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Comparative Studies of Some *Triticum* Species by Grain Protein and Amino Acids Analyses

[1]A.E. Hassan, [2]S. Heneidak and [1]S.M.H. Gowayed
[1]Department of Agricultural Botany, Faculty of Agriculture, Suez Canal University, Egypt
[2]Department of Biological Sciences, Suez Faculty of Education, Suez Canal University, Egypt

Abstract: The mature grains of two Egyptian and six imported *Triticum* species were analyzed for protein patterns, total protein and amino acids content to characterize the variations between them. The data showed twenty two bands of total proteins with an obvious variation in the number and position of bands from one species to another. The highest numbers of proteins bands were recorded in *T. paleocolchicum* (18 bands) whereas, the lowest ones in *T. durum* (12 bands). The eight examined *Triticum* species share nine bands (6, 13, 16, 19, 20 and 21), while there were also some bands which characterize each species. The band (10) is characteristic for *T. paleocolchicum* and the band (12) for *T. dicoccoides*. Cladistic analysis support the delimitation of studied species in the two subgenera Triticum and Boeoticum. A high degree of similarity (94%) was observed between *T. aestivum* and *T. spelta*. Total protein of the grains varied from a minimum of 9.3% in *T. aestivum* to a maximum of 14.8% in *T. dicoccoides*. Most amino acids showed a significant variation between the examined *Triticum* species and all essential amino acids compared well with FAO/WHO reference pattern. The nutritional quality of proteins as measured by their essential amino acids chemical scores ranged from 14.29% for tyrosine in *T. spelta* grain protein to 239.29% for isoleucine in *T. durum* grain protein. Most essential amino acid of grain protein in *T. aestivum* and *T. dicoccoides* record higher values than the FAO/WHO (1990) recommended pattern. All the studied *Triticum* species had high content from the non-essential amino acids, particularly glutamic acid that had the greatest proportion ranging from 24.86 g/100 g protein in *T. dicoccoides* to 36.13 g/100 g protein in *T. spelta*. The six studied *Triticum* species imported from outside Egypt had pronounced total protein and amino acids content and consistent the most suitable condition for growing under Ismailia conditions.

Key words: Amino acids, electrophoresis, poaceae, protein patterns, total protein, *Triticum*

INTRODUCTION

Wheat is most important temperate cereals (17000 cultivars) of complex ancestry involving closely allied *Aegilops* species (Mabberley, 1997). Five *Triticum* species were distinguished by Boulos (2005) from Egypt (*T. aestivum*, *T. durum*, *T. dicoccum*, *T. pyramidale* and *T. turgidum*). He also mentioned that the wheat is one of the most important cereal crops grown successfully in Egypt for the grains using principally as flours.

Galili and Feldman (1983 and 1985) observed twenty one discrete bands in *T. aestivum* and *T. durum* and considered that *Triticum* species were rich source of glutenins and gliadins which have proved to be important for technological properties. Ciaffi *et al.* (1993) mentioned that the endosperm proteins of *T. dicoccoides* of two classes proteins; gliadin and glutenin, which have a good deal in determining the nutritional and technological properties. El-Akkad (1998) studied the protein electrophoresis of two cultivars of *T. aestivum* and noticed distinct variation between them. In the same time, Hassan and Eid (1998) examined the protein patterns of *T. aestivum* and *T. durum* and *Triticale* genotypes and found that glutenins, gliadins and subunits of these proteins bands were varied among wheat and *Triticale* genotypes. Tarekegne *et al.* (2000) identified Ethiopian wheat cultivars by grain protein electrophoresis on the basis of gliadins and glutenin subunit banding patterns, which were unique for all cultivars and distinguish between them. El-Akkad and El-Abd El-Kariem (2002) studied the protein patterns of 12 cultivars of *T. aestivum* and *T. durum* and found obvious variation in the number and position of the protein bands.

