Amino Acid Composition of Wheat: Effect of Mutation

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Introduction

In view of the present deficient and the predicted world food shorage, considerable research is being directed towards increasing the nutritional qualities of wheat. In Pakistan modern plant breeding has played a vital role in enhancing the quantity and quality of wheat, Triticum aestivum (AABBDD, 2n=6x=42) [1-2]. The determination of total protein and amino acids composition is essential in evaluating the nutritional and certain plant resistance properties of wheat. Various methods have been developed to study the wheat quality, based on simple chemical and physical test [3]. In our present work we have carried out total protein analysis and amino acid composition of eight parent wheat cultivars and their respective mutants.

Results and Discussion

The total protein content (N x 5.7) Table 1 in different wheat cultivars analysed ranged from 9.75 to 13.62 % with mutant M-37 and Sindh 81 containing the lowest and highest amount respectively. A total of 18 amino acids were identified in the eight parent cultivars and their respective mutants (Table 1). Statistical analysis of the amino acid contents for all samples were done to establish any statistically significant difference between the parent and the mutant wheat cultivars. Mutant-11 derived from 35 kR treatment of wheat cultivar C-591 was endowed with significantly higher quantity of proline than the parent cultivar. M-11 produced lower grain yield than the parent cultivar C-591 [4], which has remained the dominant cultivar throughout Indo-Pak subcontinant before the advent of the so called Green revolution. M-11 also produced significantly higher quantity of tyrosine.

Mutant-37 derived from Indus-66 (20 kR) is characterised by radiation-induced necrotic spots on the leaf and the grain yield of M-37 is significantly

Table 1: Total Protein (%), Amino Acids (g/16 g N) contents of wheat cultivars**

Wheat Cultivar	C-391	M-11	Indus 66	M-37	6134 x C 271	TDS	Sindh 81	M-179	Sarsabz	M-147	Pavon	M-143	Sonalika	M-233	Nayab	Jauhar 78
Total Protein	12.77	12.14	11.26	9.75	12.80	10.94	13.62	11.91	10.93	11.23	11.12	12.03	11.40	12.08	10.77	10.15
Asp	4.72	4.76	4.66	4.70	5.10	4.70	4.19	4.56	5.69	4.73	4.36	4.85	5.49	4.19	3.54	2.75
Thr	2.36	1.66	2.51	1.59	1.71	2.54	2.31	2.47	2.79	2.46	2.50	2.54	3.08	2.49	2.08	1.66
Ser	3.17	1.33	3.62	1.20	1.29	3.60	3.01	3.76	4.06	3.60	3.30	3.26	4.63	3.54	2.92	2.26
Glu	31.61	28.09	29.90	29.11	32.31	29.86	23.50	28.43	33.43	31.44	30.64	30.78	29.68	25.21	25.79	20.71
Pro	9.39	11.14	8.61	8.36	9.46	8.96	7.24	7.98	9.35	8.57	8.44	9.08	7.06	5.97	6.99	6.70
Gly	3.63	3.64	3.34	3.65	3.61	3.56	3.31	3.75	4.42	4.23	3.83	3.57	4.13	3.20	3.36	1.88
Ala	2.92	2.91	2.78	2.91	2.76	2.82	2.76	3.01	3.66	3.61	3.06	2.83	3.32	2.49	2.69	2.41
Cys	1.34	1.15	1.87	1.79	2.00	2.05	1.17	1.55	1.36	1.24	1.43	1.26	1.48	1.74	2.17	2.16
Val	4.07	3.79	3.79	3.51	3.95	3.66	3.58	4.25	4.52	4.51	4.76	4.14	3.79	3.25	3.73	2.84
Met	1.82	1.65	1.55	1.63	1.86	1.73	1.43	1.39	1.91	2.01	1.87	1.98	2.12	1.94	2.01	1.84
Ile	3.07	2.63	2.95	2.73	2.88	2.82	2.57	3.21	3.56	3.51	3.27	2.97	2.99	2.65	2.94	2.27
Leu	5.74	5.22	5.43	5.29	5.68	5.27	4.96	5.64	6.47	6.18	6.24	5.68	5.48	4.93	5.29	4.12
Tyr	2.67	3.10	2.95	2.74	3.32	3.27	2.26	3.43	3.93	3.38	3.66	3.85	3.90	3.93	2.83	2.27
Phe	4.18	3.49	4.02	3.41	3.97	3.70	3.62	3.87	4.25	3.77	4.32	4.01	3.72	3.76	3.43	2.48
Lys	1.98	1.94	1.87	1.95	2.01	1.83	1.75	2.16	2.25	2.52	1.93	1.95	2.23	1.82	1.89	1.48
NH_3	3.59	4.55	3.74	4.54	4.16	4.17	3.79	5.88	6.84	4.80	4.63	4.28	5.05	4.65	7.54	8.04
His	2.14	1.87	1.66	1.79	2.05	1.73	1.42	1.84	2.25	1.84	1.75	1.71	1.78	1.59	1.74	1.67
Arg	3.65	3.58	3.95	3.53	3.85	3.86	3.77	3.68	4.39	4.52	3.94	1.53	4.46	3.89	3.60	2.66
Trp	1.12	1.63	1.30	1.03	1.82	1.36	1.54	1.99	1.16	2.04	1.21	1.84	1.30	1.74	1.18	1.13

