Assessment of high molecular weight glutenin sub-units and baking quality related traits in some of the Iranian bread wheat (*Triticum aestivum* L.) landraces

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Abstract

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High molecular weight (HMW) glutenin sub-units and baking quality related traits were studied in 49 Iranian wheat landraces. The protein content ranged from 11.2% to 13.55%, and SDS sedimentation volume varied between 40 and 60 milliliters. High Molecular weight glutenin electrophoresis profiles revealed that at the Glu-A1 locus, the frequency of null allele was higher than sub-units 1 and 2*. Allelic variation for Glu-B1 locus was also considerable as sub-units of 7, 7+8, 6+8, 14+15, 7+9, 17+18, 13+16 and 20 were observed. The highest and lowest frequencies of Glu-B1 belonged to sub-units 7+8 (56%), and 13+16 (2%), respectively. For Glu-D1, 2+12 sub-units (74%) were of higher frequency in comparison with 5+10 sub-units (14%). At this locus, the rare 2***+12' sub-units with frequency of 2% were also observed. Scoring of germplasm based on electrophoresis patterns using Payne method showed that the scores varied from 4 to 8. Based on this scoring, three landraces were ranked as superior. Cluster analysis based on electrophoresis patterns and Jaccard similarity criteria divided the landraces into three groups. Forty landraces with *cv.* Chamran, as check, were grouped in the first cluster. There was no similarity between grouping pattern based on HMW glutenin sub-units and quality related traits. Considering high variation observed for quality related traits and HMW glutenin sub-units, it can be concluded that these landraces are potential sources of desirable quality traits to be used in bread wheat breeding programs to improve bread- baking quality.

Key words: Bread Wheat, Landraces, Baking quality, Quality traits, and Higher Molecular Glutenin Weight.

Introduction

Bread wheat is one of the major food crops and accounted as staple food for at least 35% of the world population. More than 90% of wheat produced in Iran is used for making bread from which 30% are wasted

due to low quality. High-molecular-weight (HMW) glutenin sub-units are significantly related to the baking quality of bread wheat (Payne and Corfield, 1979; Ahmad, 2000; Schwarz *et al.*, 2004). The HMW glutenin sub-units are encoded by genes at the Glu-A1, Glu-B1 and Glu-D1 loci on the long arms of homoelogous chromosomes; 1A, 1B and 1D (Payne *et al.*, 1981). Two tightly linked genes are present at each Glu-1 locus, encoding sub-units of higher (HMW) lower (LMW) molecular weight glutenin, and are designated as the *x* and *y*, respectively (Harberd *et al*., 1986). At the Glu-1A locus, the *x* sub-unit is occasionally expressed and the *y* sub-unit is always absent. The *x* and *y* sub-units coded by the Glu-1B and Glu-1D loci are usually expressed, i.e. the Glu-B1 *y*-sub-unit can also be absent. The HMW glutenin alleles 1 and 2* at Glu-1A locus,17+18 and 7+8 or 9 at Glu-1B locus and 5+10 at Glu-1D locus are connected with stronger dough and better baking properties, whereas Null, 6+8 and 2+12 are associated with poor baking quality (Payne *et al*., 1987).

The primitive varieties, landraces and wild relatives of crop plants constitute useful genetic variability generally required in breeding programs (Juhász *et al*., 2003; Arzani *et al.,* 2005). Much of the rich plant biodiversity that supported agriculture in the past has been eroded or is being rapidly eroded by the introduction of new high yielding cultivars. Moreover, it is thought that old cultivars or landraces are better adapted to sustainable ecological production systems (low-input and organic farming systems) than modern cultivars (Shroyer and Cox, 1993). This implies new avenues for further studies, since organic production has increased in recent years due to growing consumer demand (Guarda *et al*., 2004).

The main objective of this study was to assess the high molecular weight glutenin sub-units and baking quality related traits of a set of 49 Iranian landraces as source germplasm for bread wheat breeding programs.

Materials and Methods

High molecular weight (HMW) glutenin sub-units and baking quality related traits were assessed in 49 Iranian bread wheat landraces and cv. Chamran cultivar as check (Table 1). These landraces were selected from 5000 native bread wheat accessions based on a preliminary experiment for

evaluation of some baking quality related traits.