Concerning the protein content, Ciaffi *et al.* (1992) found that the variation in *T. dicoccoides* protein content was large, ranging from 16-27%, compared to diploid wheat (20-28%), confirming the finding that wild wheat relatives have a wider range of variation for grain protein

Corresponding Author: Dr. Samia Heneidak, Department of Biological Sciences, Suez Faculty of Education, Suez Canal University, Suez, Egypt

content than cultivated ones. Borghi *et al.* (1996) studied twenty-five *T. monococcum* lines and found that the protein content of these lines ranged from 13.2 to 22.8% higher than those found for bread wheat which ranged from 10.8 to 13.3%. Mesfin *et al.* (2000) studied the suitability of *Triticum aestivum* for many food products depends on its grain protein content. Oliveira (2001) studied *T. dicoccum* and *T. spelta* to obtain information about their agronomical and grain quality characteristics and found that their protein content was higher in the cultivars. In addition, Bramble *et al.* (2002) studied the protein variance structure in *Triticum aestivum* to quantify the variation of protein structure.

As regard to the amino acids, Molino *et al.* (1988 and 1989) isolated the amino acids from the grains of three *Triticum aestivum* varieties and found that they had the greatest proportion of glutamic acid. Nevo and Beiles (1992) showed the highest values of lysine and isoleucine contents in *Triticum dicoccoides* compared to other studied species of wild wheat and the lowest one of proline was observed in *T. aestivum*. Acquistucci *et al.* (1995) found positive correlations between grain protein content and amino acid values of *T. monococcum* strains for glutamine and proline and a negative correlation for threonine, cystine, valine, isoleucine, leucine, asparagine, serine, glycine and alanine. Moreover, Cervantes *et al.* (2002) studied the amino acid composition of commercial wheat and found high variations with high content from the essential amino acids.

The present study carry out for the comparison of protein electrophoretic patterns, total protein and amino acid composition of the most common two Egyptian *Triticum* species with six imported *Triticum* species to distinguish the variation between them. In addition, assessment was made for the quality of total proteins and amino acids for the six imported *Triticum* species and their suitability for the cultivation in Ismailia Governorate, Egypt.

MATERIALS AND METHODS

The grains of investigated eight *Triticum* species were obtained from three different sources; Agricultural Research Institute, Dokki, Giza; Center International de Mejoraminento de Maiz Y Trigo, int., Mexico (CIMMYT) and National Small Collection, USDA-ARS Aberdeen, USA (NSGC) as in Table 1. These grains were cultivated in the Experimental Farm of the Faculty of Agriculture, Suez Canal University, Ismailia Governorate, Egypt on fifteen November of 2004/2005. The grains were collected to study the proteins and amino acids.

Protein electrophoresis: Total endosperm storage protein were extracted from grain after embryo remove by treatment with a solution containing 2% (w/v) sodium dodecyl-sulphate (SDS), 6M urea and 1.5% (w/v) 2-mercaptoethanol (2-ME). The extraction solvent was prepared fresh for each electrophoretic run. The solution used for extraction included 0.002% (w/v) of tracking dye (bromophenol blue). Distal half grains were crushed individually and placed in a 1.5 mL plastic microcentrifuge tube to which was added 0.4 mL of the extracting solution. The samples were left overnight at room temperature. Then 10 μL of the samples were used directly for electrophoresis (Mahgoub, 1988).

