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Effect of Environmental Changes on Phytic Acid Content of Wheat (*Triticum aestivum*)

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Abstract: Wheat (*Triticum aestivum*) is one of the most important food grain crops in all South Asian countries especially in India and Pakistan. These countries have diversifying soil and climatic conditions inserting measurable effect on nutritional as well as anti-nutritional parameters of wheat. Wheat varieties included in this study are collected from different agro-ecological zones of Pakistan. Myoinositol hexa-phosphate (phytic acid) one of major anti-nutritional factors wheat. Phytic acid of collected samples was determined to facilitate the crop breeders and agronomists, so that they would also consider this factor while conducting research works. It was observed that wheat varieties showed different levels of phytic acid at different locations. At one location (Islamabad), a variety (Pari-73) showed the highest value of Phytic acid (1.343%) and at other location (Faisalabad), same variety the showed lowest phytic acid (0.74%). This maximum variability (44%) also indicated that there was significant effect of change in location on phytic acid contents of wheat varieties. It is mainly due to presence of available phosphorus reserves in soil as phytate has direct relation to soil phosphorus.

Key words: *Triticum aestivum*, wheat varieties, Myoinositol hexa-phosphate phytic acid, environmental changes

INTRODUCTION

Wheat may be the first crop to be domesticated and acquired by most number of people as a foodstuff of life. It occupies a unique position in human diet since ancient times and is consumed in various forms in all part of the world (Anjum *et al*., 1998). Wheat is Asian most important cereal and staple food and demand has been growing much faster than for the rice. Wheat grains contain carbohydrates (60-80%) mainly as starch, protein (8-15%), which contain adequate amount of all essential amino acids except lysine, tryptophane and methionine, fat (1.5-2%) and vitamin B complex and vitamin E (Simmonds, 1976).

Even though its importance in the human nutrition is un doubtable, it also possesses anti-physiological factors such as phytic acid (Reddy *et al*., 1982) and polyphenols (Bressani and Elias, 1980) that tends to impair its nutritional quality. Phytic acid is known to interfere with the bioavailability of minerals in the diet and interacts with proteins (Bassirz and Nahapetian, 1976) and inhibits several proteolytic enzymes and amylases (Singh and Krikorian 1982; Sharma *et al*., 1978).

Phytate concentration in typical wholegrain cereal and oilseeds ranges from 1% (dry basses) for corn rice and wheat to 5% for defatted sesame meal (Erdman and Forbes, 1977).

Presence of phytic acid is considered detrimental to the nutritional quality of grain. It has been observed that variation in the environmental and organic factors has a greater influence on the concentration of various nutrients (Bassirz and Nahapetian, 1976; Sattar *et al*., 1985). Phytic acid and total phosphorous has great relationship with each other (Lolas *et al*., 1976) Similarly effect of varietal and environmental changes has great influence on the phytic acid content durum wheat's and their milled products (Tabekhia and Donnelly, 1982).

Phytic acid is chemically myo-inositol hexaphos-phate) having molecular formula of phytic acid is $C_6 H_{18} O_{24} P_6$ (MW. 660.03). Inositol is chemically hexahydroxycylohexane i.e. stereoisomeric alcohols. When OH^- group in inositol is replace with six phosphate groups than inositol hexaphosphate is form, which is commonly named as myoinositol hexaphosphate for its presence in muscles tissues. When two hydrogen atoms from phosphate group in myoinositol hexaphosphate are replaced with Ca, Fe, Zn, Mg etc result in formation insoluble salts of phytates as shown in (Fig. 1) and the minerals are not available (Erdman and Forbes, 1977).

Environmental and varietal difference exerted great effect on phytate content, which is significantly correlated with total phosphorus concentration. Harvesting year tends to influence the total phosphorus in the soil and ultimately to phytate content of the wheat (Kim *et al*., 2002).

The varieties selected for present study to check the effect of environment and variety are constantly used in

