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THE EFFECTS OF ALLELIC VARIATION FOR GLUTENIN HMW-GS ON DOUGH QUALITY IN SOME BREAD WHEAT CULTIVARS

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ABSTRACT

The end-use quality of bread wheat is sensitive to cultivar (genotype) and the dominated extreme environmental conditions during the grain filling, as they effect on syntheses and accumulation of storage proteins (gliadin and glutenin) in grain. A field trials were carried out for three bread wheat cultivars (bohoth6, cham4 and cham6) at the four different environment zones in Syria for two seasons 2007 and 2008 to study the effects of the allelic variation in each studied cultivar (genotype) and effect of the dominant environmental conditions at each zone on gluten content and dough quality. Glutenin protein were analyzed by sodium dodecyl sulphate polyacrylamide gel electrophoresis SDS-PAGE that demonstrated presence some allelic variations and the absence (deletion) of some alleles at loci on the chromosomes. Three different allelic were identified at (Glu-A1 and Glu-B1) loci. The gluten content was the best in bohoth6, because there were no any allelic deletion at loci in comparison cham4 and cham6. So, the gluten content reduced when air temperature was raised above 30 ºC for long duration coincident with water deficit during the grains filling period. The gluten quality was analyzed by Farinograph test (development time, stability and mixing tolerance), this test confirmed that bohoth6 has the best allelic group for syntheses and accumulation of glutenin in grains. bohoth6 at zone2 and zone4 gave a dough strength ranging from the strongest in season 2007 to the medium grade in season 2008 as a result of effect the unusual extreme climatic conditions. The results indicated that bohoth6 was more tolerant to these extreme environmental conditions than cham4 and cham6.

Keywords: Glutenin, SDS-PAGE, Gluten content, Bread wheat quality, Environmental conditions, Farinograph test and Dough quality.

INTRODUCTION

In Syria, wheat is the most important field crop. The majority of grown wheat is durum wheat (*T. durum*) and bread wheat (*T. aestivum*). Bread wheat is the most widely grown food crop in the world and distinguished for its dough quality and bread making properties. There is significant relationship between the different environmental conditions, syntheses and accumulation of storage protein, and the dough quality, which suggests that climatic conditions and weather models, climatic zones and genotype could be useful or not useful in predicting grain quality (Peterson *et al.,* 1998). The total protein content and the glutenin and gliadin ratio also affect on dough and baking properties (Uthayakumaran *et al*., 2004). The wheat storage protein genes exhibit a co-dominant Mendelian inheritance (Gupta and Shepherd, 1990, Wrigley, 1996).

Three genetically unlinked loci Glu-A1, Glu-B1, and Glu-D1 present on homeologous chromosomes 1A, 1B, 1D control the synthesis of the HMW glutenins (MacRitchie and Lafiandra, 2001, Gálová *et al*., 2002). Correlation studies (Gupta and MacRitchie, 1994) have indicated that dough 'strength' and bread-making potential of flour are positively related with subunits 5+10, 7+8, 17+8, 1 and 2* and negatively associated with subunits 6+8, 2+12 and 20 Goesaert *et al*., 2005; Lagrain *et al*., 2006. It was also observed that, where subunits 7+8 and 2* occurred together (Khatkar *et al.*, 1996). Mir Ali, (1995) reported that the studied lines were characterized by having higher SDS sedimentation values due to the presence of subunits 17+18 at *Glu-B*1 when compared to those that has subunits 7+8. SDS page separation of HMW glutenins from several wheat cultivars have demonstrated a number of alleles at each loci (Payne & Lawerence, 1983; MacRitchie and Lafiandra, 2001). Although grain protein composition depends primarily on genotype, it is significantly affected by the environment factors and their interactions (Triboï *et al*., 2000; Daniel and Triboï, 2002***;*** Zhu and Khan, 2001). For certain varieties, flour, dough, and baking quality parameters were reported to be altered in response to a short period of heat stress >35 °C, and some of these effects have been linked to an increased gliadins-to-glutenins ratio (Blumenthal *et al*., 1991**,** 1993*;* Wardlaw *et al*., 1995, 2002). The water deficits severely effect end-use quality for several cultivars of wheat (Guttieri *et al.*, 2001). This study will focus on, 1- Study of the allelic variations at loci of glutenin subunits HMW-GS and their effect on total protein and gluten contents in three bread wheat cultivars and define the suitable environmental zones to each cultivar. 2- Study the effect of the deletion of some important alleles on the end-use quality (dough). Define the most tolerant cultivar to extreme environmental conditions (heat and drought stress).