Endosperm storage proteins are separated and classified into their subunits by sodium dodectyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE). The method fractionated proteins mainly according to their molecular weight. The discontinuous buffer system of the high resolution one-dimensional SDS-PAGE used to fractionate the proteins was adapted from that described by Laemmli (1970) with some modifications proposed by Payne *et al.* (1981) for wheat storage proteins. The separating gel contained 0.36 M Tris-HCL, pH 9.1 and 0.1% (w/v) SDS. Gels were made from either 10% (w/v) acrylamide and 0.125% (w/v) Bis (N, N methylenbis-

Table 1: Classification, chromosome number (Dorofeev *et al.*, 1979) and source of the studied *Triticum* species

Subgenus	Section	Group of species	Species	Source	2n
Triticum L.	*Triticum* L.	Naked hexaploids	*T. aestivum* L. (Common wheat)	Sakha 69	42
		Spelt wheats	*T. spelta* L. (Spelt)	CIMMYT	42
	Dicoccoidea Flaksb.	Emmer wheats	*T. dicoccoides* (Koern. Ex Aschers. et Graebn.) Schweinf. (Wild emmer)	CIMMYT	28
			T. paleocolchicum Menabde	NSGC	28
		Naked tetraploids	*T. durum* Desf. (Durum wheat)	Beni Swif 3	28
			T. polonicum L. (Polish wheat)	CIMMYT	28
Boeoticum	Monococcon Dum.	Small spelts	*T. monococcum* L. (Einkorn)	CIMMYT	14
Migusch. et Dorof.	Timopheevii A. Filat. et Dorof.	Emmer wheats	*T. timopheevii* (Zhuk.) Zhuk. (Timopheevi wheat)	CIMMYT	28

Beni Swif3 and Sakha 69: From Agricultural Research Institute, Dokki, Giza. CIMMYT: Center International de Mejoraminento de Maiz Y Trigo, int., Mexico. NSGC: National Small Collection, USDA-ARS Aberdeen, USA

acrylamide) or 5% acrylamide and 0.26% Bis. The stacking gel consisted of 3% (w/v) acrylamide, 0.25% (w/v) Bis, 0.1% (w/v) SDS and 0.006 M Tris-phosphate (pH 6.7). Both gels were polymerized by adding ammonium per sulphate and TEMED (N, N, N, N-tetramethylethlenediamine) immediately before pouring the gels. The cathode buffer was 0.04 M Tris-Glycine (pH 8.9), containing 0.1% (w/v) SDS. The anode buffer was 0.12 M Tris-HCL (pH 8.1). The proteins were electrophoresis at a constant current of 50 mA and 150 volts until the bromophenol blue front has entered the separating gel and then at 90 mA until the tracking dye front migrated to about 0.5 cm from the end of the gel. The gels were stained with a solution of 0.01% (w/v) coomassie brilliant blue R and 0.003% (w/v), coomassie brilliant blue G dissolved in 18% (w/v) methanol, 5% (w/v) trichloroacetic acid (TCA) and 6% (w/v) acetic acid (HAC) (the dye was dissolved first in methanol, filtered and then added to a TCA-HAC solution). Gels were stained overnight, then distained for at least two days in distilled water and photographed. In order to compare protein bands and obtain an index of similarity between the species, the percent coefficient of similarity was calculated as described by Todaria *et al.* (1983) as follow:

$$\text{Percent coefficient of similarity} = 2 \times \frac{W}{A+B} \times 100$$

Where:

W = No. of similar bands between the two compared species a and b
A = Total No. of bands in species a
B = Total No. of bands in species b.

Protein content: Protein was determined according to improved Kjeldahl methods of AOAC (1970) modified by distilling the ammonia into boric solution and titrated with standard acid according to Page *et al.* (1982) at control Laboratory of Food Science, Faculty of Agriculture, Cairo University.

Amino acids: Samples of 1 g taken from different studied *Triticum* species dried grains were defatted and weighed in the screw-capped tubes; 5 mL of HCl 6.0 N were added to each tube. The hydrolysis was attached to a system, which allows the connection of nitrogen and vacuum lines without disturbing the sample. The tubes were capped 7 mol placed in an oven at 110°C for 24 h. (AOAC, 1995). The tubes were then opened and the content of each tube was filtered and then evaporated for dryness in a rotary evaporator. A suitable volume of sodium citrate buffer (pH 2.2) was added to each dried film of the hydrolyzed sample. After all soluble materials completely dissolved the samples were then filtered using a 0.2 μm membrane filter, (Winder and Eggum, 1966). The samples were analyzed using High Performance Amino Acid Analyzer, Biochrom 20 (Auto sample version) Pharmcia Biotch constructed at Nuclear Centre for Radiation Researches Technology, Cairo (NCRRT). Data analysis of chromatogram apparatus, which was done by EZChrom™ Chromatography Data System Tutorial and Users Guide-Version 6.7.