Total grain protein was extracted and high molecular weight glutenin sub-units of the landraces were fractionated using SDS- poly acrylamide gel electrophoresis (SDS-PAGE) mainly with 10% poly acrylamide gels following Payne *et al*. (1981). Staining of the gels was done using Commassie Brilliant Blue R-250 in presence of Tri-chloroacetic acid (TCAA) and ethanol over night. Destaining of the gels was performed with 3% NaCl solution. To separate sub-units 2* and 2 which normally overlap in 10% SDS-PAGE gels, in landraces carrying 2+12 sub-units SDS-PAGE method was employed in the presence of urea using %8 original gel (C = 2.67) (Lafiandra *et al.,* 1993). Detected bands were scored following Payne and Lawernce (1983).

Presence or absence of sub-units was scored by 1 and zero, and cluster analysis was performed based on Jaccard similarity index and Unweighted Pair Grouped Method Using Arithmetic Average (UPGMA) clustering method. Genotypic scoring was made following Payne *et al.* (1984).

Results and Discussion

Analysis of variance showed no significant differences among bread wheat landraces for baking quality related traits, with the exception of water absorption which was significant at the $P<0.05$ (Table 2).

Analysis of farinografh characteristics revealed that duration for dough development varied from 1 to 4.9 minutes for landraces No. 4 and 37, respectively (Fig. 2). However, dough stability ranged between 1.2 to 17.6 minutes for *cv.* Chamran and landrace No. 49, respectively (Fig. 1 and 3). Dough softening in 10 minutes varied from 1.6 to 227 farinograph units for landraces No. 32 and 31, respectively. While, dough softening in 12 minutes varied from one to 265 farinografh units for landraces No. 49 and 31, respectively. Farinograph quality scores ranged from 14 to 134 for landraces No. 4 and 49, respectively.

Genotypic scores are presented in Table 3. Based on allelic combination, landraces obtained scores of 4, 5, 6, 7 and 8. Landrace No. 45 with allelic combination of 5+10, 20, 1 and landrace No. 10 with 5+10, 6+8 and 2*, and landraces No. 48 and 49 with 2+12, 13+16, 2* and 2+12, 7+8, 2*,

and *cv*. Chamran with 5+10, 7, and 2* allelic combination, obtained higher genotypic scores (Table 3 and Fig. 4). At Glu-A1 locus, 82%, 14% and 4% of landraces had null, 2* and 1 alleles, respectively. While at Glu-B1 locus, the highest and lowest allelic frequencies were observed for 7+8 (56%) and 13+16 (2%) alleles, respectively. However, at Glu-D1, 5+10, 3+12, 2+12 and 2***+12' had frequencies of 14%, 6%, 74% and 2%, respectively (Table 4).

Table 1. Origin an accession No. for 49 Iranian wheat landraces

Landrace No.	Accession No.	Origin	Landrace No.	Accession No.	Origin
1	374	Saheb Moghan	26	4186	Mashhad
2	4100	Mashhad	27	4188	Mashhad
3	4107	Mashhad	28	4191	Mashhad
4	4114	Mashhad	29	4192	Mashhad
5	4116	Mashhad	30	4196	Mashhad
6	4117	Mashhad	31	4197	Mashhad
7	4118	Mashhad	32	4201	Mashhad
8	4119	Mashhad	33	4202	Mashhad
9	3120	Mashhad	34	4205	Mashhad
10	4121	Mashhad	35	4206	Mashhad
11	4124	Mashhad	36	4207	Mashhad
12	4125	Mashhad	37	4209	Mashhad
13	4129	Mashhad	38	4227	Mashhad
14	4130	Mashhad	39	4228	Mashhad
15	4132	Mashhad	40	4232	Mashhad
16	4134	Mashhad	41	4234	Mashhad
17	4135	Mashhad	42	4237	Mashhad
18	4137	Mashhad	43	4240	Mashhad
19	4140	Mashhad	44	4250	Mashhad
20	4163	Mashhad	45	4254	Mashhad
21	4176	Mashhad	46	4703	Khalkhal
22	4180	Mashhad	47	4704	Khalkhal
23	4181	Mashhad	48	4974	Unknown
24	4183	Mashhad	49	4975	Unknown
25	4184	Mashhad	50	Chamran	CIMMYT