MATERIALS AND METHODS

Seeds of three bread wheat cultivars Bohoth6, Cham4 and Cham6 were sown in three replicated trials at four zones with different environmental conditions for two seasons 2007 and 2008. These zones were zone1: (Ghab research center, Hama), zone2: (Himo research center, Al-Hassake), zone3: (Idleb research center, Idleb), zone4: (Malikieh research center, Al-Hassake) in each zone, the daily meteorological data was recorded (air temperature and rainfall) during the grain filling period from 15 April to 30 May (Table 1). The climatic stress was calculated as number of daily extreme temperature ≥ 30 °C during the grain filling period at each zone. The grain filling period was defined based on the average maturity of cultivars grown in the trials.

Table 1: Environmental factors (the extreme high temperatures (heat stress) and rainfall (water stress) during the grain filling period

The dominant climatic conditions	Season 2007				Season 2008			
	zone1	zone2	zone3	zone4	zone1	zone2	zone3	zone4
Rainfall during filling period (mm)	97.4	35.2	80.0	50.5	37.8	3.5	28.1	17.2
Number days (≥ 30 ºC)	20	19	17	18	16	32	18	30

At the harvesting stage, the grains were harvested and brought to the seed biotechnology laboratory and biotechnology laboratory in General Commission for Scientific Agricultural Research, Douma, Damascus.

Near-infrared reflectance (NIR): the percentage of the total protein content (GPC) and wet gluten content (WG) and Sodium Dodecyle Sulphate sedimentation volume SDSs volume of sample grains was determined by Near-infrared reflectance (NIR) spectroscopy using an Infratec 1241 (Grain Analyzer, made in FOSS company, Tecator, Hö͡ganăs, Sweden).

Milling of the Wheat flour for Farinograph test: Reduction flour was mixed to determine the dough strength of the flour by farinograph. Brabender Farinograph-E worldwide standard was used to assess the rheological properties of wheat flour in accordance (AACC 54-21). Farinograph is measured in Brabender Units (BU), which refers to the dough resistance to mixing. The Farinograph was used to identify the gluten quality and to measure dough characteristics of flours during the test such as development time (FDT) is the needed time for dough and water to mix together to develop strength, dough stability (FST), dough mixing tolerance (MT). And the Farinograph results were interrelated in comparison to the Farinograph parameters (Table 2).

Table *2:* Guidelines interpretation of the Farinograph parameters According to (Williams *et al* ., 1986).

(Rating)	SDS sedimentation volume (ml)	FDT (min)	FST (min)	MT (BU)
Exceptionally weak	Less than 20	-	-	-
Very weak	20-29	0- 2	0- 2	200-250
Weak	30-39	2-4	2-4	150-199
Near of weak	40-49	-	-	-
Medium strength	50-59	4-6	4-7	100-149
Near to strong	-	6-8	7-10	-
Strong	60-69	8-10	10-15	50-99
Very strong	70-79	Over 10	Over 15	0-49
Exceptionally strong	Over 80	-	-	-

FDT, development time**; FST, Dough Stability, MT, Mixing Tolerance;** BU, Brabender Units.

Sodium Dodecyle Sulphate Polyacrylamid Gel Electrophoresis (SDS-PAGE): It is generally known that Gluten strength is associated with certain High Molecular Weight (HMW) Glutenin subunits. Thus, the High Molecular Weight (HMW) Glutenin composition of wheat is determined utilizing sodium dodecyle sulphate polyacrylamid gel electrophoresis (SDS-PAGE).

Preparation of Samples for SDS-PAGE Electrophoresis:

HMW-GSs were analyzed by SDS-PAGE method. Dual slab electrophoretic system Hoefer SE 600 (gel size – 16 × 18 cm) was used for the analyses. Three grains of every cultivar were tested for four zones in two seasons 2007 and 2007. The remaining pellet after extraction of gliadin protein was extracted for the obtaining on glutenins according to a sequential procedure (Singh *et al.,* 1991). Electrophoresis of glutenin subunits was

performed on SDS-PAGE according to (peňa *et al.,* 2007). Allele identification was by using the standard wheat varieties and respective HMW-glutenin profiles were Pavon: (2*, 17+18 and 5+10), Opata: (2*, 13+16 and 2+12) Liu *et al*., 2008, and Pitic62: (1, 7+8 and 2+12) Cornish, 2007. HMW glutenin alleles at *Glu-A1, Glu-B1* and *Glu-D1* loci were identified and allelic variations were rated by numbering each HMW glutenin sequentially, based on mobility in SDS-PAGE and the classification of (Payne and Lawrence, 1983).