The contents of the different amino acids recovered were expressed as g per 100 g protein and were compared with the FAO/WHO (1990) reference pattern (Vijayakumari *et al.*, 1997; Shaheen and Hamed, 2003).

The essential amino acid chemical score was calculated as follows:

$$\text{Essential amino acid chemical score} = \frac{\text{Essential amino acid in 100 g of the test protein}}{\text{g of essential amino acid in 100 g of FAO/WHO reference pattern}} \times 100$$

Statistical analysis

For protein patterns: The data matrix was built based on the presence/absence of bands obtained from the protein analysis of the grains in the electrophoresis unit. These results used to construct a neighbor-joining tree of individuals using Euclidean distances computed between all pairs of individuals. A neighbor-joining tree of the relationships among individuals was constructed using the UPGMA method on the matrix of Euclidean distances.

RESULTS AND DISCUSSION

Protein electrophoretic patterns: The total proteins of the grains of the eight studied *Triticum* species were analyzed and the electrophoretic pattern is shown in Table 2-4 and Fig. (1) with twenty two bands. These bands were distributed along the gel with molecular weights ranging from 143 to 6 KD. There is an obvious variation in the number and position of bands from one species to another. The highest number of bands were 18 for total proteins and 4 for high molecular weight glutenin in *T. paleocolchicum*; 5 for high molecular weight gliadin in *T. aestivum*, *T. spelta*, *T. dicoccoides*

