

Effect of Salinity on Proteins in Some Wheat Cultivars

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Abstract: Two field experiments were carried out at the Agricultural Experimental Station of Desert Research Center, at Ras Sudr, South Sina Governorate during the winter seasons of 2006/2007 and 2007/2008 to study the effect of different salinity levels of irrigation water on proteins in some wheat cultivars. The experiment included two saline irrigation water [S1=4480 (moderate level) and S2=8614 ppm (high level) well water used for irrigation in Ras Sudr] and four wheat cultivars (Sakha93, Gimeza7, Gimeza10 and Giza168). Also, the same wheat cultivars grown under Nile Valley and irrigated with water [S0=512 ppm (low level)]. The obtained results show that total protein recorded increment under moderate level of salinity for all studied wheat cultivars as compared with the low level. In this regard, Sakha93 recorded the highest value of total protein under moderate level of salinity. On the other hand, high level of salinity had a negative effect on total protein content for all studied wheat cultivars except Sakha93. Data showed that Sakha93 and Gimeza7 exceeded Gimeza10 and Giza168 in soluble protein under moderate level of salinity. Gliadin, glutenin and gluten in grains of Sakha93 were increased under moderate and high salinity levels. The same cultivar produced the highest value of gliadin, glutenin and gluten under moderate level of salinity. Also, such contents in grains of Gimeza7 were accumulated under the same level of salinity. On the other hand, salinity had a negative effect on protein fractions in grains of Giza168. Separation of proteins in grains of four wheat cultivars by SDS-PAGE showed that, no detectable change on number of bands among salinity treated plants. In addition, there was detectable change in band intensities for wheat cultivars grown under salinity stress. In this regard, Sakha 93 and Gimeza 7 resolved into 27 bands, while Gimeza10 and Giza168 resolved into 24 bands. Also, data cleared that the molecular weight of protein sub units ranged between 21 to 95 kDa. Otherwise, the increase of band intensities in addition to the other obtained results may be a part of metabolic adjustment modifications in response to salinity treatment in addition to genetic background interaction. The predominant essential amino acid in grains of all wheat cultivars is leucine followed by phenylalanine and valine. These amino acids were increased under moderate level of salinity for all studied wheat cultivars as compared with the low level. Such contents in grains of Sakha93 took the same trend under high salinity level. The main amino acid is glutamic acid for all studied wheat cultivars, followed by proline. In this regard, there was increment in such contents for Sakha93 and Gimeza7 under moderate and high salinity levels as compared with the low level. Farinograph was used to determine some parameters of flours as related to protein quality. Sakha93 had the highest value of water absorption percent (74.5%) and dough stability (5.0 min) under moderate level of salinity. While, the dough tolerance index and dough weakening index were decreased under the same level of salinity. The dough stability increased for sakha93 as the protein content increased as a result of moderate level of salinity. This gave also a good indication of its quality. Meanwhile, Gimeza 10 had the minimum dough stability (2.0 min) under moderate and high levels of salinity.

Key words: Wheat, salinity, protein fractions, amino acids, rheological properties and quality parameters.

INTRODUCTION

The new goals of the Egyptian agricultural policy are to increase the local wheat production through the expansion of the cultivated wheat area in the newly reclaimed lands to offset the gap between the production and consumption. The most new lands in Egypt are subject to salinity stress such as Wadi Sudr in south of Sinia. The rainfall or the existing fresh water in this region is limited. So, irrigation in this region depends

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mostly on under ground water. Also, the soil of Wadi Sudr showed to be saline and highly calcareous. Salinity is known to influence morphological, physiological and biochemical changes in plants, which results on overall performance of the plant (Khan *et al.*, 2008).

Wheat is one of the three major cereals dominating world agriculture to date. Grain protein is a major contributor to the nutritional quality of wheat. Quality characteristics have been found largely be influenced by an interaction between the quality and quantity of the different protein subunits (Wrigley *et al.*, 1998). The importance of wheat is attributed to the gluten storage proteins present in the endosperm, conferring unique viscoelastic properties to dough (Shewry *et al.*, 1997). Gluten storage proteins divided into two major classes: gliadins that confer extensibility and glutenins that bestow elasticity. In this regard, the gluten complex has elasticity and flow properties of unique value for the baking of bread and other products.

