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Nutritive Appraisal of Various Wheat Varieties/Lines for Developing Biofortified Wheat (*Triticum Aestivum L.*)

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Abstract

Essential micronutrients such as iron and zinc deficiencies affect more than two billion people globally especially the pregnant women and children below the age of five. Wheat, like many other staple cereals, contains low levels of the essential micronutrients iron and zinc. It contributes 13.1 percent to the value added in agriculture and 2.8 percent to GDP of Pakistan. National Wheat Breeding program at Faisalabad, Pakistan analyzed 240 samples of wheat varieties/lines both from irrigated and rainfed conditions. The analysis revealed that 1000 grain weight ranged from 23.9-50.2 in irrigated and 31-42.0 g in rain-fed conditions while test weight range was found to be 59.9-75.8 (irrigated) and 64.5-79.9 Kg hl^{-1} (rain-fed). Protein and gluten content ranged between 12.0-16.1 & 13-16.2 and 21-34 & 21-38% in irrigated and rainfed trial, respectively. Starch content was found to be 51.8-57.1 and 51.9-56.1% in irrigated and rain-fed set, respectively. Falling No. (FN) values were recorded in the range of 352-814 in irrigated and 352-814 sec in the rain-fed set. Most of the varieties/lines had narrow range of Zn (31-32.6 & 31.2-33.9) and Fe (35-40 & 35-43 ppm) in irrigated and rainfed trial, respectively. In irrigated, conditions, cluster 3(5 genotypes) represented relatively high value of Fe and Zn contents while in rainfed condition, cluster 2 (31 genotypes) and cluster 3(15 genotypes) represented relatively high value Zn. Statistical analysis of both sets showed gluten & protein being directly correlated to each other, showing a positive correlation with Fe & Zn but a negative one with starch. In both sets, a direct correlation of FN with starch was observed only in rainfed set.

Keywords: Nutritive appraisal; Biofortified; Developin; Wheat

Introduction

Wheat production was estimated at 25.750 million tons during 2016-17 [1] which was surplus than country requirement and serves as an important indicator of food security. Annual consumption of wheat on per capita basis is 125 Kg [2] and mostly it is consumed as chapatti (unleavened flat bread).

Wheat, like many other staple cereals, contains low levels of the essential micronutrients iron and zinc. Globally up to two billion people are victim of iron and zinc deficiencies, particularly in regions with predominantly cereal-based diets [3]. Nutritional considerations, therefore, are vital. It contributes 13.1 percent to the value added in agriculture and 2.8 percent to GDP of Pakistan.

Wheat crops play an important role in satisfying daily calorie intake in Pakistan, but they are inherently very low in Fe, Zn and protein concentrations in grain, particularly when grown on Fe and Zn-deficient soils. Wheat serves as an important dietary item of the people of Pakistan and accounts for nearly 843 Kcal/capita/day of energy (37 percent of daily calories) and 22 g/capita/day of protein (37 percent of daily protein consumption). Therefore, it calls for quality depiction to determine nutritive value in respect of its intake.

Wheat was physico-chemically evaluated to find out its qualitative status in order to develop bio-fortified wheat which may be useful in overcoming Fe and Zn deficiency among vulnerable population. National Wheat Breading program based 240 samples of various wheat varieties/lines included in Irrigated and Rainfed National Uniform Wheat Yield Trials NUWYT) during 2016-17 were physico chemically analyzed for quality characteristics like 1000 grain weight, test weight, protein, starch, gluten, falling number, Fe and Zn.

