Ind J Plant Physiol. (April–June 2013) 18(2):183–186
DOI 10.1007/s40502-013-0025-z

SHORT COMMUNICATION

Characterization of grain nutritional quality in wheat

S. A. Mallick · Kousar Azaz · Moni Gupta · Vikas Sharma · B. K. Sinha

Received: 2 April 2012 / Accepted: 15 April 2013 / Published online: 6 August 2013

Abstract Ten Indian wheat varieties viz. RSP-566, RSP-561, PBW-396, HD-2687, C-306, PBW-175, RSP-81, PBW-550, DBW-17 and WH-542 were characterized for grain nutritional quality parameters viz., macronutrients (viz. starch, protein, protein fractions, sugars, fat), essential elements (calcium, phosphorus, iron and zinc), carotenoids, antioxidant and antinutritional parameters (phytic acid, total phenol, polyphenol oxidase (PPO) and trypsin inhibitor). RSP-561 possessed highest starch content, total protein, albumin, globulin, microelements (iron and zinc) and lowest antinutritional phytic acid and its grain contained second highest values of gluten (gliadin + glutenin), calcium, carotenoids and antioxidant contents and second lowest in antinutritional total phenol, PPO, trypsin inhibitor compositions. HD-2687 showed highest content of albumin, gliadin and total phenol constituents besides highest starch and total protein content. PBW-175 had highest sugar, calcium and carotenoids. However, antinutritional trypsin inhibitor, total phenol and PPO were found lowest in RSP-566, PBW-550 and RSP-81 respectively. The finding of this study concludes that on the basis of overall nutritional status, RSP-561 genotypes can be selected as one of best genotypes.

Keywords Grain quality · Starch · Protein fractions · Carotene · Antinutritional factors

S. A. Mallick (✉) · K. Azaz · M. Gupta · V. Sharma · B. K. Sinha
Division of Biochemistry and Plant Physiology, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu 180009, India
e-mail: mallick.sam@rediffmail.com

Among cereals, wheat is the most important crop in terms of production and consumption. World nutrition mostly depends on wheat and wheat products viz. chapati, bread, biscuit, pasta and fermented products, as the people all over the world consume wheat product(s) in one of these forms (Agrawal and Gupta 2006). A balanced food containing enough calories, balanced proteins and micronutrients with low antinutritional components is needed for the proper growth and development. Around three billion people throughout the world face problem of malnutrition due to micronutrient deficiency (Anonymous 2000). So, emphasis is being given to improve wheat grain nutrition quality to meet the challenge of world malnutrition. Therefore, along with optimal level of starch and protein, adequate level of essential elements like calcium, phosphorus, iron, zinc and carotenoids and antioxidant are needed to fight against world malnutrition. High protein and starch are important for growth and energy whereas gluten, a complex protein made of glutenin (Gln) and gliadin (Gld), is essential for water and gas retention ability for making loaf and chapati. Water soluble albumin and globulin improve biological value of protein and are considered as factors for nutritional superiority (Stehno et al. 2008). The divalent iron, calcium and zinc, which are directly involved in haemoglobin biosynthesis, ossification, and brain development respectively, are feared to be deficient with the increase of phytic acid level as they are made unavailable due to chelating action by phytic acid (Ekhlom et al. 2003), whereas trypsin inhibitor inhibits protein digestion and polyphenol produces brown coloured compound on oxidation by polyphenol oxidase (PPO) which makes flour and its product brown. Knowledge of nutritional status of wheat genotypes is being exploited for breeding programme for enhancing nutritional quality. Therefore, a detailed study of nutritional status of diverse wheat genotypes was

undertaken to characterize these genotypes in basis of quality traits.

This experiment was conducted during *rabi* (2010–2011) at Chatha farm, Sher-e-Kashmir University of Agricultural Sciences and Technology-Jammu, with ten leading wheat cultivars namely RSP-566, RSP-561, PBW-396, HD-2687, C-306, PBW-175, RSP-81, PBW-550, DBW-17 and WH-542. Sugars were extracted from harvested powdered grain sample by washing with hot 80 % ethanol. Starch was then extracted from sugar free residue by treating with 52 % cold (4 °C) perchloric acid. Both total sugar and starch were estimated colorimetrically by phenol sulphuric acid method (Dubois et al. 1956). Starch content was obtained by multiplying the glucose value by factor of 0.9. Reducing sugar was estimated from ethanol extract by the method of Miller (1972). Total crude protein was determined by micro-kjeldahl method (Sadasivam and Manickam 1992). Different protein fractions were extracted following the method of Dvoracek et al. (2001) and then estimated by the method of Lowry et al. (1951). Albumin (A) and globulin (G) were extracted from grain samples by dissolving with distilled water and 0.5 N NaCl solution respectively. Gln and Gld were then extracted from residue step wise by homogenizing with 5 ml of Na-Borate buffer pH 10.0, 70 % ethanol and 5 mM β-mercapto-ethanol (β-ME) gradually. Fat content was estimated following petroleum ether extraction (AOAC 1990).