Regarding to salt stress effect on proteins in wheat grains, Shen *et al.* (2007) found that protein content increased and protein accumulation amount decreased with increasing soil salt content. They also found that the contents of various components of protein increased with soil salt content. Moreover, the ratios of albumin, globulin and glutenin contents to protein decreased and the ratio of gliadin to protein increased with increasing soil salinity. Also, Khan *et al.* (2008) showed that salinity increased protein content of wheat grains and the gluten content of salt tolerant varieties was higher than that of salt sensitive varieties. In this concern, Zhang *et al.* (2007) indicated that genotype, environment, and genotype-by-environment interaction affected most of quality traits and amount of protein fractions. They also reported that the quantity of glutenin, HMW-GS, and LMW-GS were highly and correlated with dough strength-related traits such as farinograph development time and stability. The objectives of this study were to:

- Examine the influence of different salinity levels of irrigation water on macro composition of wheat cultivars, protein fractions, electrophoretic analysis and amino acids composition.
- Determine quality parameters using Farinograph.

MATERIALS AND METHODS

Two field experiments were conducted at Agricultural Experimental Station of Desert Research Center at Ras Sudr, South Sinai Governorate in 2006/2007 and 2007/2008 seasons. Grains of the four wheat cultivars (Sakha93, Gimeza7, Gimeza10 and Giza168) were obtained from Agricultural Research center, Giza, Egypt. Wheat grains were sown on November 18th to study the effect of salinity on proteins in wheat grains. The experiment included two saline irrigation water [S1=4480 (moderate level) and S2=8614 ppm (high level)] well water used for irrigation in Ras Sudr] and four wheat cultivars. Also, the same wheat cultivars grown under Nile Valley and irrigated with water [S0=512 ppm (low level)]. Chemical analysis of irrigation water is shown in Table (1). The samples (grains) were taken after harvesting. Grains of cultivated genotypes were tested for proteins fractions, minerals, ash, electrophoretic pattern of proteins, amino acids and rheological properties.

Table 1: The chemical analysis of irrigation water.

Salinity levels	EC dS/m	ppm	pH	Cations (meq/L)				Anions (meq/L)			
				Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	CO ⁼	HCO ⁻	Cl ⁻	SO ⁴⁼
S0	0.80	512	7.0	1.48	1.47	4.5	0.10	----	2.00	2.67	2.83
S1 (Well 1)	7.00	4480	7.1	12.51	8.19	45.46	0.201	----	2.02	36.58	27.14
S2 (Well 2)	13.46	8614	7.3	32.41	16.35	79.11	0.415	----	3.62	69.13	55.03

Chemical analysis:

Determination of moisture:

The moisture was determined as recommended by A.O.A.C. (1980).

Determination of total nitrogen and crude protein:

The total nitrogen was determined in dried sample using micro Kjeldahl method described in A.A.C.C. (1994). The total protein content was calculated as N x 5.7.

Determination of soluble protein:

Soluble protein content was determined according to Khan *et al.* (1989).

Determination of non-soluble protein:

The non-soluble protein was calculated by subtracting the amount of soluble protein from the total protein content.

Determination of minerals:

Potassium content was determined using flame photometer model Perkin-Elmer PFP7 according to Allen (1974). Phosphorus was determined according to Murphy and Riley (1962). Manganese and zinc contents were determined by Atomic Absorption according to Cook (1997).

Determination of ash:

Ash content of wheat grains was determined according to A.A.C.C. (1994).

Determination of protein fractions:

The extraction procedure is the original Osborne-Mendel method which described by Sharobeem *et al.* (1986). Protein content was determined in a definite volume for every supernatant fraction by Kjeldahl method according in A.A.C.C. (1994).

SDS-PAGE of protein in grains:

Sodium dodecylsulphate polyacrylamide gel electrophoresis for total protein extracted from wheat grains was performed on vertical slab using Biogene Limited Apparatus according to the method of Laemmli (1970) and as modified by Studier (1973).

Quantitative determination of total amino acids:

Total amino acids composition for wheat grains hydrolysate was determined by amino acid analyzer apparatus model (Eppendorf LC 3000). Hydrolysis was carried out according to the method of Richard *et al.* (1978).