Table 2. Summary of analysis of variance for some grain quality related traits in Iranian wheat landraces

S. O. V.	d.f.	Traits					
		Protein (%)	Zeleny No.	Bread volume	Water absorption	SDS	Grain HI
Replication	1	0.04	10.24	21.159	0.072	27.040	0.040
Block(adj.)	8	0.277	2.885	2410.570	0.474	13.626	0.537
Landrace	49	0.523	3.351	5127.004	1.291*	32.265	3.440
Landrace (adj.)	49	0.433	3.390	4490.369	1.063	31.294	3.149
Residual	41	0.495	4.918	4427.254	0.700	35.730	3.747

*: Significant at the 5% of probability level.

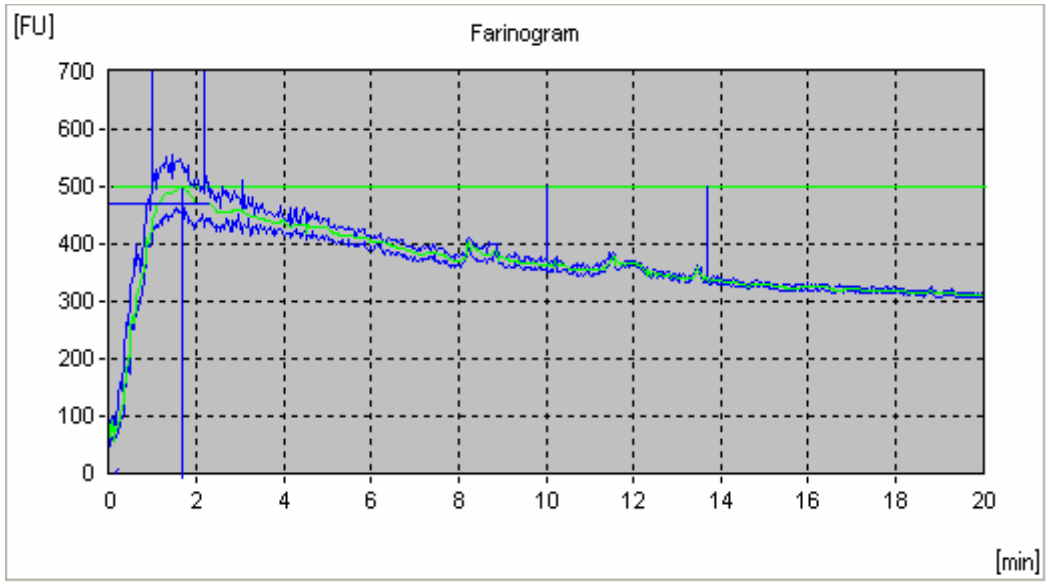

Fig. 1. Farinogram for *cv.* Chamran.