**Average of triplicate determinations.

lower than Indus-66 [44]. M-37 produced significantly higher ($P < 0.05$) glycine, which is perhaps a reflection of the implication of glycine in physiological mechanism connected with photosynthesis.

The spontaneous mutant TDS derived from the natural population of 6134xC271 is characterised by significantly reduced plant height which provides effective protection against lodging and is oriented to very high inputs of nitrogenous fertilizers. It has been documented that when wheat is fertilized with increasing amounts of nitrogen, more protein will be deposited in the prolamines [5]. In the present study TDS produced significantly higher ($P < 0.05$) quantities of threonine and serine.

Considerable efforts have been devoted at international level for increasing the lysine content of wheat [5-7]. In this work a new wheat mutant M-179 has been detected which produces significantly more ($P < 0.05$) lysine content than the parent cultivar Sind-81. M-179 also produced significantly higher quantity of valine in addition to serine, glutamic acid, glycine and cystine. In recent years this is perhaps the most outstanding example of a wheat mutant representing induced genetic changes for the production of different amino acids.

Mutant-147 is derived from the cultivar Sarsabz, produced significantly higher quantities of two essential amino acids namely lysine and methionine in comparison with Sarsabz. This is a significant finding, because this mutant can be utilized for improving the lysine content of Sarsabz through a series of backcrossing. Mutant-143 (Soghat-90) produced higher quantity of aspartic acid in comparison with Pavon, while no significant increase in the amino acid composition of the mutants, M-223 and Jauhar-78 were observed.

In the existing wheat cultivars lysine contents were significantly higher ($P < 0.05$) in Sarsabz followed by Sonalika. Likewise leucine contents were significantly higher in Sarsabz in comparison with the all other existing cultivars. Valine contents were high in Pavon. This cultivar also possessed significantly higher quantities of phenylalanine followed by Sarsabz. Sonalika and Nayab produced higher quantities of methionine. Sarsabz possessed significantly higher ($P < 0.05$) isoleucine in comparison with all other existing cultivars. Threonine contents were significantly higher ($P < 0.05$) in Sonalika followed by Sarsabz. Similarly histidine production was high in Sarsabz. Proline was high in 6134xC271 while Sonalika produced higher content of glutamic acid in comparison with all other

Table 2: Mineral composition of wheat cultivars.

