenin (in 0.05N acetic acid solution), its content ranged from 10.22 to 20.47%, while glutenin that insoluble in 0.05N acetic acid ranged from 20.65 to 33.87%. The ratios between glntenin and gliadin showed a value of 1.39, 1.47, 0.95 and 0.70 for bread wheat cultivars namely sids-12, Gemmiza-7, sakha - 93 and Giza - 168 respectively, while durum wheat resulted in a ratio of 1.38 and 1.19 for Beni-sweif-3 and Beni-sweif-5.

Table (1): Physico- chemical properties of some Egyptian wheat cultivars (on dry weight).

Samples	Flour extraction %	Ash %	Oil %	Wet Gluten %	Dry Gluten %	Gluten Water holding Capacity %
Bread wheat:						
1) sids -12	74.6	0.77	1.96	34.6	11.71	195.5
2) Gemmiza-7	77.2	0.75	1.50	33.6	11.5	192.2
3) Giza -168	73.6	0.73	1.50	30.2	11.0	174.5
4) Sakha - 93	74.0	0.67	1.80	28.0	9.5	191.7
Durum wheat:						
5) Beni-Sweif-3	75.0	0.82	2.13	35.00	12.2	186.9
6) Beni-Sweif-5	70.0	1.0	1.20	35.80	12.6	184.1

The above mentioned data illustrated that good technological properties could be obtained from sids-12, Gemmiza-7, sakha-93, Beni-sweif-3 and Beni-sweif-5 for making pan bread. While Giza-168-is unsuitable.

Table (2):Chemically protein fractionation of some new Egyptian wheat cultivars (on dry weight).

Samples	Protein Fraction of wheat flour							
	Protein %	Albumin %	Globulin %	Gliadin %	Glutenin Soluble %	Glutenin Insoluble %	Glutenin Total %	Glutenin / Gliadin
Bread wheat								
1) Sids-12	14.6	14.9	7.7	31.3	20.47	25.63	46.1	1.47
2) Gemmiza-7	13.5	14.4	5.9	47.0	12.05	20.65	32.7	0.70
3) Giza-168	13.0	14.9	7.1	40.0	14.66	23.34	38.0	0.95
4) Sakha-93	15.6	14.8	6.3	33.1	11.93	33.87	45.8	1.38
Durum wheat								
5) Beni-sweif-3	15.4	13.8	5.9	36.7	10.22	33.38	43.6	1.19
6) Beni-sweif-5	14.6	14.9	7.7	31.3	20.47	25.63	46.1	1.47

These data are in agreement with Promeranz (1988), who showed that loaf volume for a group of widely different flour varied inversely with the amount of glutenin which soluble in 0.05N acetic acid and directly with the amount insoluble one in the same solvent (residue protein). He reported also, that albumin and globulin contents of widely different bread wheat are relatively constant. In addition Wieser *et al*., (2003) reported that, both amount of glutenin subunits (positively) and the ratio of gliadin to glutenin subunits (negatively) had strong influence on the maximum resistance and extension area of gluten and on the bread volume. Moreover Ames *et al*., (2003) reported that, higher protein or very strong gluten results in better quality durum and play a significant role in the end product.

Fractionation of wheat flours protein using SDS-PAGE:

Wheat flour protein of some Egyption bread and durum wheat were fractionated to obtain information on the molecular weights (MWs) and its relative ratio (Fig.1,2 and Table 3). The results showed that MWs distribution of wheat flour protein subunits found to be in the range of 43 to 269 KDa. The data of MWs and relative area percentage of dominant molecular weight are illustrated in Fig. (2). It could be observed that the subunits with MW45 KDa was detected in all samples. The obtained results revealed that, the dominant molecular weights of flour protein subunit were 81,80,70,70,72 and 71 KDa with relative ratio of 19.14, 17.05, 12.22,13.75,16.11 and 13.37% respectively for sids-12, Gemmiza-7, Giza-168, Sakha-93, Beni-sweif-3 and Beni-sweif-5.
In general the electrophortic profile results of wheat flour protein generally corresponded to the earlier reported data of Wieser *et al*., (2003) and Hill *et al*., (2008).

