

Nutritional evaluation of some commercial wheat varieties grown in Pakistan

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Abstract. The nutritive value of some commercial wheat varieties grown in Pakistan was measured chemically, including amino acid analysis, and biologically in N-balance experiments with growing rats. The protein content ranged from 13.2% in Punjab-83 to 16% in Barani-83. Lysine per 100 g protein varied between 2.46 and 2.75%. The available carbohydrate ranged from 67.3 to 74.7%. Iron content was highest in Sonalika while the concentration of zinc and manganese was highest in Sarhad-82. The protein digestibility (TD), biological value (BV) and net protein utilisation (NPU) varied between 92-95%, 56-68% and 53-65% respectively. Level of wheat protein was negatively correlated with available carbohydrate ($r = -0.93$), lysine per unit protein ($r = -0.67$) and BV ($r = -0.76$). The lysine content (g/16gN) of commercial wheat varieties showed a positive correlation ($r = +0.95$) with the BV. The protein quality was lowered in varieties having higher content of protein.

Introduction

Cereal grains are the dietary mainstay of mankind and provide three quarters of man's energy needs and more than one half of his protein needs. Wheat is the main staple food in Pakistani diets and constitutes 83 percent of the total cereals intake. The protein content and lysine per unit protein of some Pakistani improved varieties of wheat ranging from 12.3 to 16.7% and 2.46 to 2.96% respectively have been reported [11]. Wheat protein has an imbalance of essential amino acids for its complete biological utilization. According to Khan [7], the order of limiting amino acids in wheat protein is lysine, threonine and valine. Mixed human diets, breakfast cereals and baby foods based on wheat have been shown to be deficient in lysine [8, 10].

Known genetic variability for lysine is substantially less in wheat than other cereals. According to Johnson et al. [5] the genetic variability for lysine in wheat is no more than 0.5 of a percentage point when lysine is expressed

as percent of protein. The amount of lysine in wheat is influenced by the level of protein [14] and the relationship is curvilinear [6].

The challenge to plant breeders is to develop cereal grain varieties that are both more productive and more nutritious. Consequently, any addition in protein quantity and/or quality will result in improved nutritional status of the population. The present paper deals with the nutritive value of some commercial wheat varieties evolved in Pakistan.

Materials and methods

Eight commercial wheat varieties grown in different parts of Pakistan were collected from the wheat programme of the National Agricultural Research Centre, Islamabad, Pakistan. All the varieties were ground to whole flour. The chemical composition was determined according to AOAC methods [12]. Available carbohydrate was estimated by using the method of Watson et al. [15]. The gross energy value was calculated by multiplying protein, fat and carbohydrate contents with factors of 4, 9 and 4 Kcal/gm, respectively. The amino acid analyses were carried out as described by Khan and Eggum [11]. Trace elements were analysed by using a Perkin-Elmer model 4000 atomic absorption spectrophotometer. All the assays were performed in duplicate. The biological utilisation of wheat protein was determined in N-balance experiments with growing rats [3].

Results

The chemical composition of commercial wheat varieties is shown in Table 1. The protein content ($N \times 5.7$) was highest in Barani-83 (16.0%) and lowest in Punjab-83 (13.2%). The fat content appeared to lie between 2.6 and 3.0% while the available carbohydrate ranged from 67.3 to 74.7%. The fibre content varied from 2.2 to 2.9% while the ash content was almost uniform in all varieties. The concentration of calcium varied considerably with the highest value of 40.0 in Punjab-83 and the lowest of 11.0 mg per 100 g in Lyp-73. The phosphorus content ranged from 284.0 to 336.0 mg per 100 g while the iron content was highest (4.8 mg per 100 g) in Sonalika and lowest (2.9 mg per 100 g) in Faisalabad-83. The concentration of zinc and manganese varied from 2.5–4.1 and 5.0–6.6 mg per 100 g respectively.

The protein concentration of wheat varieties were negatively correlated with the available carbohydrate. The relationship is given in the following regression equation.