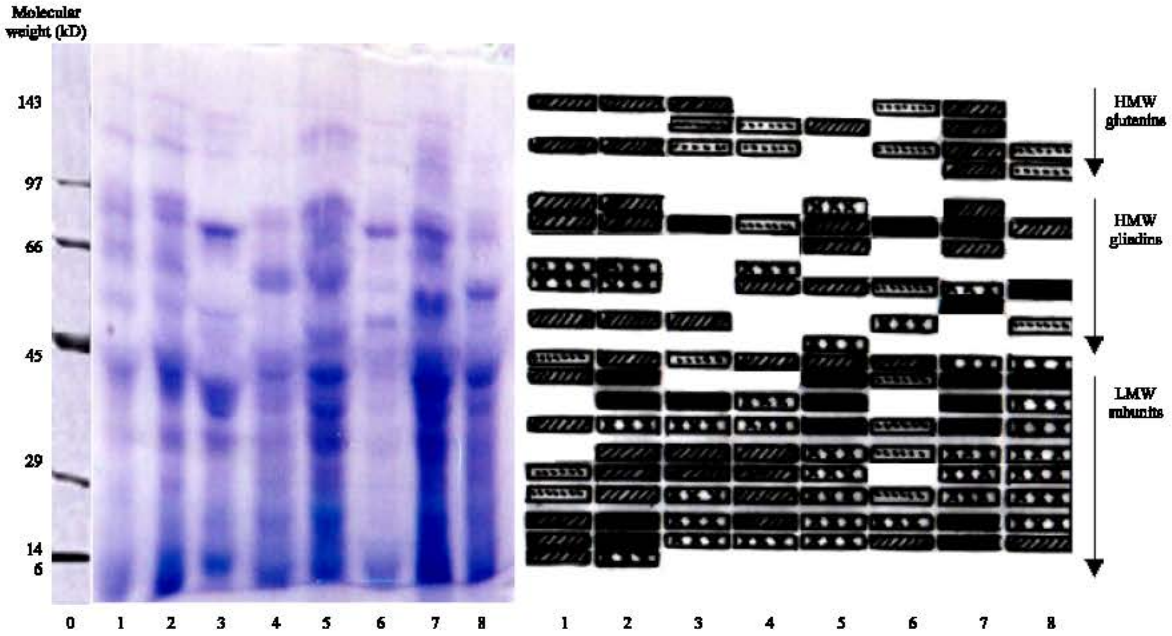

Fig. 1: Polyacrylmide gel electrophoresis SDS-PAGE for total proteins of the eight studied *Triticum* species. 0. Molecular weight of marker bands (97, 66, 45, 29 and 14 kD), 1. *T. aestivum*, 2. *T. spelta*, 3. *T. monococcum*, 4. *T. timopheevii*, 5. *T. dicoccoides*, 6. *T. durum*, 7. *T. paleocolchicum* and 8. *T. polonicum*. (= Faint; = Light; = Medium; = Condensed; HMW = High Molecular Weight; LMW = Low Molecular Weight)

Table 2: Distribution of total protein, glutenin and gliadin bands in the different examined *Triticum* species. (HMW = High Molecular Weight; LMW = Low Molecular Weight)

Species	Total No. of protein bands	No. of HMW glutenin bands	No. of HMW gliadin	No. of LMW subunit bandes
T. aestivum	15	2	5	8
T. spelta	17	2	5	10
T. monococcum	13	3	2	8
T. timopheevii	13	2	3	8
T. dicoccoides	15	1	5	9
T. durum	12	2	3	7
T. paleocolchicum	18	4	5	9
T. polonicum	14	2	3	9

Table 3: Distribution of protein bands in the different examined *Triticum* species (1 = Present; 0 = Absent)

	Band No.																					
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
T. aestivum	1	0	1	0	1	1	0	1	1	0	1	0	1	1	0	1	0	1	1	1	1	1
T. spelta	1	0	1	0	1	1	0	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1
T. monococcum	1	1	1	0	0	1	0	0	0	0	1	0	1	0	1	1	1	1	1	1	1	0
T. timopheevii	0	1	1	0	0	1	0	1	1	0	0	0	1	0	1	1	1	1	1	1	1	0
T. dicoccoides	0	1	0	0	1	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	0
T. durum	1	0	1	0	0	1	0	0	1	0	1	0	1	1	0	1	1	0	1	1	1	0
T. paleocolchicum	1	1	1	1	1	1	1	0	1	1	0	0	1	1	1	1	1	1	1	1	1	0
T. polonicum	0	0	1	1	0	1	0	0	1	0	1	0	1	1	1	1	1	1	1	1	1	0

Table 4: Percent coefficient of similarity between the different studied *Triticum* species on the basis of the number of protein bands

	Species as in column 1							
Species	1	2	3	4	5	6	7	8
T. aestivum	X							
T. spelta	94	X						
T. monococcum	71	80	X					
T. timopheevii	71	80	85	X				
T. dicoccoides	67	75	71	79	X			
T. durum	82	83	80	72	67	X		
T. paleocolchicum	73	80	77	77	85	73	X	
T. polonicum	76	84	82	82	76	85	81	X

and *T. paleocolchicum* and 10 for low molecular weight subunits in *T. spelta*. On the other hand, the lowest number of bands (12) were recorded in *T. durum*; one band of high molecular weight glutenin in *T. dicoccoides*; two bands of high molecular weight gliadin in *T. monococcum* and 7 bands of low molecular weight subunits in *T. durum*.