Table (3) show the technological parameters of quantitative analysis of wheat protein subunits fractionated by SDS-PAGE. From the account of molecular weight of wheat protein subunits, it is clear that the molecular weight > 34 KDa to 70 KDa reprensts gliadin fraction, while molecular weigh > 70 KDa represents glutenin fraction. Fido *et al*., (1997) reported that, the proximate average molecular masses of gliadin have been reported as 31,000D for α and β- gliadin, 35,000D for γ gliadin and 40,000-70,000D for ω-gliadin. Therefore, it is clear that sids-12, Gemmiza-7, Beni-sweif-3 wheat flour protein resulted in glutenin/ gliadin ratios of 1.23, 1.51, and 1.26

respectively. While Giza-168 showed the lowest ratio (0.68) followed by Sakha-93 (0.69) and Beni-sweif-5 (0.92). Which were slightly differ than that chemically determined Table (2). This means that electrophortic separation resulted in more accuracy than that of chemically determination. These data means that sids-12 and Gemmiza-7 are more suitable for making pan, Fino and shamy bread, but Giza-168 and Sakha-93 are more suitable for making balady bread, Meanwhile Beni-sweif-3 and Beni-sweif-5 are excellent source for making good long pasta products and pan bread. These results are in accordance with those results of Antes and Wieser (2001), who reported that the extensibility of dough and gluten was dependent on ratio of gliadin to glutenin. Lawrence *et al*., (1988) indicated that quantitative differences in specific HMW glutenin subunits may also be important in determining bread making quality differences among bread wheat. In addition Wieser *et al*., (2003) reported that with higher, glutenin/ gliadin ratios were generally superior in cooking pasta quality to those with lower ratios.

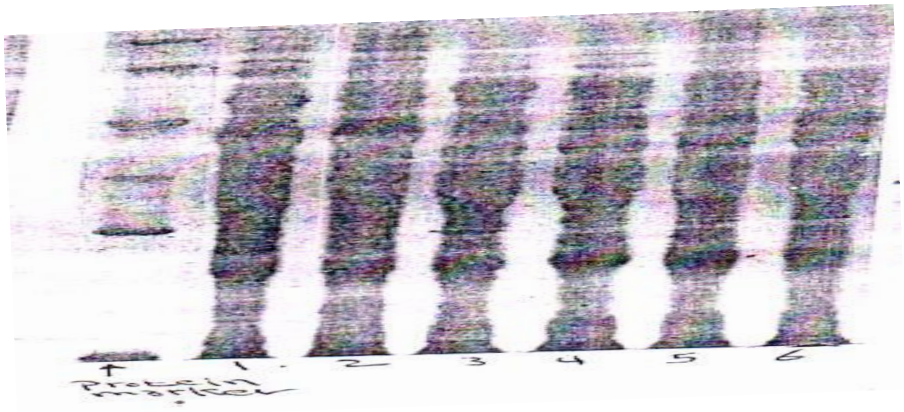

Figure (1): Electrophortic of protein pattern of some Egyption wheat cultivars.
Lane1= sids-12, lane2= Gemmiza-7, lane3= Giza-168, lane4= sakha-93, lane5= Beni-swief-3, lane6= Beni-sweif-5.

Lane	**Dominant molecular weight of protein subunits (KDa)**														
		34	36	45	64	68	70	71	72	80	81	83	84	85	122
1	M.W			■	■						■				■
	Ratio%			6.24	7399						19.14				4.54
2	M.W	■		■					■	■					
	Ratio%	6.92		6.68					11.25	17.05					
3	M.W		■	■			■						■		
	Ratio%		9.05	4.02			12.22						7.27		
4	M.W		■	■			■					■			
	Ratio%		9.17	6.81			13.75					10.28			
5	M.W			■					■			■			
	Ratio%			15.60					16.11			12.34			
6	M.W			■		■		■						■	
	Ratio%			3.21		8.84		13.57						11.21	

Figure (2):Dominant molecular weight (M.W) protein subunits of wheat flour frationated by SDS –PAGE.