Table 1. Chemical composition (dry basis) of some Pakistani commercial wheat varieties

	g per 100 g					Gross energy (Kcal/100 g)	mg per 100 g				
	Protein (N × 5.7)	Fat	Available carbohydrate	Crude fibre	Ash		Ca	P	Fe	Zn	Mn
Sonalika	15.7	2.7	68.6	2.2	1.6	362	37.0	336.0	4.8	3.3	5.8
Lyp-73	14.8	2.7	70.0	2.5	1.7	364	11.0	315.0	3.9	2.8	6.0
Pak-81	14.3	2.9	72.5	2.5	1.6	373	18.0	287.0	4.1	3.0	6.3
Sind-81	13.3	2.7	72.9	2.2	1.5	369	25.0	310.0	4.5	3.5	5.5
Sarhad-82	14.5	2.7	72.7	2.7	1.5	374	20.0	284.0	3.8	4.1	6.6
Faisal- abad-83	14.3	2.6	70.8	2.6	1.6	365	30.0	319.0	2.9	2.9	5.3
Punjab-83	13.2	2.7	74.7	2.8	1.6	375	40.0	325.0	4.2	3.7	5.5
Barani-83	16.0	3.0	67.3	2.9	1.7	360	19.0	309.0	3.8	2.5	5.0
Mean	14.51	2.75	71.2	2.6	1.6	368	25.0	310.6	4.0	3.2	5.8
S.D.	1.0	0.13	2.47	0.26	0.08	5.80	10.0	17.76	0.56	0.53	0.53
C.V.	6.9	4.73	3.47	10.20	5.0	1.58	40.0	5.72	14.0	16.41	9.22

S.D. = Standard deviation; C.V. = coefficient of variability.

$$\text{Available carbohydrate (\%)} = 103.76 - 2.25 \times \text{protein (\%)}$$

$$\text{r.s.d.} = 0.76, \text{ S.E.} = 0.36, r = -0.93,$$

where r.s.d. is the residual standard deviation and S.E. is the standard error of the regression coefficient. The regression coefficient differed significantly ($P < 0.01$) from zero.

The amino acid contents of wheat varieties are presented in Table 2. Lysine per 100 g protein ranged from 2.46 in Barani-83 to 2.75% in Punjab-83. The glutamic acid, glycine and serine contents were higher while the levels of lysine, threonine, and cystine were lowest in Barani-83 having highest content (16.0%) of protein. The lowest concentration of protein (13.2%) in Punjab-83 resulted in an increase in lysine, threonine and valine and simultaneous decrease in proline content. Highest content (3.88 g/16 gN) of methionine and cystine in variety Sonalika and lowest (3.45 g/16 gN) in Sarhad-82 were found. There was a negative correlation ($r = -0.67$) between lysine content (g/16 gN) and protein concentration. The relationship is given in the following regression equation:

$$\text{Lysine (g/16 gN)} = 3.59 - 0.07 \times \text{protein (\%)}$$

$$\text{r.s.d.} = 0.52; \text{ S.E.} = 0.31.$$

The regression coefficient differed significantly ($P < .05$) from zero.

Results obtained on true protein digestibility (TD), biological value (BV) and net protein utilization (NPU) of the wheat varieties are summarised in Table 3.

The TD was highest (95.0%) in Sind-81 and Punjab-83 and the lowest value (92.0%) was found in Sonalika and Sarhad-82. The BV and NPU ranged from 56–68% and 53–65%, respectively. A negative correlation ($r = -0.76$) between BV and protein concentration as shown in the following regression equation was found.

$$\text{BV(\%)} = 106.68 - 3.05 \times \text{protein (\%)}$$

$$\text{r.s.d.} = 0.67 \text{ S.E.} = 1.08.$$

The regression coefficient differed significantly ($P < 0.05$) from zero. However a positive correlation ($r = +0.95$) between BV and lysine content (g/16 gN) of commercial wheat varieties was found. The regression coefficient differed significantly ($P < 0.01$) from zero. The relationship is given in the following regression equation.

Table 2. Amino acid composition (g per 16 g N) of some Pakistani commercial wheat varieties