Micro-elements were extracted by digesting wheat grain powder with di-acid mixture (nitric acid:perchloric acid 4:1 v/v). Zinc and iron were determined by atomic absorption spectrophotometer (HITACHI, Z-2300, Japan). Calcium and phosphorus content were estimated titrimetrically (Cheng and Bray 1951) and colorimetrically (Koenig and Johnson 1942). Carotenoids were estimated colorimetrically from ethanol extracted samples following Jensen (1978). For antioxidant assay, methanol (80 %) extracted flour sample was assayed by auto-oxidation of carotene and linoleic acid coupled reaction followed by the method of Emmons and Peterson (1999).

Antinutritional phytic acid was extracted from powdered grain sample with 3 % trichloroacetic acid and then precipitated as ferric salt and the iron content was estimated colorimetrically after developing colour with potassium thiocyanate. Phytate phosphorus content was calculated from this value assuming a constant 4Fe:6P molecular ratio in the precipitate (Wheeler and Ferrel 1971). Total polyphenol content was estimated colorimetrically from methanol extracted sample (Schanderi 1970). PPO was extracted from sample with ice cold 0.1 M Tris–HCl buffer (pH 7.5) containing 5×10^{-3} m mercapto-ethanol and PPO activity was assayed by measuring the rate of increased absorbance at 410 nm caused due to oxidation of substrate catechol (Augustin et al. 1985). Trypsin inhibitor was extracted in

Table 1 Grain nutritional quality parameters in different wheat varieties

Variety	Starch (%)	Total protein (%)	Total sugar (%)	Reducing sugar (%)	Albumin (%)	Globulin (%)	Glutenin (%)	Gliadin (%)	Fat (%)
RSP-566	72.33	11.58 (3.55)	4.01 (2.25)	3.08 (2.02)	1.27 (1.51)	1.82 (1.68)	4.37 (1.68)	4.14 (2.27)	1.29
RSP-561	74.15	12.60 (3.68)	4.03 (2.26)	3.32 (2.08)	1.36 (1.54)	1.77 (1.67)	5.30 (1.89)	4.25 (2.29)	1.32
PBW-396	70.95	10.71 (3.42)	3.34 (2.08)	2.25 (1.80)	1.21 (1.49)	1.68 (1.63)	3.66 (1.63)	4.18 (2.28)	1.58
HD-2687	74.30	12.83 (3.72)	3.01 (2.03)	2.32 (1.88)	1.49 (1.58)	1.56 (1.59)	5.01 (1.85)	4.78 (2.40)	1.45
C-306	69.50	11.18 (3.49)	4.73 (2.39)	3.55 (2.18)	1.43 (1.56)	1.56 (1.59)	5.02 (1.85)	3.20 (2.05)	1.54
PBW-175	66.15	12.06 (3.61)	5.80 (2.47)	3.83 (2.20)	1.46 (1.57)	1.44 (1.54)	5.08 (1.87)	4.07 (2.25)	1.71
RSP-81	66.47	11.85 (3.58)	5.10 (2.45)	4.32 (2.31)	1.24 (1.50)	1.50 (1.57)	5.07 (1.87)	4.02 (2.24)	1.55
PBW-550	68.90	12.33 (3.65)	4.86 (2.43)	3.05 (2.01)	1.46 (1.57)	1.42 (1.53)	5.08 (1.87)	4.25 (2.29)	1.59
DBW-17	67.80	11.00 (3.46)	3.85 (2.21)	2.91 (1.97)	1.45 (1.57)	1.56 (1.59)	4.29 (1.67)	3.72 (2.17)	1.27
WH-542	66.17	11.72 (3.57)	4.01 (2.25)	3.05 (2.14)	1.41 (1.55)	1.47 (1.56)	4.52 (1.70)	3.67 (2.16)	1.39
CD(0.05)	**2.340**	**0.240**	**0.420**	**0.200**	**0.025**	**0.016**	**0.170**	**0.140**	**0.11**

Within parentheses are transformed values

Table 2 Essential elements, carotenoids and antioxidant composition of the wheat varieties