RESULTS AND DISCUSSION

Analysis of HMW-GSs Protein: The effects of the HMW glutenin protein is evident from the results that were obtained by sodium dodecyl sulphate polyacrylamide gel electrophoresis SDS-PAGE Analysis in this study. Analysis results of the SDS-PAGE of the other cultivars demonstrated absence (deletion) of some alleles at loci on the chromosomes. Three different allelic were identified, two different alleles 2*, null (N) were corresponded to the Glu-A1 locus, and two different alleles (7+8 and 17+18), were corresponded to the Glu-B1 locus and one allele 2+12 was corresponded to Glu-D1 locus. This the last allele 2+12 was present into three studied cultivars. The HMW proteins present in three studied cultivars (cham4, cham6 and bohoth6) that were tested by using SDS-PAGE (Table 3; Figure 1 and 2).

Table 3: Compositions and deletion of glutenin alleles HMW-GS in three studied cultivars (cham4 cham6 and bohoth6).

Cultivars	HMW glutenin alleles		
	Glu-A1	Glu-B1	Glu-D1
Cham4	-	17+18	2+12
Cham6	2*	7+8	2+12
Bohoth6	2*	17+18	2+12

SDS-PAGE analysis was used to further verify the HMW-GSs protein allelic patterns of the studied cultivars in both seasons 2007 and 2008. But, when the gels of both seasons were compared together, the obtained results by electrophoresis to determine the responsible alleles from dough strength were similarly and they didn't change when the climatic conditions were changed at four studied environmental zones in season 2008. These results indicated the subunits (alleles) don't affect by the extreme climatic conditions, viz the responsible genes in genetic loci (Glu-A1, Glu-B1 and Glu-D1) on chromosome 1 expressed despite of the dominant bad climatic conditions in season 2008 at zone2 and zone4 (Table 1). This result was similar to that reported by Dupont *et al*., (2006). However, each studied cultivar included 3–5 bands of HMW-GSs. Cham4 has subunit (null), 17+18 and 2+12 at loci (Glu-A1, Glu-B1 and Glu-D1), respectively. Cham6 has subunit 2*, 7+8 and 2+12 at loci (Glu-A1, Glu-B1 and Glu-D1), respectively. Also, Bohoth6 has subunit 2*, 17+18 and 2+12 at loci (Glu-A1, Glu-B1 and Glu-D1), respectively (Figure 1, 2 Table 3).

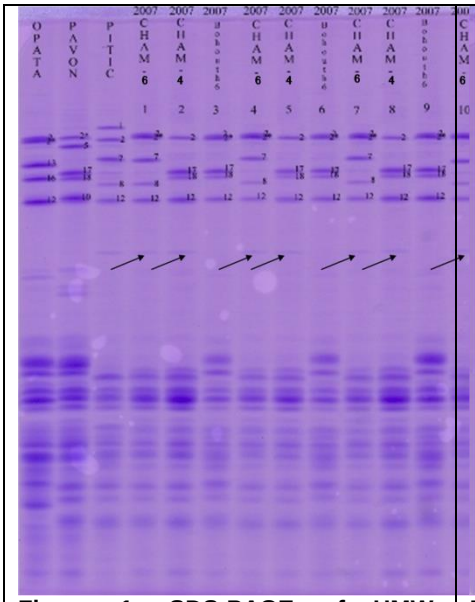

Figure 1: SDS-PAGE of HMW-glutenin subunits of the bread wheat cultivars Cham4, Cham6 and Bohoth6 in four zones in season 2007 and standard wheat cultivars (Pavon, Opata and Pitic 62). They were numbered according to Payne and Lawrence (1983).