There were some bands in common between the eight studied species (6, 13, 16, 19, 20 and 21), while there were also some bands which characterize each species. The band (10) is characteristic for *T. paleocolchicum*; the band (12) for *T. dicoccoides*; the band (4) for both *T. paleocolchicum* and *T. polonicum* and the band (22) for both *T. aestivum* and *T. spelta*. These results are in harmony with the data obtained by Galili and Feldman (1983 and 1985), Pogna *et al.* (1990) and Hassan and Eid (1998) who observed that 17 to 20 total protein bands were resolved in the common wheat cultivar and durum wheat with three main groups; 1-4 bands of high molecular weight glutenin; 5-9 bands of high molecular weight gliadin and 10-21 bands of low molecular weight subunits.

The neighbor-joining tree illustrated the relationships between the eight studied *Triticum* species based on the UPGMA clustering is presented in Fig. 2 and the values of similarity percentage in Table 4. This tree consists of two major groups, one comprising the two species of subgenus *Boeoticum* moderately supported with 85% similarity percentage and the other the six species of subgenus *Triticum*, which are separated into three subgroups. The first subgroup comprises the two hexaploids; *T. aestivum* and *T. spelta* of section Triticum which is strongly supported with 94% similarity percentage. The two remaining subgroups have the four tetraploids species of section Dicoccoidea with the same taxonomic distance; The two species of Emmer wheats group; *T. dicoccoides* and *T. paleocolchicum* form moderately supported subgroup with 85% similarity percentage. The other two species of Naked tetraploids group; *T. durum* and *T. polonicum* form the other moderately supported subgroup with 85% similarity percentage. These results confirm the classification of Dorofeev *et al.* (1979) and in agreement with the morphological, anatomical and pollen grains data obtained by Gowed (2003).

Total protein percentage: Data in Table 5 show that there is notable variation in total protein values determined in the grains of the eight examined of *Triticum* species. The maximum value of total protein percentage (14.8%) was recorded in *T. dicoccoides*, while, their minimal values (9.3%) were observed in *T. aestivum*. Ciaffi *et al.* (1992) found also the protein content of *T. dicoccoides* ranged from 16-27%. The variation in the amount of grain proteins was the main factor responsible for the differences in bread (Ciaffi *et al.*, 1993). These results are in agreement with those obtained by Borghi *et al.* (1996) who observed that the protein content of twenty-five *T. monococcum* from 13.2 to 22.8% higher than those found for bread wheat which ranged from 10.8 to 13.3%.

Amino acids: Table 5 and 6 show obvious differences in the amounts of different essential and non-essential amino acids existing in the grains of the eight studied *Triticum* species.

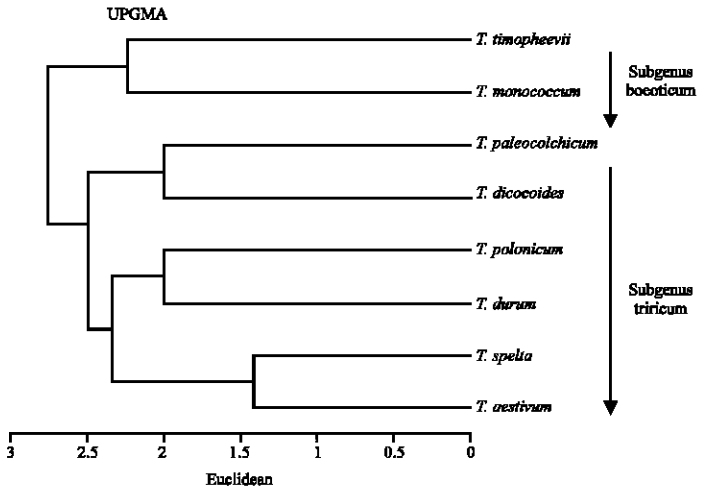

Fig. 2: A neighbor-joining tree illustrating the relationships among the studied species of *Triticum*

Table 5: Mean values of total protein and essential amino acids content existing in mature grains of the studied eight *Triticum* species (expressed as g per 100 g protein). (Practice values = essential amino acid chemical score)