Wheat Cultivar	Calcium µg/g	Zinc µg/g	Copper µg/g	Iron µg/g	Sodium (%)	Magnesium (%)
C-591	221.43 ±10.10	49.96 ±0.85	4.73 ±0.61	58.59 ±1.52	0.107 ±0.001	0.171 ±0.00
M-11	196.43 ±5.01	53.51 ±3.56	5.98 ±8.53	42.80 ±1.52	0.140 ±0.001	0.187± 0.00
Indus-66	178.57 ±1.20	44.37 ±1.10 I	6.42± 0.00	35.79 ±0.00 I	0.091± 0.002	0.142± 0.001
M-37	210.72 ±5.06	58.33 ±1.31	4.53 ±0.00	29.65 ±1.52	0.086 ±0.001	0.139 ±0.001
6134 X C271	20.00 ±10.10	38.85 ±0.77 I	2.64 ±0.00 I	N.A	0.114 ±0.003	0.170 ±0.001
TDS	19.10 ±9.21	52.10 ±2.20	4.84 ±0.40	N.A	0.1380 ±0.002	0.173 ±0.002
Sind-81	185.72 ±1.01	39.29 ±1.01	4.53± 0.00	20.88 ±1.52 I	0.134± 0.00	0.129 ±0.001
M-179	235.72 ±10.01	33.11 ±4.59	4.53 ±0.00	1.58±.0.00	0.0885 ±0.001	0.121± 0.001
Sarsabz	167.86 ±5.05 I	44.02 ±13	5.10± 0.49	32.28 ±3.04 I	0.168 ±0.005	0.153 ±0.001
M-147	150.01 ±5.05	43.74 ±0.73	6.07 ±0.60	44.56 ±1.56	0.095 ±0.001	0.163± 0.001
Pavon	182.14 ±5.10	48.76 ±0.73	5.10 ±0.49	46.48 ±1.16 I	0.076 ±0.003	0.117± 0.001
M-143	185.72± 5.05	53.13 ±2.17	5.73 ±0.60	56.39 ±0.58	0.085 ±0.003	0.155 ±0.002
Sonalika	189.29 ±5.11 I	48.13 ±1.53	4.07± 0.40 I	53.33 ±1.52 I	0.235 ±0.004	0.177 ±0.002
M-233	171.00± 1.01	44.37 ±1.23	2.64 ±0.00	12.99 ±1.52	0.143 ±0.003	0.144± 0.003
Nayab	228.57 ±0.00 I	44.01 ±0.72 I	4.81 ±0.49	16.49± 1.52 I	0.069 ±0.004 I	0.155 ±0.001 I
Jauhar	210.72± 5.06	39.96 ±0.77	6.07 ±0.60	12.99 ±1.52	0.109 ±0.001	0.122 0.002

[I] Denotes that the mutant value is significantly different from its mother variety.

existing cultivars. In serine production Sonalika was higher followed by Sarsabz. Similarly in glycine and alanine production Sarsabz surpassed all the cultivars. Nayab produced significantly higher ($P < 0.05$) cystine in comparison with other cultivars. Sonalika was most outstanding with respect to arginine production.

The nutritional quality of all the cultivars of wheat studied in the present work was evaluated (Table 2) by comparing the essential amino acids composition with that of FAO provisional pattern [8]. Except for lysine adequate amount of essential amino aicds were present in wheat cultivars.

Experimental

Eight cultivars of bread wheat, Triticum aestivum (AABBDD, 2n = 6 x 42) and their respective mutants were obtained from the Atomic Energy Agricultural Research Centre (AEARC) Tando Jam, Pakistan. The details are as follow:

Parent	Mutant	Parent	Mutant
C-591	M-11	Sarsabz	M-147
Indus-66	M-37	Pavon	M-143
6134 x C 271	TDS	Sonalika	M-233
Sind-81	M-179	Nayab	Jauhar-78

Wheat samples were milled at the laboratory of AEARC. These flour samples were stored in polyethylene bags for further analysis. Crude protein was determined by the standard kjeldahl method [9].

Table-3: Amino acids composition of the present wheat cultivars in comparison to the levels set by FAD.

Amino acid	Mean value in 16 cultivars of wheat (g/16 g Nitrogen)	FAD Level*
Lys	1.97 (1.48 - 2.52)	3.3
Thr	2.30 (1.59 - 3.08)	4.3
Val	3.89 (2.84 - 4.76)	2.8
Ile	2.94 (2.27 - 3.56)	4.3
Met	1.79 (1.39 - 2.12)	N.A
Leu	5.48 (4.12 - 6.47)	4.9
Tyr	3.22 (2.26 - 3.93)	2.5
Phe	3.75 (2.48 - 4.32)	2.9

*Source : Okoh et al.

The factor used for computing the protein contents were N x 5.7. Amino acids composition of wheat were carried out by cation exchange chromatography after using the hydrolysis procedure of Gehrke *et al.* [10] on Hitachi Model 835-A amino acid analyzer. Cystine and methionine were determined separately as cysteic acid and methionine sulfone respectively according to the procedure described by Gehrke *et al.*. [10]. Tryptophan was determined by the spectrophotometric method [11]. Quantitative analysis of each amino acid was performed by determining the peak height on the chart recorder at 570 nm, while the amino acid (Proline) at 440 nm after calibrating the instrument with standard mixture of amino acids.

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