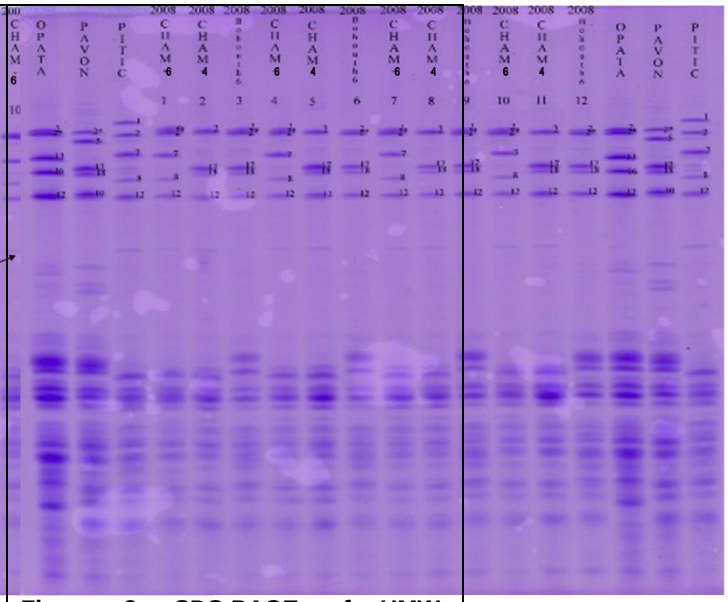

Figure 2: SDS-PAGE of HMW-glutenin subunits of the bread wheat cultivars Cham4, Cham6 and Bohoth6 in four zones in season 2008 and standard wheat cultivars (Pavon, Opata and Pitic 62). They were numbered according to Payne and Lawrence (1983).

When the comparison between loci to three cultivars was noticed that subunit 17+18 at Glu-B1 locus were present in both cham4 and bohoth6 and subunits 2+12 at Glu-D1 locus were present in all studied three cultivars. Also, subunits 7+8 at Glu-B1 locus were present in cham6 and subunits 2* at Glu-A1 locus were present in both cham6 and bohoth6 (Figure 1 and 2). However, the subunit 20 Glu-B1 loci and subunits 5+10 in Glu-D1 don't present in none from the three studied cultivars. This results indicated the HMW-GSs allelic pattern compositions in cham4 (17+18 and 2+12) are to bohoth6, and in cham6 are (2* and 2+12) are similar to bohoth6 at same locus. However, all subunits significantly affected on some of the quantitative and qualitative traits of GPC and WG contents (Table 4 and 5). So that some tests like SDSs volume and Farinograph as (FAB, FDT, FST and MT) were affected with changing both quantitative and qualitative traits of GPC and WG. The (2*, 17+18 and 7+8) are positively influenced on content of both traits and increasing of SDSs volume. This result was indicated by correlation studies to (Gupta and MacRitchie, 1994) who have confirmed that dough 'strength' and bread-making potential of flours are positively related with subunits 17+8, 7+8, and 2* and negatively associated with subunits (null) and

2+12. Also, the results in this study were similar to those by Gregova *et al*. (2006); Goesaert *et al*., 2005; Lagrain *et al*., 2006). Also, Branlard and Dardevet (1985) confirmed subunits 2* and 17+18 are associated with a strong dough. In general, when the alleles 2* and 17+18 are together in bohoth6, they show highest positive effects to GPC and WG. This result is explained that the wheat storage protein genes exhibit a co-dominant Mendelian inheritance (Gupta and Shepherd, 1990).

So here, present both the alleles 2* and 17+18 together showed the highest positive effects to GPC and WG, accordingly both traits effected positively on SDSs volume and farinograph test (FDT and FST) and these results were confirmed by Mir Ali (1995). Whereas, bohoth6 has subunits 17+18 that contributed to increase SDSs volume more than cham6 which has subunits 7+8 and 2+12 together. Because subunits 7+8 and 2+12 together have minimum positive effects on the mean of SDSs volume, and this also reported by Khatkar *et al*, (1996). Thus, in our study, cham6 that has subunits 7+8 showed minimum positive effects on the mean of SDSs volume in comparison with bohoth6 that has subunits 17+18 that expresses a higher gluten contents than subunits 7+8 in cham6. So, the deletions in the glutenin loci resulted in significantly ($p<0.05$) reduced the mean of GPC and WG by comparison between the means of three studied cultivars in each season alone (Table 4 and 5). The deletions to subunit 2* at Glu-A1 as in cham4, subunits 17+18 in cham6 and subunits at Glu-B1 reduced the quality of GPC and WG in flours of both cultivars, because subunit 2* and subunits 17+18 affect positively on the dough strength. So, bohoth6 had a strong dough in its flour, because it has at both loci (Glu-A1 and Glu-B1) the positive subunits 2* and 17+18 that result in a high dough strength. Gupta and MacRitchie (1994) have indicated that dough 'strength' and bread-making potential of flour are positively related with subunits 7+8, 17+8 and 2*. Anyhow, the Farinograph tests had indicated significant effects of GPC and WG contents on dough strength at four studied environmental zones in both the seasons 2007 and 2008. Cham4 which has a the deletion (null) and 17+18, cham6 which has subunits 2* and 7+8, and bohoth6 which has subunits 2* and 17+18. These cultivars in season 2007 were affected by the usually extreme climatic conditions at four studied zones, so cham4 and cham6 produced medium GPC and WG, but bohoth6 produced high GPC and WG (Table 4 and 5). While, GPC and WG in Cham4 and cham6 in season 2008 lowed to medium, and GPC and WG in bohoth6 lowed to the medium dough according to Farinograph tests (FDT, FST and MT) and SDSs volume and the studied cultivars means (Table 2, Figures 4, 6, 8, and 10). Because they were affected by the unusually extreme climatic conditions (Table 1). In fact, presence of the subunits 17+18 and 2+12 together in the genomic material of bohoth6 resulted in stronger dough than the dough which has subunits 7+8 and 2+12 together as in cham 6, perhaps because the subunits 17+18 are responsible of synthesis glutenin proteins more than subunits 7+8 as indicated by Mir Ali (1995). The deletion in cham4 to subunit 2* at Glu-A1 locus negatively effected on the GPC and WG of flour, after that on the dough and bread quality. Because the deletion changes the composition of GPC and WG during duration synthesis and accumulate total proteins (gliadin and