Rheological characteristics:

The rheological assessment of different dough samples was carried out by using farinograph test [Egyptian Baking Technology Center (E.B.T.C)] according to the method of A.A.C.C. (1994). A Brabender farinograph was used to determine the water absorption, whereas three hundred grams of tested samples (14% moisture) were placed in the bowl of the apparatus, sufficient water was added so that the dough consistency was such that the curve centered on the 500 Brabender unit line at the point of maximum development. The following readings were taken from farinograms: water absorption, mixing time, dough stability, dough tolerance index and dough weakening index.

RESULTS AND DISCUSSION

Effect of salinity on chemical composition in grains of four wheat cultivars:

Data listed in Table (2) showed the effect of different salinity levels on total protein in grains of four wheat cultivars. Results recorded increment in total protein under moderate level of salinity for all studied wheat cultivars as compared with the low level. Also, there was a slight increment in such content for Sakha93 under high level of salinity. Also, Sakha93 recorded the highest value of total protein under moderate level of salinity. These results are in agreement with those recorded by Al-Bana (1999), Bahmaniar (2006), Shen *et al.* (2007) and Khan *et al.* (2008) on some wheat cultivars. On the other hand, high level of salinity had a negative effect on total protein content for all studied wheat cultivars except Sakha93. Regarding the effect of salinity levels on soluble protein, data showed that it was increased in Sakha93, Gimeza7 and Gimeza10 under moderate level of salinity. In addition, Sakha93 and Gimeza7 exceeded Gimeza10 and Giza168 in soluble protein under moderate level of salinity. Data in the same table showed that non-soluble protein was increased for all studied wheat cultivars except Gimeza10 under moderate and high levels of salinity.

Regarding ash content, data showed that salinity affected negatively on Sakha93, Gimeza7 and Giza168, and positively on Gimeza10. In this connection, Nakatsu *et al.* (2006) found that ash content in wheat grains was highly correlated with the phosphorus content. Results in the same table indicated that the amount of potassium was found to be different from cultivar to another. In this respect, potassium content was decreased in sakha93 and Gimeza 7 under moderate and high levels of salinity. Also, the same trend was true for Giza168 under high level. In this regard, the differences of potassium concentration between wheat cultivars were noticed by Elsikhry and Ali (1999). Also, the reduction effect of salinity on potassium concentration has been reported by Ahmed (1997), Mehdi *et al.* (2002), Sharma *et al.* (2005) and Nabipour *et al.* (2007) on some wheat cultivars. In addition, Nabipour *et al.* (2007) showed that high sodium concentration strongly induced a reduction in K grain.

It is obvious from the results that, salinity affected negatively on phosphorus content. There was decreased in phosphorus content for Sakha93 and Gimeza10 under moderate and high levels of salinity as compared with the low level. This was true for Giza168 and Gimeza7 under moderate and high salinity level, respectively. Data of phosphorus concentration obtained as a result of salinity in this study are in agreement with those

recorded by Ahmed (1997), Hasani *et al.* (1995), Al-Bana (1999), Mehdi *et al.* (2002) and Sharma *et al.* (2005). On the other hand, Hu and Schmidhalter (1997) indicated that phosphorus concentration in grains of wheat was not affected by salinity. As to the effect of salinity on the concentrations of Mn and Zn in wheat grains under Ras Sudr conditions. Data showed that Mn content was accumulated in grains of Gimeza7, Gimeza10 and Giza168 under moderate and high salinity levels. Also, salinity affected positively on Zn content for all studied wheat cultivars. Generally, concentration of Mn and Zn of wheat grains increased with salinity, this leads to a probable suggestion for mobility of these ions from the plant tissues to grains by salinity action. The increases of Mn and Zn as result of salinity are in agreement with those recorded by Sekina *et al.* (1993) and Ahmed (1997). On the other hand, Hu and Schmidhalter (2001) suggested that the micronutrient concentration in wheat plants is probably not much affected by salinity.