Material and Method

Protein was determined by Kjeldahl method (Instruction manual VELP Scientifica). Two grams sample was taken and added a tablet of digestion mixture and 10 ml suphuric acid. Digested sample was diluted. After distillation sample was titrated against sodium hydroxide. Protein was determined after multiplying correction factor with nitrogen percentage. Starch by NIR instrument (instruction Manual Omeg Analyzer G) wheat sample was taken in hopper and used eighteen mm sample spacer for getting reading of starch content value [4]. Gluten content by glutomatic apparatus used in ISO-17025 certified CT Lab [5]. A 10 gram sample of flour weighed and placed into the glutomatic washing chamber on top of the polyester screen. The sample was mixed and washed with a 2 percent salt solution for 5 minutes. The wet gluten was removed from the washing chamber, placed in the centrifuge holder and centrifuged. The residue retained and passed through the screen was weighed. α-amylase activity by falling number apparatus being used in ISO-17025 certified CT Lab [6]. About seven gram sample of ground wheat was weighed and combined with 25 ml of distilled water in a glass falling number tube with a stirrer and shaken to form slurry. As the slurry was heated in a boiling water bath at 100 Degree Celsius and stirred constantly, the starch gelatinized and formed a thick paste. The time took the stirrer to drop through the paste was recorded as the falling number value. 1000 grain weight was determined by counting the grains from seed counter, Numigral II (Chopin, France). After counting 1000 grains, their weight was done with the help of balance (GR 200, Japan) used in the ISO-17025 Certified cereal technology laboratory. Test weight of the wheat samples was assessed with test weight apparatus. A bowl of one liter capacity was filled with wheat

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grains and by weighing with the help of this apparatus test weight was measured. Test weight of the wheat samples was assessed with test weight apparatus. A bowl of 1 liter capacity was filled with wheat grains and by weighing with the help of this apparatus, test weight was measured. Iron and Zinc were analysed by Atomic Absorption Spectrophotometer (Model: 969, Unicam Limited, Cambridge, UK); Furnace (Model: GF 90, Unicam Limited, Cambridge, UK) with temperature range 250-600 ± 10°C and Furnace Auto-Sampler (Model: FS 90, Unicam Limited, Cambridge, UK) through AOAC Method No. 985. 35 [7].

Results and Discussion

National uniform wheat yield trials (Irrigated and Rain-fed) samples were physico- chemically analysed for various quality characteristics. Analysis of the various quality parameters revealed; 1000 grain weight ranged from 23.9-50.2 g in Irrigated and 31.0-42.0 g in rain-fed condition while test weight range was found to be 59.9-75.8 (Irrigated) and 64.5-79.9 Kg hl^{-1} (rain-fed). Higher grain weight and test weight of varieties are related to higher production of wheat and are helpful to improve food security in the country [8]. Protein content ranged between 12.0-16.1 and 13.0-16.2 % in irrigated and rain-fed trial, respectively while gluten was found to be in the range of 21-34 % in irrigated set and 21-38 % in the rain-fed set. Higher values in combination with other foods [9] may be helpful to cover Protein Energy Malnutrition (PEM) Starch contents were found to be 51.8-57.1 and 51.9-56.1% in irrigated and rain-fed set, respectively and falling number value was recorded in the range of 352-814 sec in irrigated and rain-fed set. Falling number value recorded as more than 250 seconds represent sound wheat which may again indirectly related to improve food security. Most of the varieties/lines had narrow range of minerals i.e. 31-32.6 and 31.2-33.9 ppm Zn in irrigated and rain-fed trial while Fe ranged from 35-40 in irrigated and 35-43 ppm in rain-fed conditions, respectively [10]. In irrigated and rain-fed set, statistical analysis showed positive correlation of gluten with protein and Zn while it was negatively correlated with starch. Protein had positive correlation with Zn and negative correlation with starch (Tables 1 and 2).

Similarly iron depicted positive association with protein and Zn. Additionally in irrigated condition, association between gluten and iron was positive while iron had negative association with starch [11,12]. The vector view of the Biplot (Figures 1 and 2) provides a concise summary of the interrelationships among the traits and genotypes. The traits values are joined to the origin by side lines. Values with short spokes do not exert strong interactive forces. Those with extended spokes put forth well-built interaction. The values representing the traits are connected to the origin. In irrigated condition (Figure 3), cluster 1, cluster 2 and cluster 3 consisted of 33, 22 and 5 genotypes, which represent 55%, 37% and 8% of total genotypes, respectively. Cluster 1 exhibited relatively high value of protein and gluten while low value of starch percentage. Cluster 2 had relatively high value of grain weight while notably lowest value of falling number. Cluster 3 represented relatively high value of Fe and Zn contents. While in rainfed condition (Figure 4), cluster 1, cluster 2 and cluster 3 consisted of 14, 31 and 15 genotypes, which