glutenin) during the grain filling period and consequently the end-use quality (Table 4 and 5). Shwery *et al*., (2003) demonstrated that allelic differences among genotypes affect the amounts and the properties of HMW-GS polymers of wheat gluten and the bread making properties of individual genotypes. Therefore, the deletion some alleles of glutenin subunits at Glu-A1 and Glu-B1 loci impacted negatively on the parameters of Farinograph test FDT, FST and MT and SDSs volume (Table 3 and figures 3, 5, 7 and 9). The dough mixing strength was significantly reduced, because the deletion of subunits at Glu-A1 loci (null) and Glu-B1 loci (Table 3).

The low amount of glutenins formed a weak gluten network was not able to extend itself, because it has the weak structure causes reduction to the dough stability and the network ruptures quickly. These results were agreed with (Branlard and Dardevet, 1985; MirAli, 1995; Gregova *et al*. (2006); Goesaert *et al*., 2005; Lagrain *et al*., 2006). Also, many studies reported that when some HMW glutenins are deleted, the dough mixing strength and bread making quality will be reduced (Lawrence *et al.,* 1988; MacRitchie and Lafiandra, 2001). The stability FST in bohoth6 in both seasons (Figure 5 and 6). This results were similar to many results obtained by (Weegels *et al*., 1994; Lafiandra *et al*., 1999; Branlard *et al*., 2001).In both seasons, the means of GPC and WG in bohoth6 were better than the means in deleted cham4 and cham6 despite that the means of GPC and WG were reduced in season 2008.

Table 4: Analysis of variances of total protein content (GPC) content in three studied cultivars at four environmental zones in two studied seasons 2007 and 2008 and the means of cultivars and zones.

Cultivars	Season	zone1	zone2	zone3	zone4	Cultivar mean
Cham4	2007	13.01Cc± 0.515	16.0Bc± 2.006	11.9Dc± 0.885	15.1Bc± 0.452	14.51d± 0.348
Cham6		14.01Db± 0.137	17.01Ab± 0.154	14.80Da± 1.668	16.1Ad± 0.201	14.85C± 0.001
Bohoth6		14.6Ca± 0.377	18.01Aa± 1.852	12.7Db± 0.782	16.5Ba± 0.251	15.20a± 0.349
Means		13.87± 0.980	17.01± 1.653	13.13± 1.720	15.90± 1047	
Cham4	2008	13.05Bc ±0.545	12.01Dc ±0.149	13.15Ac ± 0.312	11.90Dc ±0.138	12.35 ±0.722
Cham6		14.40Ab± 0.178	12.25Cb± 0.718	14.20Bb ± 0.111	12.25Cb± 0.139	13.46± 0.094
Bohoth6		15.50Aa± 0.367	12.50Da± 0.569	15.20Ba ± 0.201	13.30Ca± 0.001	14.13± 0.816
Means		14.32± 1.008	12.25± 1.056	14.18± 0.874	12.48± 0.826	
Grand mean		14.138				
LSD 0.05 Cultivar X zone		0.035				
CV%		0.2				

LSD, Least significant difference of the means (5% level); CV, Coefficients of variation.The numbers with superscript capital letters (A, B, C and D) refer to significant variation among varieties, while numbers with superscript small letters (a, b, c and d) refer to significant variation among zones.

Table 5: Analysis of variances of wet gluten content (WG) in three studied cultivars at four environmental zones in two studied seasons 2007 and 2008 and the means of cultivars and zones.