Lane1= sids-12, lane2= Gemmiza-7, lane3= Giza-168, lane4= sakha-93, lane5= Beni-swief-3, lane6= Beni-sweif-5

Table (3):Quantitave analysis of wheat flour protein subunits prepared by SDS-PAGE.

Lane	Glutenin	Gliadin	Glutenin / Gliadin
	F.P.M.W* 71-269 KDa%	F.P.M.W 34-70 KDa%	
1	55.67	45.23	1.231
2	60.18	39.84	1.511
3	40.62	59.42	0.684
4	41.07	59.65	0.689
5	55.70	44.32	1.257
6	47.82	52.16	0.917

Lane 1= Sids-12; lane 2= Gemmiza-7; lane 3= Giza-168; lane 4= sakha-93; lane 5= Beni-sweif-3, lane 6= Beni-sweif-5.
***= Flour protein molecular distribution**

The rheological properties of different wheat flour dough:

The rheological properties of different wheat dough are shown in Table (4). Farinograph tests recorded that, values of water absorption, arrival time, development time and stability time were higher for sids-12 dough than other bread wheat ones, meanwhile its dough weakening recorded the lowest value. These data conifirm with data in Table (2) and Fig. (2) which revealed that sids-12 had highest protein (15.2%), and highest molecular weight of glutenin subunits; (122 KDa with relative value 7.54%) compared with other wheat dough (Fig.2) Concerning durum dough, it was found that Beni-sweif-3 had the best values of the mentioned farinograph parameters compared with Beni-swef-5.

Table (4): Rheological properties of some new bread and durum wheat flour dough.

Samples	Water absorption %	Arrival time (min.)	Development time (min.)	Stability time	Dough weakening B.U.
Bread wheat 1) Sids-12	64.7	1.5	2.5	9.0	50
2) Gemmiza-7	62.7	1.5	1.5	3.5	140
3) Giza-168	62.0	1.0	1.5	2.5	150
4) Sakha-93	55.6	0.5	1.0	2.5	160
Durum wheat 5) Beni-sweif-3	68.0	2.0	4.5	6.5	80
6) Beni-sweif-5	69.4	1.0	2.5	3.5	90

This may be due to its high protein content (15.6%), which characterized with its high glutenin/ gliadin ratio 1.38 Table (2), and high ratio (12.34%) distribution of high molecular weight (83 KDa) glutenin subunit (Fig.2). These data are in agreement with those of Cuniberti *et al.* (2003), who reported that, water absorption correlates well with protein composition. Moreover Uhlen *et al*., (2004) reported that development time and stability time of farinogram depend on polymeric protein and not on total protein amount in wheat flour. Stronger flour normally require a longer development time and stability time than do weaker flour. A comparison of development time and stability time indicate the relative strength of different wheat flour.

Organoleptic and baking properties of pan bread:

Table (5) show the organoleptic and baking properties of pan bread produced from bread and durum wheat. It is clear that, the organoleptic and baking properties values showed good quality of pan bread produced from all wheat cultivars except Giza-168. The quality of pan bread were ranked the following sequence sids -12> Gemmiza-7> sakh-93> Beni-swief-3> Beni-sweif-5> Giza-168. The total scores of organleptic properties ranged from 76.6-96.5% for pan bread produced form bread wheat. Meanwhile it ranged from 90.0-91.6 % for durum wheat ones. Also baking properties showed that loaf volume and specific loaf volume (loaf volume/loaf weight) ranged from 450-660 Cm^3 and 2.7-4.4 Cm^3/gm respectively for bread wheat, meanwhile these values ranged from 515-530 Cm^3 and 3.2-3.4 Cm^3/gm respectively for durum ones. From the above mentioned data, it is clear that, Sids-12, Gemmiza-7 Sakha-93, Beni-sweif-3 and Beni-sweif-5 were good sources for making pan bread, while Giza-168 showed to be unsuitable. Despite Sakha-93 which contained lowest protein and wet gluten, it showed pan bread with higher values of organolptic and baking quality than durum wheat which characterized with high protein and wet gluten. This may be due to its high content of glutenin/gliadin ratio and the high molecular weight of glutenin subunits of its protein gluten. (Table 2, 3 and Fig. 2). Finally the quality of pan bread organoleptic and baking properties increased by increasing the percentages of high molecular glutenin subunits. The statistical analysis showed a significant differences between the organoleptic and backing characters, this may be due to the variation between glutenin/gliadin ratio and the dominant molecular weight of flour protein subunits. These data are in agreement with Uheln *et al*., (2004), who reported that differences in gluten protein composition and in particular to high molecular weight glutenin subunit, which are essential for mixing requirement and resistance of the dough.

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Conclusion

From data revealed through this research, it could be concluded that determination of high molecular weight glutenin subunits of gluten protein is very important to determine the wheat flour quality and end-use product, while determination of protein and/ or wet gluten insufficient. The values of organoleptic and baking properties of pan bread produced from Sakha-93 were higher than that of durum pan bread, despite of its lowest content of protein and wet gluten. Therefor determination the end-use product of different wheat flour require determination the percentage of high molecular glutenin subunits. Based on high molecular glutenin subunits percentage, glutenin/gliadin ratio, rheological, organoleptic and baking test properties, it could be concluded that, Sids-12, Gemmiza-7, Sakha-93, Beni-sweif-3 and Beni-sweif-5 were more suitable for making pan bread than other tested wheat cultivars, meanwhile Giza-168 unsuitable.

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الخصائص الوظيفية لمكونات بروتين بعض الأقماح المصرية الجديدة وعلاقتها بجودة الدقيق وخبز القوالب.

السيد عباس مبارك
معهد بحوث تكنولوجيا الأغذية – مركز البحوث الزراعية – الجيزة – مصر

أجري هذا البحث لدراسة المحتوى البروتيني ومكونات البروتين وعلاقتها بجودة الدقيق وخبز القوالب لأربعة أصناف جديدة من قمح الخبز المصري (سدس -١٢، جميزة -٧، جيزة -١٦٨، سخا -٩٣) وصنفان جديدان من أقماح الديورم المنتجة من قسم بحوث القمح بمركز البحوث الزراعية بالجيزة = مصر.ولقد تم دراسة الصفات الفزيوكيماوية، الريولوجية ومفردات البروتين (مكوناته) ونسبة الجلوتنين/ الجليادين كما تم دراسة الوزن الجزئي لمكونات بروتين القمح باستخدام الكتروفريسس (SDS- PAGE) وأيضاً تم دراسة الصفات الحسية وصفات خبز القوالب لكل صنف على حدة.

وكانت النتائج هي:

زادت جودة الصفات الفيزيوكيماوية و الريولوجية بزيادة نسبة كلا من الجلوتنين ذو الوزن الجزئي العالي ونسبة الجلوتنين/ الجليادين في بروتين الدقيق أضف إلى ذلك الصفات الحسية والتكنولوجية (صفات الخبز) تحسنت بزيادة نسبة الجلوتنين المرتفع الوزن الجزئي ونسبة الجلوتنين/ الجليادين. حيث أتضح من الدراسة أنه خبز القوالب المنتج من الصنف سخا – ٩٣ حاز على صفات جودة حسيه وتكنولوجية أعلى من قمح الديورم ذو المحتوى العالي من البروتين والجلوتين الرطب بالرغم من أنه أقل من جميع الأصناف في محتواه من البروتين لذلك فإن نسبة الجلوتنين المرتفع الوزن الجزئي كما أن نسبة الجلوتنين/ الجليادين من أهم المؤشرات المحددة لجودة الدقيق وليس نسبة البروتين أو الجلوتين الرطب فقط. والخلاصة أن الصنف سدس -١٢، جميزة -٧، سخا -٩٣ و بني سويف -٣، بني سويف -٥ مناسبة لإنتاج خبز القوالب بينما دقيق الصنف جيزة ١٦٨غير مناسب لإنتاج خبز القوالب.