	GW	Tw	Protein	Starch	Gluten	FN	Fe
TW	0.022						
P-Value	0.868						
Protein	0.110 0.402	0.160 0.223					
Starch	-0.156 0.234	0.203 0.121	-0.471** 0.000				
Gluten	0.094 0.477	-0.021 0.872	0.683** 0.000	-0.615** 0.000			
FN	-0.230 0.077	0.027 0.838	0.205 0.116	-0.125 0.339	-0.034 0.798		
Fe	-0.086 0.515	0.252 0.052	0.691** 0.000	-0.225** 0.084	0.402** 0.001	0.227 0.081	
Ze	0.121 0.358	0.088 0.504	0.696** 0.000	-0.379** 0.003	0.530** 0.000	0.067 0.609	0.695** 0.000

1000-Grain weight (GW), Test weight (TW), Falling number (FN), Iron (Fe), Zinc (Zn)
*Significant at 5% level and ** highly significant at 1% level.

Table 1: Correlation coefficients for qualitative traits in bread wheat under irrigated condition.

	GW	TW	Protein	Starch	Gluten	FN	Fe
TW	0.013						
P-Value	0.922						
Protein	-0.204 0.117	-0.228 0.080					
Starch	-0.148 0.259	0.155 0.238	-0.483** 0.000				
Gluten	-0.156 0.234	-0.234 0.072	0.629** 0.000	-0.511** 0.000			
FN	-0.073 0.581	0.103 0.434	-0.294* 0.022	0.318* 0.013	-0.225 0.084		
Fe	0.001 0.996	-0.070 0.594	0.602** 0.000	-0.148 0.260	0.359** 0.005	-0.128 0.329	
Ze	0.026 0.844	0.036 0.786	0.564** 0.000	-0.211 0.105	0.265* 0.041	-0.150 0.252	0.593** 0.000

1000-Grain weight (GW), Test weight (TW), Falling number (FN), Iron (Fe), Zinc (Zn)
*Significant at 5% level and ** highly significant at 1% level.

Table 2: Correlation coefficients for qualitative traits in bread wheat under rainfed condition.

Cluster Centroids								
Variables	Cluster-1		Cluster-2		Cluster-3		G. Centroid	
	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
Grain Wt (grams)	35.855	37.400	37.998	36.971	37.12	37.690	36.746	37.251
Test Wt (kg/hl)	69.455	75.611	69.786	75.479	70.91	74.437	69.697	75.249
Protein (%)	14.808	14.711	14.489	14.977	14.59	15.190	14.673	14.968
Starch (%)	54.523	54.425	54.784	54.190	54.64	53.737	54.628	54.132
Gluten (%)	28.121	27.321	27.909	28.097	26.70	28.867	27.925	28.108
Falling No.(Sec)	597.788	660.964	478.114	565.210	696.80	463.633	562.158	562.158
Fe (ppm)	37.742	38.768	37.205	39.645	38.30	39.500	37.592	39.408
Zn (ppm)	31.842	32.400	31.825	32.447	31.86	32.620	31.837	32.479

Table 3: Cluster analysis of wheat varieties/lines under irrigated and rainfed conditions.

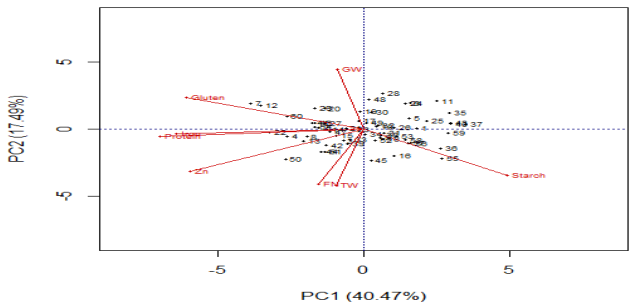

Figure 1: Biplot of wheat varieties/lines under irrigated condition.