Variety	Essential elements (mg 100 g^{-1} dry wt)				Carotenoids (μg 100 g^{-1})	Antioxidant (%)
	Calcium	Phosphorus	Iron	Zinc		
RSP-566	68.00	45.70	3.95	2.75	66.00	15.71
RSP-561	71.75	58.96	4.45	3.95	105.67	16.68
PBW-396	76.67	43.01	3.82	2.69	118.00	17.06
HD-2687	68.50	55.51	4.03	3.42	87.00	11.78
C-306	57.33	57.73	3.83	3.01	89.33	14.98
PBW-175	40.94	55.26	4.07	2.62	93.00	17.75
RSP-81	*25.42*	48.89	4.12	2.57	68.00	10.45
PBW-550	48.50	63.94	4.36	3.52	96.00	12.64
DBW-17	27.42	54.16	4.39	*2.50*	72.00	9.88
WH-542	28.00	41.57	4.18	2.53	65.33	12.56
CD (0.05)	0.52	2.82	0.08	0.13	7.35	0.49

distilled water and estimated spectrophotometrically using benzyl-DL-arginine para-nitroanilide Manjunath et al. (1983).

All measurements were made on samples drawn in triplicates. The data were analyzed by analysis of variance (ANOVA) and CD was calculated at $P \leq 0.05$.

Grain quality parameters for all the genotypes are shown in Table 1. HD-2687 showed highest values in starch, total protein, gluten and albumin but lowest in sugar, whereas RSP-561 possessed starch and total protein contents at par with HD-2687, had maximum water soluble protein (albumin + globulin = 3.13 %) and high gluten content (9.55 %) on the other hand PBW-175 revealed highest levels of total and reducing sugar and fat compositions, but had lowest starch content. RSP-566 recorded maximum values in globulin and starch (at par with HD-2687 and RSP-561) with moderate levels in sugars and proteins. Starch, besides energy and palatability provider also maintains the viscosity of flour to increase extensibility of the dough, an important factor for bakery products. In our study HD-2687, RSP-561 and RSP-566 with maximum starch content are potential candidates for bakery industry. Protein is an essential component for bread/or chapati making quality of wheat. High protein was reported to improve nutritional as well as bread/chapati making quality (Balla et al. 2011) and proteins assist to improve quality of food (Stehno et al. 2008). RSP-561 which possessed highest in albumin + globulin value was considered best for nutritionally rich protein. On the other hand, glutenin and Gld, the gluten constituents, responsible for gas and water retention capacity for better loaf/chapati making property were maximum in HD-2687 and RSP-561.

Besides enough calories and quantity/quality of protein, a balanced level of micronutrients is essential for proper growth and development. Table 2 depicts that grain calcium varied from 25.42 to 76.67, phosphorus 41.57–63.94, iron 3.82–4.45 and zinc 2.50–3.95 mg g^{-1} respectively. Carotenoids and antioxidant were highest in PBW-396 and PBW-175 respectively. RSP-561 had maximum iron and zinc content and was second highest in calcium and carotenoids. It is therefore considered most potential genotype that can overcome micronutrient deficiency in consumers.

Table 3 Antinutritional parameters in grains of the wheat varieties

Variety	Total phenol (mg g^{-1})	PPO (unit min^{-1} 100 g^{-1} grain)	Phytic acid (mg 100 g^{-1} grain)	Trypsin inhibitor (TIU)
RSP-566	3.93	3.63	0.53	66.33
RSP-561	3.88	3.59	0.38	98.33
PBW-396	4.94	6.75	0.42	135.67
HD-2687	5.14	6.73	0.35	114.00
C-306	4.68	8.63	0.46	318.83
PBW-175	4.9	6.74	1.19	368.33
RSP-81	3.89	6.93	0.66	394.09
PBW-550	5.07	3.36	0.65	150.05
DBW-17	4.24	4.78	1.20	154.02
WH-542	4.77	4.52	1.60	114.02
CD(0.05)	0.32	0.50	0.03	16.99

Data for antinutritional parameters revealed that phytic acid varied from 0.35 (HD-2687) to 1.60 mg 100 g^{-1} (WH-542), total phenol 38.80 (RSP-81) to 51.44 mg 100 g^{-1} (HD-2687), PPO 3.36 (PBW-550) to 10.63 unit min^{-1} 100 g^{-1} (PBW-396) and trypsin inhibitor 66.33 (RSP-566) to 394 TIU (RSP-81) respectively (Table 3). Antinutritional factors cause negative impact directly or indirectly to consumer's health and hence should be lowered down or removed from wheat grains to improve quality. Reducing antinutritional parameters has become an important criteria of breeding programme to improve wheat grain quality (Guttieri et al. 2006). In the present study, RSP-561 and RSP-566 had low total phenol and PPO and relatively low phytic acid and trypsin inhibitor values. So, both RSP-561 and RSP-566 are considered to have less antinutritional effect with better nutritional quality.