Wheat varieties	Sonalika	Lyp-73	Pak-81	Sind-81	Sarhad-82	Faisalabad-83	Punjab-83	Barani-83	Mean	S.D.
Aspartic acid	4.79	4.61	4.94	4.91	4.78	4.60	4.83	4.53	4.75	0.15
Threonine	2.75	2.63	2.68	2.77	2.61	2.58	2.79	2.56	2.67	0.09
Serine	4.59	4.54	4.60	4.75	4.48	4.66	4.71	4.90	4.67	0.13
Glutamic acid	29.80	29.84	30.29	29.74	28.99	30.50	30.11	30.81	30.01	0.55
Proline	10.16	10.12	10.49	10.05	10.15	10.52	10.00	10.19	10.21	0.19
Glycine	3.90	3.82	3.96	4.06	3.90	3.82	4.01	4.10	3.95	0.10
Alanine	3.37	3.27	3.36	3.45	3.28	3.26	3.41	3.31	3.34	0.07
Valine	4.41	4.37	4.22	4.43	4.17	4.26	4.49	4.30	4.33	0.11
Isoleucine	3.48	3.45	3.57	3.57	3.38	3.43	3.51	3.44	3.48	0.07
Leucine	6.41	6.38	6.49	6.68	6.12	6.36	6.44	6.38	6.41	0.15
Tyrosine	2.94	2.94	3.13	3.06	2.99	2.88	3.13	3.09	3.02	0.09
Phenylalanine	4.37	4.35	4.38	4.42	4.15	4.47	4.33	4.34	4.35	0.09
Lysine	2.62	2.54	2.63	2.71	2.60	2.48	2.75	2.46	2.60	0.10
Histidine	2.28	2.21	2.20	2.28	2.14	2.18	2.15	2.23	2.20	0.05
Arginine	4.70	4.42	4.55	4.65	4.54	4.43	4.54	4.68	4.56	0.11
Methionine	1.56	1.50	1.49	1.55	1.32	1.43	1.46	1.37	1.46	0.08
Cystine	2.32	2.27	2.13	2.28	2.13	2.13	2.24	2.11	2.20	0.08
Tryptophane	1.02	1.20	1.18	1.35	1.25	1.30	1.15	1.05	1.19	0.11

Table 3. Protein quality of some Pakistani commercial wheat varieties

	True digestibility		Biological value		Net protein utilization	
	(%)	(S.D)	(%)	(S.D)	(%)	(S.D)
Sonalika	92.0	0.8	62.0	1.1	57.0	1.0
Lyp-73	93.0	0.9	61.0	1.5	57.0	1.8
Pak-81	93.0	1.3	63.0	1.1	59.0	1.5
Sind-81	95.0	1.0	66.0	1.6	63.0	1.5
Sarhad-82	92.0	1.4	65.0	1.4	60.0	1.4
Faisal-abad-83	94.0	0.8	58.0	1.4	55.0	1.6
Punjab-83	95.0	0.9	68.0	1.7	65.0	1.9
Barani-83	94.0	0.9	56.0	1.6	53.0	1.3

$$BV(\%) = -35.01 + 37.47 \times \text{Lysine (g/16 gN)}$$

$$r.s.d. = 1.37 \text{ S.E.} = 4.9.$$

Discussion

The quantity and quality of wheat protein depend on its genetic potential [6], production climate [1, 13] and soil fertility [4].

The present results indicate that high protein wheat (Barani-83) was low in lysine whereas the wheat (Punjab-83) that was highest in lysine was lowest in protein. The lysine content per unit protein is negatively correlated with protein concentration. The depression of lysine associated with elevation of protein content may result from altered ratios of the four solubility fractions that comprise the protein. According to Johnson et al. [6] the proportions of water and salt soluble albumins and globulins is highest in low protein wheats. Lysine in these fractions is significantly higher than that in the glutenin and gliadin fractions. The ratio of gliadin to total protein increases with protein content but albumin and globulin decreases. The lysine depressing effect occurs because gliadin is essentially devoid of lysine.

As lysine is the first limiting amino acid in wheat protein, a decrease in this amino acid must result in a reduction in BV. The BV shows a linear decrease with increase in protein concentration due to the lower lysine per unit protein. A similar relationship was reported by Khan and Eggum [11]. According to Eppendorfer [4], increased levels of N-fertilization resulted in an increase in the non essential amino acids glutamic acid and proline but a simultaneous decrease in lysine, threonine and cystine. In the present study, the glutamic acid, glycine and serine contents were higher while the

level of lysine, threonine and cystine were lowest in wheat having highest content of protein. Consequently, the BV was lower than in wheat low in protein. Similar results have also been reported by Eggum [2]. The net dietary protein calorie per cent of wheat bread has been reported by Khan and Eggum [9] to be above 5% and should theoretically meet the protein requirement of adults if consumed in adequate amounts.

The improvement in the quantity and quality of wheat grain should be achieved through breeding new varieties characterised by both high yield potential (per unit of time, land, water, and energy) and high protein with good balance of essential amino acids.

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