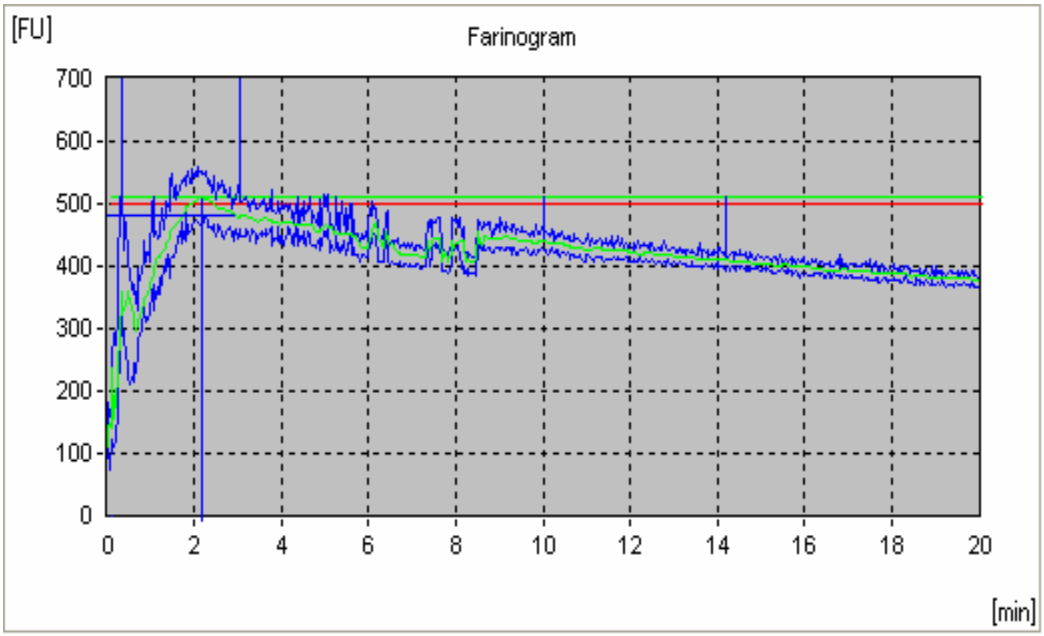

Fig. 2. Farinogram for landrace No. 4.

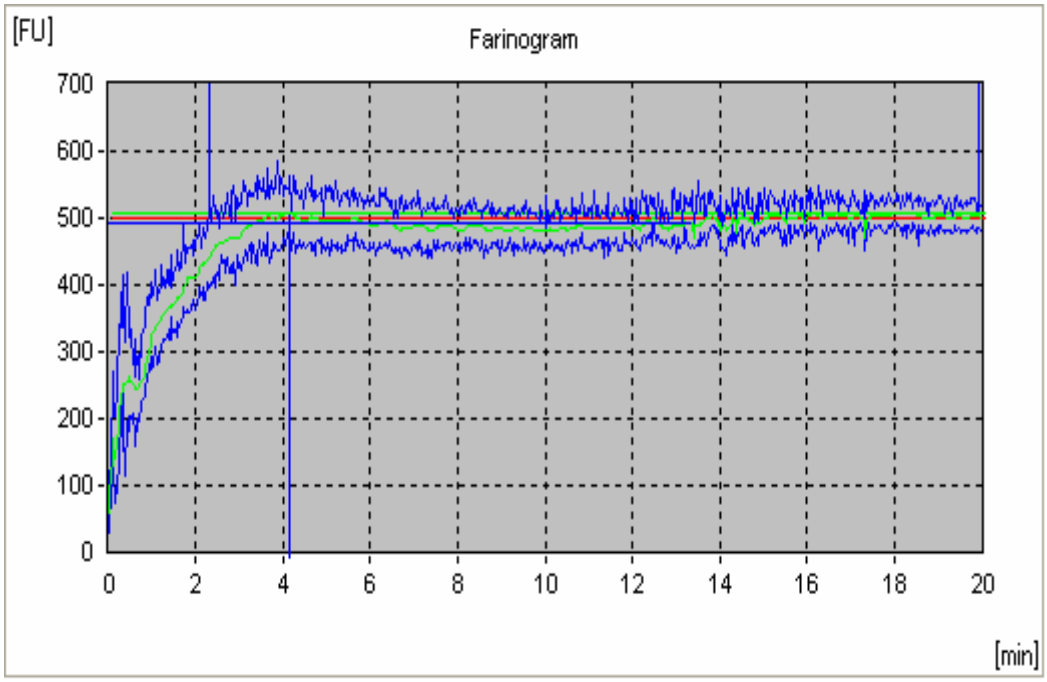

Fig. 3: Farinogram for landrace No. 49.

Table 3. Allelic combination and genotypic scores based on high molecular weight glutenin sub-units for 49 Iranian wheat landraces.