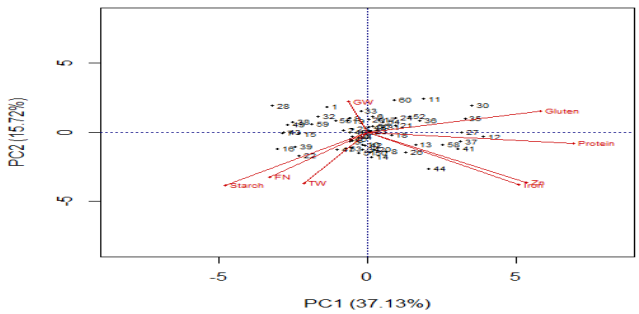

Figure 2: Biplot of wheat varieties/lines under rainfed condition.

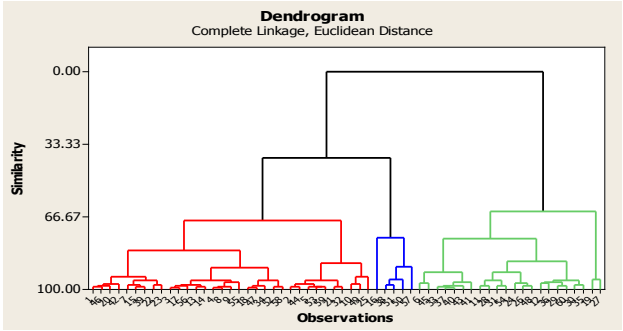

Figure 3: Dendrogram of wheat varieties/lines under irrigated condition.

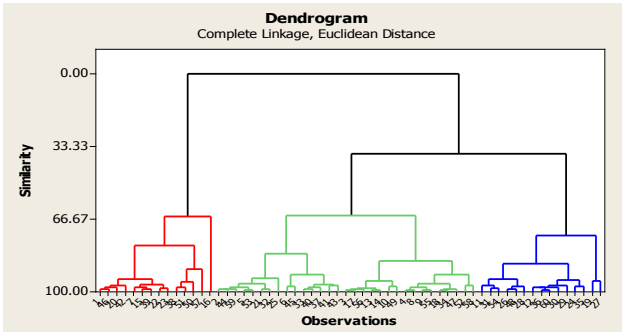

Figure 4: Dendrogram of wheat varieties/lines under rainfed condition.

represent 23%, 52% and 25% of total genotypes, respectively. Cluster 1 exhibited relatively high value of test weight. Cluster 2 had high value of Fe. Cluster 3 represented relatively high value of grain weight, protein, gluten and Zn while lowest value of falling number (Table 3). To cover iron and zinc deficiency among vulnerable population, it is the need of the time to fortify wheat flour with iron and zinc. Moreover, Blackstrap molasses may be added in the bakery products to replace their sugar contents and also to improve their iron content. Among other techniques best preferred approach is to develop wheat varieties containing high iron and zinc content [13]. For this purpose, various wheat varieties/lines are being screened for iron and zinc contents to develop bio-fortified wheat.

Conclusion

The analysis revealed that 1000 grain weight was higher (23.9-50.2 g) in irrigated than the rainfed condition (31-42.0 g) while test weight was found to be lower in irrigated condition (59.9-75.8) higher in rainfed condition (64.5-79.9 Kg hl^{-1}). Protein, gluten, and starch content ranged between 12.0-16.1, 13-16.2, 21-34 & 21-38 and 51.8-57.1 and 51.9-56.1% in irrigated and rainfed trials, respectively. Falling No. values were remained the same in both condition(352-814 sec) Most of the varieties/lines had narrow range of Zn (31-32.6 & 31.2-33.9) and Fe (35-40 & 35-43 ppm) in irrigated and rainfed trial, respectively. Statistical analysis of both sets showed gluten & protein being directly correlated to each other, showing a positive correlation with Fe & Zn but a negative one with starch. In both sets, a direct correlation of falling No. with starch was observed only in rainfed set. In irrigated, conditions, cluster 3(5 genotypes) represented relatively high value of

Fe and Zn contents while in rainfed condition, cluster 2 (31 genotypes) and cluster 3(15 genotypes) represented relatively high value Zn. To overcome iron and zinc deficiency among defenseless population, there could be several approaches such as fortifying wheat flour with iron and zinc, adding blackstrap molasses in the bakery products, however, the most preferred and sustainable option is the development of bio fortified wheat varieties and makes those available to the vulnerable masses.

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