Cultivars	Season	zone1	zone2	zone3	zone4	Cultivar means
Cham4	2007	32.1Dc± 0.01	39.14Ab± 1.837	34.8Bb± 0.81	34.6Cc ± 2.657	35.16± 2.177
Cham6		35.1Db± 0.055	37.4Cc± 2.968	39.5Ba± 2.445	40.9Ab ± 0.578	38.23± 0.888
Bohoth6		35.6Ca± 0.045	41.9Ba± 1.132	34.2Dc± 3.255	42.8Aa ± 2.078	38.63± 1.288
Means		34.27± 3.070	39.48± 2.143	36.17± 1.17	39.43± 2.097	
Cham4	2008	33.2Ab ±0.652	24.01cD ±0.258	32.01Bc± 0.345	31.55Cc± 0.565	30.19± 0.450
Cham6		32.5Bc± 0.456	24.25bC ±0.091	32.5Bb ±0.2625	33.15Aa± 0.628	30.60 ± 0.078
Bohoth6		33.4Ba± 0.196	24.45aD ±0.349	34.01Aa ±0.608	33.10Cb± 0.062	31.24 ± 0.562
Means		33.03± 2.356	24.24± 6.441	32.84± 2.1625	32.60± 1.9225	
Grand mean		33.961				
LSD 0.05 Cultivar X zone		0.184				
CV%		0.35				

The interactions of subunit 2* with subunits 17+18 in bohoth6 resulted in the best composition and higher contents of the GPC and WG than cham4 that has subunits 17+18, and cham6 that has only subunit 7+8. These results in our study are a strong evidence on co-dominant to both subunit 2* and subunits 17+18 together. Therefore, bohoth6 which has subunits 2*, 17+18 had larger means of GPC and WG than both of the cultivars cham4 and cham6 that have (subunits 17+18, subunits 2* and 7+8) respectively. Peña *et al*., (1995) confirmed common wheat varieties possessing five HMWG subunit components generally have stronger gluten character than the ones possessing three or four components. Too, the results in this study indicated bohoth6 has next subunits 2*, 17+18 and 2+12 at (Glu-A1, Glu-B1 and Glu-D1) respectively, whereas it express the higher glutenin percentage into the extreme climatic conditions (high temperatures and water deficit). Also, other similar results to our results were confirmed by (Mir Ali, 1995; Gregova *et al*., (2006); Goesaert *et al*., 2005; Lagrain *et al*., 2006).

The variances of GPC and WG means at studied environmental zones were noticed (Table 4 and 5). In season 2007 at zone2 and zone4 the means of GPC were 17.01% and 15.9% respectively, and WG were 39.48% and 39.43% respectively, the means of GPC at zone2 and zone4 were higher than the means 13.87% and 13.13% of both zone1 and zone3 respectively, Also, the means of WG at zone2 and zone4 were 34.27% and 36.17% of both respectively, (Table 4 and 5), despite there wasn't any significant difference between the means at zone2 and zone4. But, in season 2008 the means of GPC at zone2 and zone4 were 12.25% and 12.48% respectively, they were lower than the means 14.32% and 14.18% of both zone1 and zone3, respectively. But, the means of WG at zone2 and zone4 were 24.24%

and 32.6% respectively, they were lower than the means 33.03% and 32.84% of both zone1 and zone3 respectively (Table 4 and 5). Depend on this the results confirmed that the extreme environmental conditions (heat and water stress) that was dominant at zone2 and zone4 in season 2008 affected on syntheses and accumulations of total protein and gluten (storage proteins), because storage proteins accumulate from approximately 6 day to the end of grain-filling (Panozzo *et al*., 2001). Also, the extreme environmental conditions that was dominant in season 2008 at zone2 and zone4 maybe resulted in shorten the grains filling period. Jamieson *et al*., (2001) has confirmed such as the fact, whereas reported that high temperature and/or drought effect the balance of protein fractions. Was reported by Blumenthal *et al*., (1993) that for certain varieties, flour, dough**,** and baking quality parameters are altered in response to a short period of heat stress >35 °C, and some of these effects have been linked to an increased gliadins-to-glutenins ratio (Blumenthal *et al*., 1991) and decreases in the proportion of the high molecular weight glutenins (HMW) (Wardlaw *et al*., 2002). So that, the means of GPC% and WG% in all studied zones in season 2007 were high, but they decreased in season 2008 in generally (Table 4 and 5). Was noticed that the decreasing average of the means GPC and WG when the comparison between the means at zone1 and zone3 in both seasons was very little. While the decreasing average of the means of GPC and WG in zone2 and zone4 in both seasons was very high when the comparison between these means. Anyway, the percentage of GPC and WG in bohoth6 at zone2 and zone4 were ((12.5% and 13.30%), (24.45% and 33.15%), respectively higher than the percentages of GPC and WG in both cultivars cham4 and cham6, whereas the percentages of GPC in cham4 were ((12.01% and 11.9%), respectively and to WG were (24.01% and 31.55%)) respectively, and cham6 were ((12.25% and 12.25%), respectively and to WG were (24.25% and 33.15%)), respectively (Table 4 and 5). Thus, this results confirmed that bohoth6 is distinguished from cham4 and cham6, because the first cultivar has the improving alleles to dough strength at both Glu-A1 and Glu-B1 loci and it is more tolerant to extreme environmental conditions as that was dominant at zone2 and zone4 in season 2008. In this results, the interaction between cultivar (genotype) and the extreme environmental conditions indicated bohoth6 was the distinguished cultivar. Other studies similar to our study reported that although grain protein composition depends primarily on genotype, it is significantly affected by environment factors and their interactions (Triboï *et al*., 2000; Zhu and Khan, 2001).