Landrace No.	Glu-A_1	Glu-B_1	Glu-D_1	Genotypic Score	Landrace No.	Glu-A_1	Glu-B_1	Glu-D_1	Genotypic Score
1	N	7	-	-	26	N	7+8	2***+12'	-
2	N	7+8	3+12	6	27	2*	7+9	2+12	7
3	N	7+8	2+12	6	28	N	7+8	2+12	6
4	N	14+15	5+10	7	29	1	6+8	2+12	6
5	N	7+8	2+12	6	30	N	17+18	2+12	6
6	N	6+8	2+12	4	31	2*	17+18	-	-
7	N	7+8	2+12	6	32	N	7+9	5+10	7
8	N	6+8	2+12	4	33	N	7+8	2+12	6
9	N	7+8	2+12	6	34	2*	6+8	2+12	6
10	2*	6+8	5+10	8	35	N	7+9	5+10	7
11	N	7+8	2+12	6	36	N	7+8	2+12	6
12	N	7+8	2+12	6	37	N	7+8	2+12	6
13	N	7+8	2+12	6	38	N	7+8	2+12	6
14	N	7+8	2+12	6	39	N	7+8	3+12	6
15	N	7+8	3+12	6	40	N	7+8	2+12	6
16	N	7+8	2+12	6	41	N	7+8	2+12	6
17	N	7+8	2+12	6	42	N	20	2+12	4
18	N	7+8	2+12	6	43	N	14+15	5+10	7
19	N	6+8	2+12	4	44	N	7+8	2+12	6
20	N	7+8	2+12	6	45	1	20	5+10	8
21	N	14+15	2+12	5	46	N	7+8	2+12	6
22	N	6+8	2+12	4	47	N	7+8	2+12	6
23	N	7+9	2+12	5	48	2*	13+16	2+12	8
24	N	7+8	2+12	6	49	2*	7+8	2+12	8
25	N	7+9	2+12	5	Chamran	2*	7	5+10	8

Analysis of variance of three gene loci for quality related traits showed that the effect of Glu-A_1 was only significant (P<010) on SDS sedimentation (Table 5). Mean comparisons revealed that for SDS sedimentation and % water absorption the role of null, 1 and 2* sub-units were significant as the role of allele 1 on SDS sedimentation and allele 2* on % water absorption was greater than the other alleles. In this study there was not considerable variation in protein content among landraces which implies similar contributions of alleles in this gene locus for baking quality related traits. Effect of Glu-B_1 was only significant on protein content, bread volume, SDS sedimentation, farinograph quality and softening of dough after 12 minutes (Table 5). Mean comparisons also indicated that for protein content 13+16 sub-units had the greatest contribution. This is in agreement with other researches who stated that in Glu-B_1 gene locus, 7+8 sub-units had greater contribution in comparison to 17+18 sub-units, and 13+16 sub-units had more significant contribution, in comparison to 7+9

sub-units, to baking quality related traits (Carrillo *et al.*, 1990) There were significant differences in farinograph related characteristics including; duration of dough development. Sub-units 13+16 had the greatest where 17+18 sub-units had the least contributions.

Effect of Glu-D_1 was only significant on % water absorption and grain hardness index (Table 5). There were not significant differences in farinograph related characteristics including; duration of dough development, dough stability and softening of dough after 12 minutes. Sub-units of this gene locus including; 2+12, 2***+12', 3+12 and 5+10 were not significantly different and grouped together. Sub- units 2***+12' had the least where 2+12, 3+12 and 5+10 sub-units had the greatest contributions.

Cluster analysis

Clustering of landraces by Jaccard method showed that there are three distinct groups (Fig. 5). In the first group there were 40 landraces including null sub-units in Glu-A_1, and 7, 7+8, 6+8, 20, 14+15, 7+9 sub-units in Glu-B_1 and 3+12, 2+12, 5+10 and 2***+12' in Glu-D_1. Landraces No. 1 and 31 had no score, because they are durum wheat, landraces No. 4 and 32 with score 7 and the remaining with scores of 4 and 6 (Table 4). Considering the origin of landraces the landrace No. 1 is from Saheb Moghan, Landraces No. 46 and 47 from Khalkhal, landraces 48 and 49 unknown, cv. Chamran from CIMMYT, Mexico, and the remaining landraces are from Mashhad (Table 1). In the second group there were 9 landraces including; Null, 1, 2* sub-units in Glu-A_1, 7+8, 6+8, 17+18, 7+9, and 7 sub-units in Glu-B_1, and 2+12 and 5+10 sub-units in Glu-D_1. Landraces No. 10, 48, 49 and *cv*. Chamran had score of 8, landrace No. 26 had no score, and the remaining landraces had scores of 6 and 7 (Table 4). Landraces No. 48 and 49 from unknown origin and the remaining landraces are from Mashhad (Table 1). In the third group there was only one landrace including 1 sub-unit in Glu-A_1, 20 sub-unit in Glu-B_1, and 5+10 sub-units in Glu-D_1 with score of 8 (Table 4). The origin of this landrace is also Mashhad.