Effect of salinity on protein fractions in grains of four wheat cultivars:

In Table (3) are given the percents of gliadin, glutenin and gluten as percent of total protein content. It is evident that gliadin and glutenin are the main components of wheat proteins, both of them constituting together the gluten. The effect of salinity levels on gliadin, glutenin and gluten in grains of wheat cultivars can be deduced from tabulated data in the same table. The results showed that the amounts of gliadin, glutenin and gluten were found to be different from cultivar to another. Gliadin, glutenin and gluten in grains of Sakha93 were increased under moderate and high salinity levels as compared with the low level. In this regard, Shaka93 produced the highest value of gliadin, glutenin and gluten than all wheat cultivars under moderate level of salinity.

Recently, Khan *et al.* (2008) found that gluten content of salt tolerant wheat varieties was higher than that of salt sensitive wheat varieties. Also, Shen *et al.* (2007) indicated that the ratios of albumin, globulin and glutenin contents to protein in wheat grains decreased and the ratio of gliadin to protein increased with increasing soil salinity. In this respect, Zhang *et al.* (2007) indicated that genotype, environment, and genotype-by-environment interaction significantly affected most of quality traits and amount of protein fractions in wheat grains. Also, Katerji *et al.* (2005) showed that salinity had a slight positive effect on the grain quality of the Cham-1 variety, whereas the Haurani variety showed no salinity effect on grain quality.

Table 2: Chemical composition in grains of four wheat cultivars grown under different salinity levels.

Treatments	Chemical composition of wheat grains						Minerals content			
	Salinity levels	Moisture (%)	Total protein (g%) dry wt.	Soluble protein (g%) dry wt.	Non-soluble protein (g%) dry wt.	Ash (g%) dry wt.	Potassium (mg/100g) dry wt.	Phosphorous (mg/100g) dry wt.	Manganese (µg/g) dry wt.	Zinc (µg/g) dry wt.
Sakha 93	S0	11.22	12.94	5.57	7.37	2.11	450	242	22	32
	S1	12.15	13.88	6.23	7.65	1.92	400	231	22	37
	S2	10.17	13.00	5.13	7.87	1.80	410	200	18	33
Gimeza7	S0	11.78	11.89	5.98	5.91	2.20	400	224	18	31
	S1	11.51	12.34	6.31	6.03	2.08	360	235	23	35
	S2	12.01	11.40	5.23	6.17	1.81	340	196	19	35
Gimeza10	S0	11.89	11.75	4.66	7.09	1.88	390	235	20	36
	S1	10.91	12.21	5.32	6.89	1.89	390	221	24	40
	S2	11.75	10.84	4.35	6.49	2.17	410	213	29	46
Giza168	S0	12.11	13.15	5.91	7.24	2.23	350	237	19	34
	S1	12.20	13.38	5.60	7.78	2.19	380	201	22	35
	S2	11.51	12.90	5.42	7.48	1.91	300	248	25	40

-Mean values of two seasons, 2006/2007 and 2007/2008.

-S0 = 512 ppm (low level), S1 = 4480 ppm (moderate level), S2 = 8614 ppm (high level).

Table 3: Protein fractions in grains of four wheat cultivars grown under different salinity levels.

Treatments	Salinity levels	Total protein (g%) dry wt	Percentage of total protein			Gli/Glu*
			Gliadin	Glutenin	Gluten	
Sakha 93	S0	12.94	34.71	28.31	63.02	1.22 : 1
	S1	13.88	40.04	34.18	74.22	1.17 : 1
	S2	13.00	36.23	29.01	65.24	1.24 : 1
Gimeza7	S0	11.89	34.48	29.11	63.59	1.18 : 1
	S1	12.34	35.70	33.25	68.95	1.07 : 1
	S2	11.40	30.96	29.31	60.27	1.05 : 1
Gimeza10	S0	11.75	30.48	28.83	59.31	1.05 : 1
	S1	12.21	33.28	26.74	60.02	1.24 : 1
	S2	10.84	29.04	28.00	57.04	1.03 : 1
Giza168	S0	13.15	34.07	27.36	61.43	1.24 : 1
	S1	13.38	32.96	25.15	58.11	1.31 : 1
	S2	12.90	32.02	26.01	58.03	1.23 : 1

-Mean values of two seasons, 2006/2007 and 2007/2008.