	EAA							
Species	Total protein	Leucine (Leu)	Valine (Val)	Threonine (Thr)	Lysine (Lys)	Isoleucine (Ile)	Tyrosine (Tyr)	Methionine (Met)
T. aestivum	9.3	7.34 (111.21)	5.14 (146.86)	3.67 (107.90)	3.49 (60.17)	2.94 (105.00)	2.20 (34.92)	-
T. spelta	9.7	6.71 (101.67)	4.65 (132.86)	3.10 (91.18)	2.58 (44.48)	2.58 (92.14)	0.90 (14.29)	-
T. monococcum	13.9	7.16 (108.49)	4.52 (129.14)	3.39 (99.71)	2.64 (45.52)	3.77 (134.64)	1.51 (23.97)	0.47 (18.80)
T. timopheevii	11.2	6.31 (95.61)	4.51 (128.86)	2.59 (76.18)	3.16 (54.48)	2.71 (96.79)	1.35 (21.43)	0.45 (18.00)
T. dicoccoides	14.8	7.90 (119.70)	4.61 (131.71)	3.62 (106.47)	3.29 (56.72)	3.29 (117.50)	1.65 (26.19)	-
T. durum	9.5	6.43 (97.42)	4.29 (122.57)	3.22 (94.71)	3.22 (55.52)	6.70 (239.29)	1.07 (16.98)	-
T. paleocolchicum	9.8	6.44 (97.58)	4.46 (127.43)	2.97 (87.35)	2.97 (51.21)	2.48 (88.57)	0.99 (15.71)	0.50 (20.00)
T. polonicum	11.6	6.70 (101.52)	4.46 (127.43)	3.13 (92.06)	3.13 (53.97)	2.68 (95.71)	1.34 (21.27)	-
FAO/WHO (1990)	-	6.60	3.50	3.40	5.80	2.80	6.30	2.50

Table 6: Mean values of non essential amino acids existing in mature grains of the studied eight *Triticum* species (expressed as g per 100g protein)

	NEAA									
Species	Glutamic (Glu)	Proline (Pro)	Aspartic (Asp)	Serine (Ser)	Phenylalanine (Phe)	Arginine (Arg)	Glycine (Gly)	Alanine (Ala)	Histidin (His)	Cystine (Cys)
T. aestivum	25.69	11.74	6.61	5.87	5.87	4.40	5.14	4.40	2.75	2.75
T. spelta	36.13	11.36	5.16	5.68	5.16	3.61	4.13	3.61	2.07	2.58
T. monococcum	28.28	12.44	6.03	5.66	7.16	4.15	4.15	3.77	2.64	2.26
T. timopheevii	32.47	12.63	6.31	4.96	5.41	4.51	4.51	4.06	2.26	1.80
T. dicoccoides	24.86	13.17	6.26	6.26	6.58	4.61	4.94	4.28	2.63	2.06
T. durum	29.49	10.72	6.43	4.83	4.83	4.29	4.83	4.29	2.15	3.22
T. paleocolchicum	34.65	11.39	5.94	5.45	4.95	3.96	4.46	3.96	2.48	1.98
T. polonicum	33.04	12.95	5.80	4.91	4.91	4.46	4.46	4.02	2.23	1.79