Table 4. Frequency of high molecular weight glutenin sub-units of 49 Iranian wheat landraces

	Glu-A1			**Glu-B1**						**Glu-D1**				
	sub-units													
	Null	2*	1	7	7+8	6+8	14+15	7+9	17+18	13+16	20	5+10	3+12	2+12	2***+12'
Freq. (%)	82	14	4	4	56	14	6	10	4	2	4	14	6	74	2

Table 5. Summary of analysis of variance for quality traits in three gene loci

S.O.V	**d.f.**	**Traits**										
		Protein %	**Zel. No.**	**B. Volume**	**SDS**	**Water Abs.**	**Grain HI**	**Dough Develop.**	**Dough Stability**	**Soft. 10 min**	**Soft. 12 min**	**Far. Score**
$GLU\text{-}A_1$	2	0.982	1.154	2246.2	120.3**	0.975	0.56	0.56	0.775	32.14	1349.2	2936.1
$GLU\text{-}B_1$	7	1.715**	15.42	11279.9**	119.1**	1.277	4.90	4.90	1.02	10.93	3698.4*	4286.4*
$GLU\text{-}D_1$	3	0.292	2.249	7671.9	38.9	4.08**	13.07**	13.07**	0.858	14.49	2831.6	3977.8

* and **: Significant at the 5% and 1% of probability levels, respectively.