-S0 = 512 ppm (low level), S1 = 4480 ppm (moderate level), S2 = 8614 ppm (high level)

*Gliadin:Glutenin.

In addition, gliadin, glutenin and gluten in grains of Gimeza7 were increased under moderate level of salinity. Also, there was a slight increment in glutenin for the same cultivar under high salinity level. In this

respect, results recorded a slight increment in gliadin and gluten for Gimeza10 under moderate level of salinity as compared with the low level. On the other hand, salinity had a negative effect on protein fractions in grains of Giza168. In this regard, Masouleh (2005) suggested that the glutenin (HMW) markers can still be used as a powerful and reliable tool for identification and prediction of important traits like grain quality. Also, Galterio *et al.* (1999) reported that the mean protein composition in wheat grains was 36% albumins/globulins, 35% gliadins and 29% glutenins.

Effect of salinity on the banding patterns of total proteins extracted from grains of four wheat cultivars:

SDS-polyacrylamide gel electrophoresis of total proteins extracted from grains of four wheat cultivars are shown and illustrated in Fig. (1) and Table (4). Data cleared that the molecular weight of protein sub-units ranged between 21 to 95 kDa. The more intensive band was presented at molecular mass 37 kDa. Also, the same table shows the homology in band intensity between the electrophoregrams of four wheat cultivars. The homologous band is labeled by double stars these bands are that having molecular weight 21, 26, 29, 31, 37, 40, 42, 56, 59, 60 and 67 kDa. Bands of molecular weight 52, 83 and 87 kDa are not presented in the samples of Gimeza 10 and Giza 168 under all salinity levels.

Data in Table (4) and Fig. (1) represent the effect of different salinity levels of irrigation water on number of bands and band intensities. Data show that no detectable change in number of bands among the salinity treated plants. In addition, there was detectable change in band intensities for all wheat cultivars grown under different salinity levels. In this regard, the increase in band intensities was at molecular mass 72,83,87,90 and 95 kDa for Sakha 93 under moderate and high levels of salinity as compared with the low level. This was true for the same cultivar at 63 and 64 kDa under high level of salinity. Also, Sakha93 showed increased in band intensities at molecular mass 34, 35 and 49 kDa under moderate level of salinity. Rathore *et al.* (2003) found that SDS-PAGE of the protein fractions for some wheat varieties showed high variation in the banding pattern. Concerning the effect of salinity levels of irrigation water on protein pattern in grains of Gimeza7, bands intensities were increased at molecular mass 61, 72, 83, 87 and 95 kDa after treatment with moderate and high levels of salinity as compared with low level. The same trend was true at 34, 35, 49 and 80 kDa for Gimeza7 under moderate level of salinity. Data showed that salinity had a positive effect on bands intensities for Gimeza10 at molecular mass 34, 35, 47, 63, 64, 72, 80, 90 and 95 kDa which had increment under moderate level of salinity. Also, under high level of salinity, the same cultivar showed increased in bands intensities at 45, 49, 72, 90 and 95 kDa.

The results showed that bands intensities for Giza168 at 63, 64, 72, 90 and 95 kDa were increased under moderate and high levels of salinity as compared with the low level. Such increment for the same cultivar was true at molecular mass 45, 47 and 80 kDa under moderate level of salinity. In this respect, Shuaib *et al.* (2007) concluded that seed storage protein profiles in wheat varieties by sodium dodecylsulphate polyacrylamide gel electrophoresis (SDS-PAGE) could be useful markers in the studies of genetic diversity and classification of adapted cultivars. Also, El-Akkad and El-Kariem (2002) used sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE) to characterize the differences between and within two species of wheat. They found that the densitometric profile data of the polypeptides showed variation in the number and position of bands from one cultivar to another.

Effect of salinity on amino acids composition of proteins in grains of four wheat cultivars:

Results in Table (5) indicate the amino acids composition in grains of four wheat cultivars after treatment by different salinity levels. Amino acids composition is an important feature in determining the nutritional value of wheat grain for human and animal diets.