Essential Amino Acids (EAA): The nutritional quality of proteins as measured by their essential amino acids chemical scores range from 14.29% for tyrosine in *T. spelta* grain protein to 239.29% for isoleucine in *T. durum* grain protein (Table 5). Most essential amino acid of grain protein in *T. aestivum* and *T. dicoccoides* record higher values than the FAO/WHO (1990) recommended pattern (threonine, 3.67 and 3.62; valine, 5.14 and 4.61; isoleucine, 2.94 and 3.29 and leucine 7.34 and 7.90 g/100 g protein, respectively). Methionine (sulphar containing amino acid) is presenting in a very low levels with scores of 0.45, 0.47 and 0.50 g/100 g protein in the grain protein of *T. timopheevii*, *T. monococcum* and *T. paleocolchicum*, respectively, while lacking in the other studied species. However, valine (aliphatic amino acid) is present at high levels in all the studied species ranging from 4.29 in *T. durum* to 5.14 g/100 g protein in *T. aestivum* compared with the FAO/WHO (1990) recommended pattern (3.50 g/100 g protein). As well as, the other aliphatic amino acid (leucine) is found in high levels in *T. polonicum*, *T. monococcum*, *T. aestivum*, *T. spelta* and *T. dicoccoides* (6.70, 7.16, 7.34, 6.71 and 7.90 g/100 g protein, respectively) comparing with the FAO/WHO (1990) reference pattern (6.60 g/100 g protein). In addition, leucine was accumulated in higher levels compared with the other essential amino acids ranging from 6.31 to 7.90 g/100 g protein in *T. timopheevii* and *T. dicoccoides*. In contrast, the levels of three essential amino acids; lysine (basic amino acid), tyrosine (aromatic amino acid) and methionine (sulphar containing amino acid) show lower values than those of FAO/WHO (1990) recommended pattern in all studies species and a great differences were found between tyrosine and methionine values comparing with the other essential amino acids values. These results are in harmony with the data obtained by Nevo and Beiles (1992) who showed that *T. dicoccoides* contains high values of lysine and isoleucine compared to the other studied wild wheat species. All the studied *Triticum* species had high content from the essential amino acids as recorded by Cervantes *et al.* (2002) in commercial wheat, or higher than that found by Shaheen and Hammed (2003) in *Eragrostis aegyptiaca* (Poaceae) and *Fimbristylis bisumbellata* (Cyperaceae).

Non-essential Amino Acids (EAA): The content of glutamic (acidic amino acid) is very high in all studied *Triticum* species ranging from 24.86 g/100 g protein in *T. dicoccoides* to 36.13 g/100 g protein in *T. spelta* (Table 6). As well as, proline (heterocyclic amino acid) show the same result, being present with a high values in all the examined species varying from 10.72 in *T. durum* to 13.17 g/100 g protein in *T. dicoccoides*. However, cystine (sulphar containing amino acid) is the limiting amino acid in all protein of the different species with the lowest amounts in *T. polonicum* (1.79), *T. timopheevii* (1.80) and *T. paleocolchicum* (1.98 g/100 g protein). *T. aestivum* contains the highest content of aspartic acids, glycine, alamine and histidin (6.61, 5.14, 4.40 and 2.75 g/100 g

protein, respectively), however *T. dicoccoides* records high values of proline and serine (13.17 and 6.26 g/100 g protein, respectively). As well as, *T. monococcum* protein contains the highest value of phenylalamine (aromatic amino acids, 7,16); *T. durum* with greatest content of cystine (3.22) and *T. polonicum* with highest content of arginine (basic amino acid, 4.46 g/100 g protein). In contrast, *T. spelta* has the smallest amounts of most non-essential amino acids content; aspartic acid (5.16), arginine (3.61), glycine (4.13), alanine (3.61) and histidin (2.07 g/100 g protein). However, *T. durum* has the lowest contents of three non-essential amino acids (proline, 10.72; serine, 4.83 and phenylalanine, 4.83 g/100 g protein). All the studied species had the greatest proportion of glutamic acid in agreement with the finding of Molino *et al.* (1988 and 1989) in three *Triticum aestivum* varieties. These results agree with Nevo and Beiles (1992) who reported that *T. aestivum* recorded low value of proline. Most non-essential amino acids values in this study seems to be higher than the previous findings in *Eragrostis aegyptiaca* and *Fimbristylis bisumbellata* (Shaheen and Hammed, 2003).

It is concluded that the six studied *Triticum* species imported from outside Egypt had pronounced total protein and amino acids content and consistent the most suitable condition for growing under Ismailia conditions. The same conclusion obtained by Gowed (2003) and Hassan *et al.* (2005) on the basis of the morphological data.

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