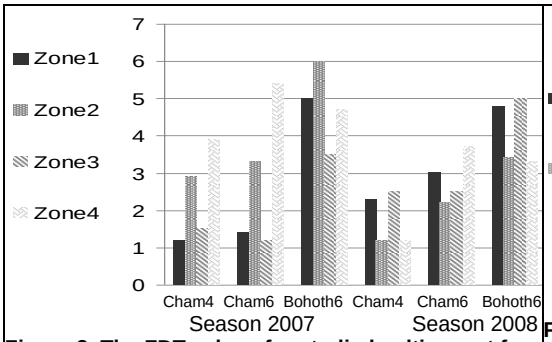

Figure 3. The FDT values for studied cultivars at four zones in two seasons.

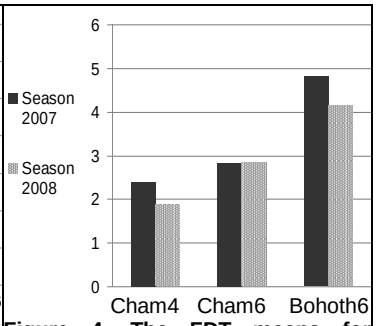

Figure 4. The FDT means for studied cultivars at four zones in two seasons.

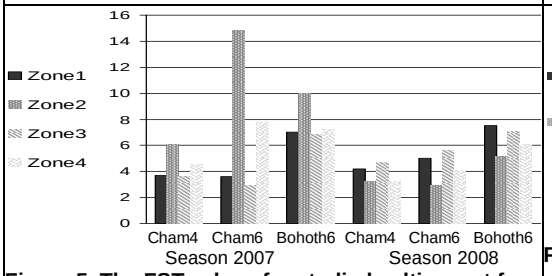

Figure 5. The FST values for studied cultivars at four zones in two seasons.

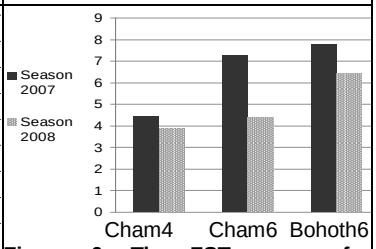

Figure 6. The FST means for studied cultivars at four zones in two seasons.

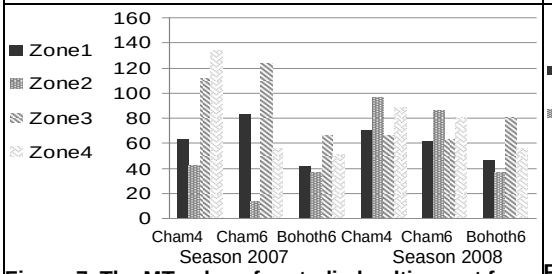

Figure 7. The MT values for studied cultivars at four zones in two seasons.

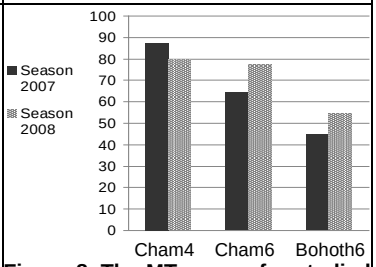

Figure 8. The MT means for studied cultivars at four zones in two seasons.