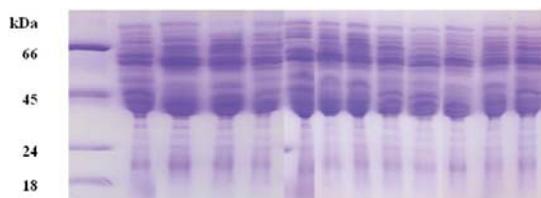
Essential amino acids:

The predominant essential amino acid in grains of all wheat cultivars is leucine followed by phenylalanine and valine. These amino acids were increased under moderate level of salinity for all studied wheat cultivars as compared with the low level. Such contents in grains of Sakha93 took the same trend under high salinity level. In this direction, Gimeza10 and Giza168 recorded increment in valine acid content under high level of salinity. On the other hand, methionine is present in low quantities comparing with other amino acids. It was increased in grains of Sakha93 and Gimeza7 after treatment by moderate and high salinity levels. The same trend was true for Gimeza10 and Giza 168 when plants treated by moderate salinity level as compared with the low level. Other essential amino acids i.e., threonine, isoleucine, tyrosine and lysine appeared to be decreased or increased with salinity and this depending on the interaction between wheat cultivars and salinity levels. In this connection, Acquistucci *et al.* (1995) on selected strains of diploid wheat and Beyer *et al.* (2008) on winter wheat grains showed that the essential amino acids in grains were threonine, cysteine, valine, methionine, isoleucine, leucine, tyrosine, phenyl alanine and lysine. Also, they found that methionine acid is presented in minute quantities.

Table 4: Molecular masses of different band spectra of total protein for grains of four wheat cultivars grown under different salinity levels.

Band number	Molecular weight (kDa)	Band intensity											
		Treatments											
		S2				S1				S0			
		Sakha 93	Gimeza 7	Gimeza 10	Giza 168	Sakha 93	Gimeza 7	Gimeza 10	Giza 168	Sakha 93	Gimeza 7	Gimeza 10	Giza 168
1	95	2	2	2	2	3	3	3	3	3	3	3	3
2	90	1	1	1	1	2	1	2	2	2	1	2	2
3	87	1	1	0	0	3	3	0	0	2	2	0	0
4	83	1	1	0	0	3	2	0	0	2	2	0	0
5	80	2	2	2	2	1	3	3	3	1	1	2	1
6	72	2	2	2	2	3	3	3	3	3	3	3	3
7	67	1	1	1	1	1	1	1	1	1	1	1	1**
8	64	1	2	3	2	1	2	4	3	2	2	3	3
9	63	1	2	3	2	1	2	4	3	2	2	3	3
10	61	4	2	3	2	3	3	3	2	3	3	3	2
11	60	4	4	4	4	4	4	4	4	4	4	4	4**
12	59	4	4	4	4	4	4	4	4	4	4	4	4**
13	56	4	4	4	4	4	4	4	4	4	4	4	4**
14	55	1	1	2	2	1	1	2	2	1	1	2	2
15	52	1	1	0	0	1	1	0	0	1	1	0	0
16	49	1	1	1	1	2	2	1	1	1	1	2	1
17	47	1	1	1	1	1	1	2	2	1	1	1	1
18	45	3	1	1	1	2	1	1	2	2	1	2	1
19	42	3	3	3	3	3	3	3	3	3	3	3	3**
20	40	2	2	2	2	2	2	2	2	2	2	2	2**
21	37	5	5	5	5	5	5	5	5	5	5	5	5**
22	35	3	3	3	3	4	4	4	3	3	3	3	3
23	34	3	3	3	3	4	4	4	3	3	3	3	3
24	31	1	1	1	1	1	1	1	1	1	1	1	1**
25	29	1	1	1	1	1	1	1	1	1	1	1	1**
26	26	1	1	1	1	1	1	1	1	1	1	1	1**
27	21	2	2	2	2	2	2	2	2	2	2	2	2**

5= very deep intensity, 4= deep intensity, 3= moderate deep intensity, 2=moderate intensity, 1= pale intensity and 0= no bands.** Homologous bands. S0=512 ppm (low level), S1= 4480 ppm (moderate level),S2=8614 ppm (high level)



Marker	S0				S1				S2			
	Sakha 93	Gimeza 7	Gimeza 10	Giza 168	Sakha 93	Gimeza 7	Gimeza 10	Giza 168	Sakha 93	Gimeza 7	Gimeza 10	Giza 168

Fig. 1: SDS-Polyacrylamide gel electrophoresis of total proteins for grains of four wheat cultivars grown under different salinity levels.