Out of the ten genotypes evaluated for nutritional RSP-561 possessed maximum levels of starch protein, iron, zinc, soluble protein fraction, gluten, calcium, carotenoids and antioxidant compositions and low phytic acid and total phenol, PPO and trypsin inhibitor. Hence, RSP-561 is considered the most nutritionally efficient genotype that can be used in the breeding programmes and processing industry for consumer.

References

Agrawal, P. K., & Gupta, H. S. (2006). Enhancement of nutritional quality of cereals using biotechnological options. In P. S. Kendurkar, G. P. Srivastava, M. Mohan & Vajpeyi (Eds.), *Proceeding of ICPHT* (pp. 48–58).

Anonymous. (2000). Fourth Report on the World Nutrition Situation, ACC/SCN (Administrative committee on coordination, subcommittee on Nutrition) and International Food Policy Research Institute. United Nations, Geneva.

AOAC. (1990). *Official Methods of Analysis, Association of Official Analytical Chemists* (15th edn.). AOAC International, USA.

Augustin, M. A., Ghazil, H. M., & Hussain, H. (1985). Polyphenol oxidase from guava (*Psidium guaava* L.). *Journal of the Science of Food and Agriculture, 36*, 1259.

Balla, K., Rakszegi, M., Li, Z., Bekes, F., Bencze, S., & Veisz, O. (2011). Quality of winter wheat in relation to heat and drought shock after anthesis. *Czech Journal of Food Science, 29*, 117–128.

Cheng, K. L., & Bray, R. H. (1951). Determination of calcium and magnesium in soil and plant material. *Journal of Soil Science, 72*, 449–458.

Dubois, M., Gilles, K. A., Hamilton, J. K., Rober, P. A., & Smith, F. (1956). Colorimetric estimation of carbohydrates by phenol sulphuric acid method. *Analytical Chemistry, 28*, 350–356.

Dvoracek, V., Moudary, I., & Curn, V. (2001). Studies of protein fractions in grain of split wheat *(Triticum split* L.) and common wheat (*Triticum aestivum* L.). *Scientific Agricultural Biochemica, 32*, 287–305.

Ekhlom, P., Liisav, M., Maija, Y., & Lisa, J. (2003). The effect of phytic acid and some natural chelating agents on the solubility of mineral elements in oat bran. *Food Chemistry, 80*, 165.

Emmons, C. L., & Peterson, D. M. (1999). Antioxidant activity and phenolics of oat groats and hulls. *Cereal Chemistry, 76*, 902–906.

Guttieri, M., Peterson, K., & Souza, E. J. (2006). Milling and baking quality of low phytic acid wheat. *Crop Science, 46*, 2403–2408.

Jensen, A. (1978). Chlorophyll and carotenoids. In A. Hellebust & J. S. Crargie (Eds.), *Hand book of phytological methods* (pp. 59–70). London: Cambridge University Press.

Koenig, R., & Johnson, C. (1942). Colorimetric determination of phosphorus in biological material. *Industrial and Engineering Chemistry, Analytical Edition, 14*, 155–156.

Lowry, O. H., Rosebrough, N. J., Farr, A. L., & Randall, R. J. (1951). Protein measurement with the Folin Phenol reagent. *Journal of Biological Chemistry, 193*, 265–275.

Manjunath, N. H., Veerabhadrappa, P. S., & Virupaksha, T. K. (1983). Estimation of trypsin inhibitors. *Phytochemistry, 22*, 2349–2357.

Miller, G. L. (1972). Use of dinitrosalicylic acid reagent for determination of reducing sugar. *Analytical Chemistry, 31*, 426–428.

Sadasivam, S., & Manickam, A., (1992). Estimation of nitrogen by Micro-Kjeldahl. In*Biochemical methods for agricultural sciences* (pp. 34–37). New Delhi: Wiley Eastern Limited.

Schanderi, S. H. (1970). *Methods in food analysis* (p. 709). New York: Academic Press.

Stehno, Z., Dvoracek, V., & Dotlacil, L. (2008). Wheat protein fractions in relation to grain quality characters of the cultivars. In *Proceedings of 11th International Wheat Genetics Symposium* (Vol. 2, pp. 556).

Wheeler, E. L., & Ferrel, R. E. (1971). A method for phytic acid determination in wheat and wheat fractions. *Cereal Chemistry, 48*, 312–320.