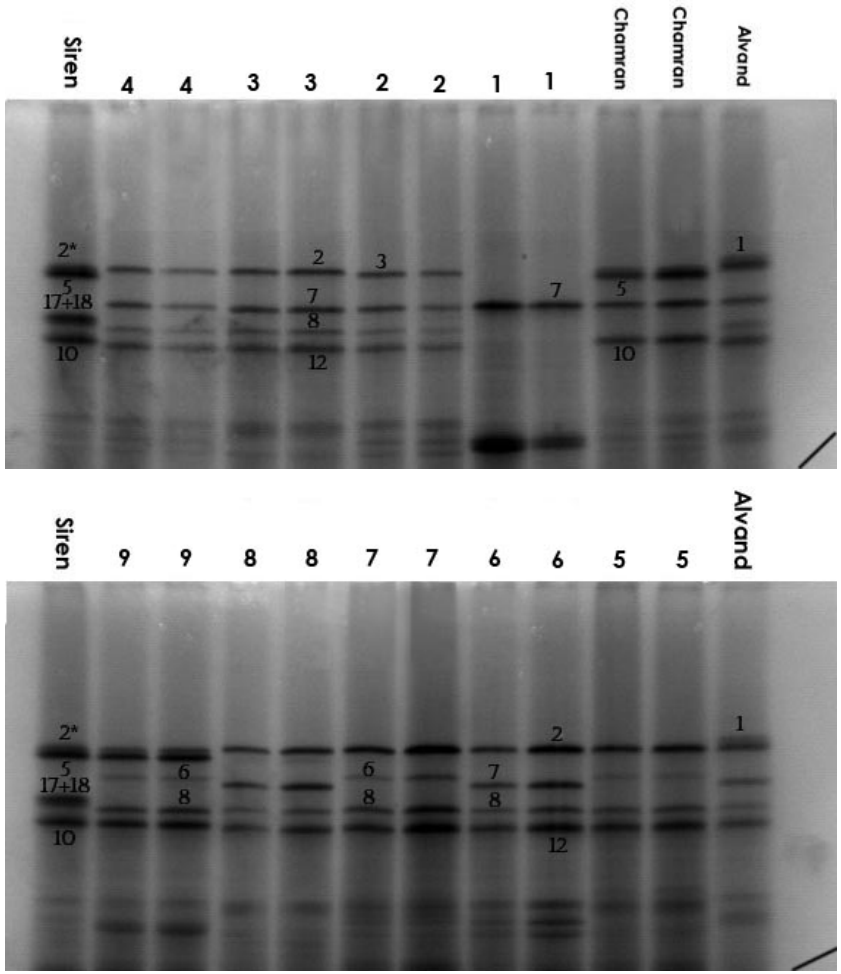

Fig. 4. High molecular weight glutenin sub-units of some Iranian wheat landraces (10% poly acrylamide gel)

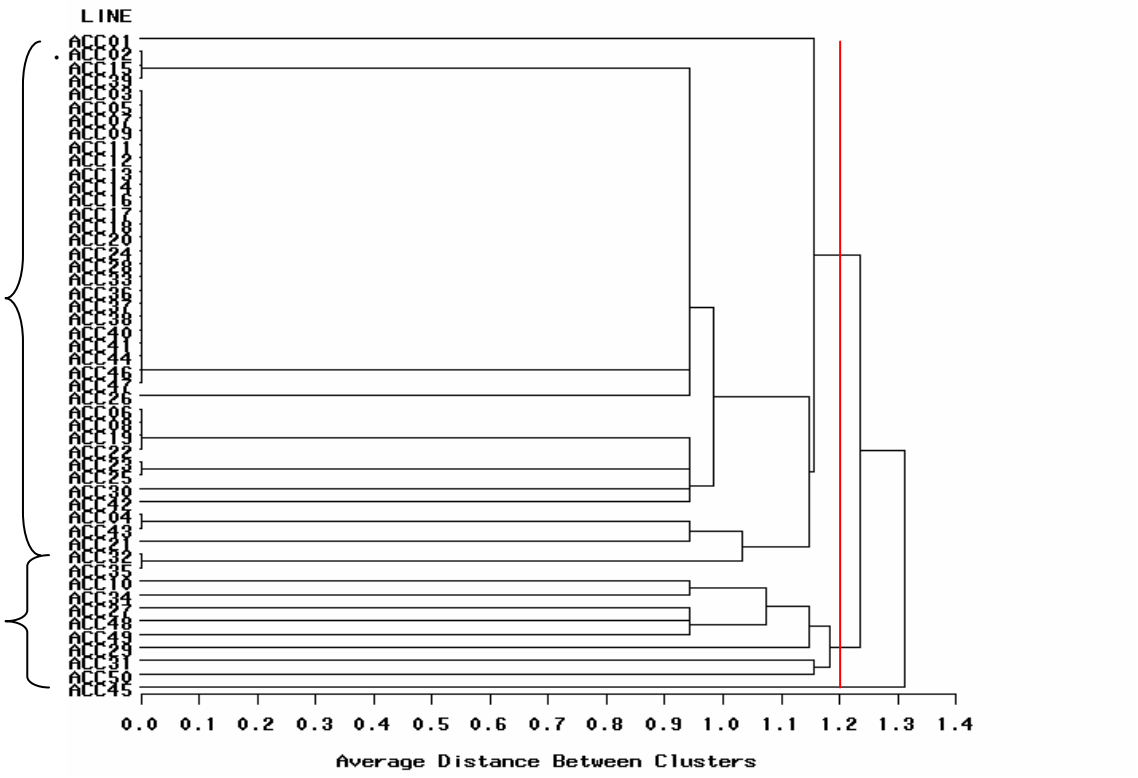

Fig. 5. Dendogram for 49 Iranian wheat landraces based on high molecular weight glutenin sub-units-using Jaccard method.

Results clearly showed that the 49 Iranian wheat landraces contain rare alleles such as 2***+12' that their impact on bread making quality needs further investigation. Considerable variations for baking quality related traits such as farinograph characteristics were also observed among bread wheat landraces. These variation for baking quality traits and properties in Iranian bread wheat landraces are potential sources to be used in bread wheat breeding programs for improvement of end-use quality.

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