Table 5: Amino acids composition in grains of four wheat cultivars grown under different salinity levels.

Wheat cultivars	Salinity levels	Amino acids composition (mg/g dry wt)															
		Essential amino acids						Non-essential amino acids									
		Threonine	Valine	Methionine	Isoleucine	Leucine	Tyrosine	Phenyl alanine	Lysine	Aspartic	Serine	Glutamic	Proline	Glycine	Alanine	Histidine	Arginine
Sakha93	S0	3.42	4.41	1.29	3.97	6.48	1.93	4.94	2.93	5.87	4.58	16.69	3.99	4.51	6.07	2.69	3.17
	S1	3.07	4.56	1.59	4.80	8.34	4.25	7.66	2.67	5.45	4.71	17.02	9.65	4.58	5.83	3.32	2.62
	S2	2.93	4.70	1.34	4.43	7.84	3.09	5.26	2.55	5.11	4.22	16.71	8.95	6.39	2.94	3.07	2.81
Gimeza7	S0	3.29	5.24	0.72	3.86	6.64	1.69	4.29	2.71	4.81	4.30	15.14	4.48	6.40	3.59	3.13	3.63
	S1	3.24	5.77	1.31	4.40	8.59	3.86	6.60	2.63	5.73	4.75	16.41	9.79	6.05	3.74	3.21	3.67
	S2	2.53	3.32	0.91	2.71	6.14	1.32	3.84	2.31	4.25	3.91	17.01	8.99	3.40	3.37	2.06	3.41
Gimeza10	S0	2.63	3.61	0.89	3.45	6.01	1.25	4.61	1.87	4.79	3.96	16.04	8.93	4.85	3.61	2.55	2.69
	S1	2.87	4.55	0.98	4.32	8.35	1.76	4.80	2.31	5.17	4.26	14.98	9.56	10.09	2.04	3.01	2.56
	S2	3.10	4.71	0.64	3.62	5.89	1.61	3.85	2.41	4.93	4.07	15.11	4.28	7.10	3.14	2.81	2.80
Giza168	S0	2.94	3.96	1.07	3.50	6.36	1.13	4.20	2.83	5.27	4.43	16.44	8.98	4.30	6.80	2.82	2.88
	S1	2.94	4.51	1.20	4.15	7.47	2.61	5.03	2.41	5.35	4.18	14.17	8.98	8.35	2.76	3.04	2.78
	S2	2.81	5.84	0.65	2.92	5.82	1.65	4.10	2.24	5.98	3.83	15.61	4.09	7.78	3.01	2.66	2.64

S0= 512 ppm (low level) , S1= 4480 ppm (moderate level), S2= 8614 ppm (high level)

Non-essential amino acids:

Data revealed that the main amino acid is glutamic which ranged from 14.17 mg/g for Giza168 to 17.02 mg/g for Sakha93 under moderate level of salinity, followed by proline. In this regard, there was increment in such contents for Sakha93 and Gimeza7 under moderate and high salinity levels as compared with the low level. Also, Gimeza10 accumulated proline acid in grains under moderate salinity level. Acquistucci *et al.*, 1995 and Beyer *et al.*, 2008 showed that the main amino acids were glutamic and proline in wheat grains. In this connection, the content of acidic amino acid (glutamic) was mostly higher than other amino acids, possibly

due to their being precursors for synthesis of most amino acids (Amer, 1989). Also, Garcial del Moral *et al.* (2007) found significant variation of amino acids composition in grains of all durum wheat genotypes, with the exception of arginine and cysteine, the major changes in amino acids composition were caused by environmental conditions.