قام بتحكيم البحث

أ.د / مسعد عبد العزيز أبو رية	**كلية الزراعة – جامعة المنصورة**
أ.د / أحمد السيد بسيونى	**مركز البحوث الزراعي’**

Table (5):Organoleptic and baking properties of some Egyptian wheat in relation to protein fraction.

Samples	Organoleptic properties								Baking properties		
	Appearance 20	Texture 20	Crust color 10	Crumb color 10	Crust characters 10	Taste 15	Odor 15	Total scores 100	Loaf volume Cm^3	Loaf Weight gm	Specific Loaf volume Cm^3/gm
Bread wheat 1) Sids-12	$19.7^{a}\pm0.21$	$19.8^{a}\pm0.46$	$9.6^{a}\pm0.53$	$9.5^{a}\pm0.46$	$9.6^{a}\pm0.35$	$14.0^{a}\pm0.46$	$14.3^{a}\pm0.29$	$96.5^{a}\pm0.76$	$660^{a}\pm2.0$	$150^{d}\pm1.15$	$4.4^{a}\pm0.15$
2) Gemmiza-7	$19.0^{ab}\pm0.46$	$19.6^{a}\pm0.35$	$9.2^{ab}\pm0.46$	$9.3^{ab}\pm0.40$	$9.5^{a}\pm0.29$	$13.8^{a}\pm0.61$	$14.0^{ab}\pm0.49$	$94.4^{ab}\pm1.7$	$580^{b}\pm2.52$	$150^{d}\pm0.57$	$3.9^{ab}\pm0.32$
3) Giza-168	$13.5^{c}\pm0.31$	$14.7^{c}\pm0.35$	$7.3^{b}\pm0.50$	$8.3^{ab}\pm0.50$	$6.3^{b}\pm0.40$	$13.5^{a}\pm0.40$	$13.0^{b}\pm0.32$	$76.6^{d}\pm0.64$	$450^{f}\pm1.53$	$165^{a}\pm1.73$	2.7c±0.17
4) Sakha-93	$18.6^{ab}\pm0.40$	$19.3^{ab}\pm0.85$	$8.6^{ab}\pm0.59$	$9.6^{a}\pm0.42$	$9.0^{a}\pm0.87$	$13.7^{a}\pm0.42$	$14.0^{ab}\pm0.38$	$92.8^{abc}\pm0.55$	$550^{c}\pm2.31$	$155^{c}\pm1.73$	$3.5^{b}\pm0.20$
Durum wheat 5) Beni-sweif-3	$18.5^{ab}\pm0.64$	$18.0^{ab}\pm0.76$	$9.0^{ab}\pm1.0$	$8.0^{b}\pm0.29$	$9.0^{a}\pm0.58$	$14.5^{a}\pm0.29$	$14.6^{a}\pm0.29$	$91.6^{bc}\pm1.15$	$530^{d}\pm1.0$	$155^{c}\pm1.15$	$3.4^{bc}\pm0.29$
Beni-sweif-5	$18.0^{b}\pm0.29$	$17.5^{b}\pm0.58$	$9.0^{ab}\pm0.58$	$8.0^{b}\pm0.69$	$9.0^{a}\pm0.76$	$14.2^{a}\pm0.25$	$14.3^{a}\pm0.42$	$90.0^{c}\pm2.08$	$515^{e}\pm1.32$	$160^{b}\pm2.08$	$3.2^{bc}\pm0.26$
L.S.D at 5%	1.26	1.83	1.96	1.47	1.79	1.30	1.15	3.95	5.73	4.59	0.74

Values are means of three replicates ± SE. Numbers in the same column followed by the same letter are not significant difference at P>0.05.