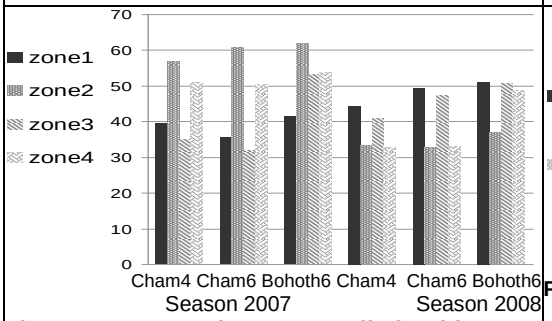

Figure 9. SDSs volume to studied cultivars at four zones in two seasons.

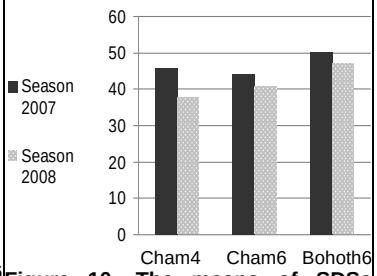

Figure 10. The means of SDSs volume to studied cultivars at four zones in two seasons.

CONCLUSION

This study indicated that bohoth6 has the subunits 2*, 17+18 and 2+12 at (Glu-A1, Glu-B1 and Glu-D1) respectively, and cham6 has the subunits 2*, 7+8 and 2+12 at (Glu-A1, Glu-B1 and Glu-D1) respectively, so cham6 expressed lower glutenin than bohoth6, but it was higher than cham4 which has the subunits 17+18 and 2+12 at (Glu-B1 and Glu-D1) respectively. The deletions in the glutenin loci resulted in significant ($p<0.05$) reduction of the mean of GPC and WG by comparison between the means of three studied cultivars and bohoth6 was the best one cham4 and cham6 that have the deletion at their loci. Also, bohoth6 had a strong dough result to the increasing of the GPC and WG content. Farinograph test and SDSs volume had indicated a presence to significant effects of the GPC and WG contents on dough strength at four studied environmental zones in both seasons. Bohoth6 was more tolerant to these extreme environmental condition than cham4 and cham6, so it gave the highest content of GPC and WG and best dough strength at same both zones (zone1 and zone2). Thus suggests that bohoth6 can perform better than cham4 and cham6 if it grows in regions of Syria having similar extreme environmental conditions to the one dominated in both zone2 and zone4 during season 2008 season**.**

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تأثير التغيرات الأليلية للجلوتينين على نوعية العجين لبعض أصناف القمح الطري

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تعتبر نوعية الناتج النهائي للقمح الطري حساسة للصنف والظروف البيئية السائدة خلال فترة امتلاء الحبة حيث يؤثران على اصطناع وتكدس بروتينات التخزين في الحبة. نفذت الاختبارات الحقلية لثلاثة أصناف قمح طري (بحوث٦، شام٤ وشام٦) في أربع مناطق مختلفة بيئياً لموسمين زراعيين ٢٠٠٧ و٢٠٠٨ لدراسة تأثيرات التغيرات الأليلية في كل صنف مدروس وتأثيرات الظروف البيئية السائدة في كل منطقة على محتوى الجلوتين ونوعية العجين. حللت بروتينات التخزين بطريقة SDS-PAGE التي أوضحت وجود بعض التغيرات الأليلية وغياب بعض الأليلات من مواقعها على الكروموزومات. الأليلات الثلاثة المختلفة كانوا محددين في المواقع (Glu-A1 and Glu-B1). أفضل محتوى للجلوتين كان في البحوث٦ بسبب عدم وجود أي حذف أليلي في مواقعه الوراثية مقارنة مع الشام٤ والشام٦. أيضاً انخفض محتوى الجلوتين عندما ارتفعت درجة الحرارة إلى ٣٠مْ وما فوق لفترة طويلة مترافقة مع نقص الماء خلال فترة امتلاء الحبة. أجريت تحاليل باختبارات الفارينوغراف (وقت تطور العجينة وثبات العجين والقدرة على تحمل العجن)،أثبت هذا الاختبار أن البحوث٦ يملك أفضل مجموعة أليلية لاصطناع وتكديس بروتين الجلوتين في الحبوب. أعطى البحوث٦ في المنطقين البيئيتين قوة عجين تراوحت بين القوة في الموسم ٢٠٠٧ إلى المتوسطة في الموسم ٢٠٠٨ نتيجة لتأثير الشروط المناخية الشديدة عيرالاعتيادية. بينت النتائج أن الصنف بحوث٦ أكثر تحملا للجفاف من الصنفين الآخرين شام ٤وشام٦.

الكلمات المفتاحية: جلوتينين، SDS-PAGE، محتوى الجلوتين، نوعية القمح الطري، الظروف المناخية، اختبار الفارينوغراف ونوعية العجين.

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