Concerning histidine acid content, it was increased in all wheat cultivars after treatment by moderate salinity level. Also, Sakha93 and Gimeza 10 took the same trend under high salinity level. In this regard, histidine being possibly a potential precursor for glucose (Stryer, 1988) which was pointed out by Muralitharan *et al.* (1993) to be significantly increased with NaCl salinity. Arginine acid content was decreased in grains of Sakha93 and Giza168 under moderate and high salinity levels. Also, this was true for Gimeza10 and Gimeza7 under moderate and high level of salinity, respectively. In this respect, arginine was reported to be degraded to proline, through synthesis of ornithine which may be reversibly converted to glutamic semialdehyde considered to produce proline as a result of higher activity of pyrroline 5 carboxylic enzyme under NaCl stress (Studhakar *et al.*, 1993). In addition, other non-essential amino acids such as aspartic, serine, glycine and alanine were found in moderate quantities and different from cultivar to another, this depending on the interaction between wheat cultivars and salinity levels.

Effect of salinity on quality parameters in flours of four wheat cultivars:

Rheological behavior of dough prepared from flours of wheat cultivars on the farinograph apparatus is shown in Table (6). Farinograph was used to determine some parameters of flours as related to protein quality. The Farinograph parameters namely water absorption, mixing time, dough stability, dough tolerance index and dough weakening index.

The effect of different salinity levels of irrigation water on quality parameters for Sakha93 using farinograph is presented in the same table. The results indicated that Sakha93 had the highest value of water absorption percent (74.5%) and dough stability (5.0 min) under moderate level of salinity as compared with the low level. While, the dough tolerance index and dough weakening index for Sakha93 were decreased under the same level of salinity. Also, Sakha93 showed a slight increment in dough stability under high level of salinity, and this correlated with decreased in dough tolerance index and dough weakening index under the same conditions. In this respect, dough stability is an important index for flour strength which is based on the quality and quantity of dough protein that could capture sufficient amounts of produced gas during fermentation. Consequently the strength depends on the actual number of protein or gluten particles per unit of dough, and the efficiency of protein particles to swell by hydration. El-Farra *et al.* (1982) reported that dough stability in minutes is the most important index for dough strength. In this regard, Huang and Khan (1997a) showed that the total qualities of HMW glutenin subunits played an important role in determining the dough mixing strength and bread-making performance of hard red spring wheat. Also, Kelman and Qualset (1993) suggested that saline irrigation may affect end-use quality. They found that wheat flour quality and baking performance were improved by saline irrigation in the first year, but in the second year, when grain filling was poor, quality was adversely affected by salinity. In addition, Zhang *et al.* (2007) indicated that the quantity of glutenin, HMW-GS, and LMW-GS were highly and significantly correlated with dough strength-related traits such as farinograph development time and stability.

Table 6: Farinograph parameters for flours of four wheat cultivars grown under different salinity levels.

Treatments		Farinograph parameters				
Wheat cultivars	Salinity levels	Water absorption %	Mixing time (min)	Dough stability (min)	Dough tolerance index(B.U)	Dough weakening index (B.U)
Sakha 93	S0	74.1	3.5	4.0	80	100
	S1	74.5	1.0	5.0	60	70
	S2	72.6	4.5	4.5	60	60
Gimeza7	S0	62.3	3.0	2.5	100	110
	S1	68.8	3.5	3.0	80	100
	S2	64.0	3.0	2.0	110	120
Gimeza10	S0	70.4	3.5	3.5	100	120
	S1	67.0	3.0	2.0	100	130
	S2	68.0	3.5	2.0	100	120
Giza168	S0	71.3	3.0	3.0	100	110
	S1	71.1	3.0	2.5	100	130
	S2	70.8	3.0	2.5	100	120

-S0= 512 ppm (low level), S1= 4480 ppm (moderate level), S2= 8614 ppm (high level) - (B.U) =Brabender unit.

Also, the obtained data show that water absorption and dough stability for flour of Gimeza7 were increased under moderate level of salinity as compared with the low level. In contrast, dough tolerance index and dough weakening index took the reverse effect for the same cultivar under the same condition of salinity. Huang and Khan (1997b) indicated that functionalities and aggregation properties of individual HMW glutenin subunits of hard red spring wheat may depend mainly on their molecular weights.

On the other hand, Gimeza 10 had the minimum dough stability (2.0 min) under moderate and high levels of salinity. In this connection, salinity had a negative effect on water absorption and dough stability for flour of Giza 168 as compared with the low level. In addition, Yanaka *et al.* (2007) found that weakness of the dough produced from soft wheat, resulting from low protein content and poor protein quality.

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