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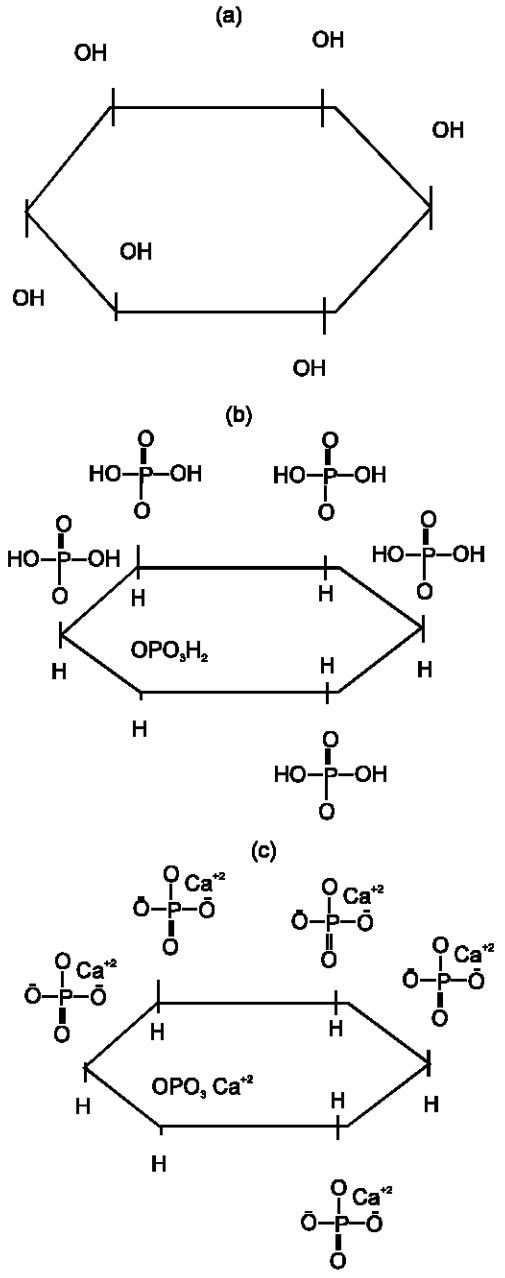

Fig. 1: Representative structure of (a) Myo-inositol (b) Myoinositol hexaphosphate (Phytic acid) (c) Calcium phytate

our crop breeding and improvement programs due to certain special features. These special features are short duration or early maturity (Sonalika, Blue silver), good bread/chapatti quality (Indus-79, Pak-81, Sindh-81, Lyp-73, Sandal, Lu-26), drought tolerance (Zamindar-80, Zarghoon, ZA-77), salt tolerance (Lu-26), high protein content (SA-75), etc.

In view of the nutritional significance of phytate, the present investigation was imitated to determine the effect of variety and environment on the phytic acid content of some wheat varieties grown in Pakistan.

MATERIALS AND METHODS

Wheat varieties used for crop quality improvement and breeding programs running at different parts of the country were collected from National Agricultural Research center, Islamabad, Ayub Agriculture Research institute, Faisalabad, Agriculture Research institute, Pirsolac, Nowshera (NWFP), Arid zone Research Institute, Quetta (Balochistan) and Tandojam University Sindh. Collected samples were stored at 10°C in polyethylene bags. Samples were grounded by using Cyclotec Mill (Cyclotec 1093, Tecator Sweden) according to the AACC (2000) method No 64-70A.

Phytic acid determination: Phytic acid was analyzed according to Haug and Lantzech (1983) method. According to this method an appropriate amount (0.8-1.0 gram) of sample was extracted with 0.2N HCl by taking 25 ml of 0.2N HCl in conical flask and shake for 1 h on shaker at 30°C and 80 revolutions per minute. 0.5 ml extract was taken into test tube fitted with a ground glass stopper. 1 ml of acidic ammonium iron-III sulphate solution of known iron content was added and the tubes were covered with a stopper and fixed with a clip. Tubes were heated in a boiling water bath for 30 min after cooling in ice water for 15 min; tubes were allowed to reach at room temperature. Contents of the tube were mixed and centrifuged for 30 min at 3000 revolutions per minute. 1 ml of the supernatant was transferred to another test tube and 1.5 ml of 2,2-bipyridine solutions was added, light pinkish color appeared. The absorbance was measured at 519 nm against distilled water. Decrease in iron, in the supernatant was measure for phytic acid contents. Standards of known phytic acid concentration were prepared and absorbance was measured at 519 nm. Standard curve was made taking phytic acid concentration in micrograms on X-axis and Optical Density (O.D) on Y-axis (Fig. 2). Phytic acid was calculated by using following formula:

$$\frac{\text{Micro gram from graph x dilution factor x 0.354 x 100}}{\text{Wt of sample x ml sample taken x 1000000}}$$

Statistical analysis: Data obtained was analyzed statistically by using complete randomized design with two factors factorial (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Phytic acid contents of 20 wheat varieties were compared for analyzing effect of environmental and varietal changes. Wheat in Pakistan is grown in planes of the Indus basin (Punjab and Sindh); coastal belt (Sindh and Balochistan); upland mountains (North-West

Table 1: Phytic acid contents of wheat varieties used in breeding program at NARC (Islamabad) and AARI (Faisalabad)

		Islamabad (NARC)		Faisalabad (AARI)		
S. No	Varieties	Phytic acid (%)	Standard Deviation	Phytic acid (%)	Standard Deviation	Variation (%)
1	Blue Silver	1.113^{c}	±0.002	0.89^{ghi}	±0.001	21
2	Pari-73	1.343^{a}	±0.036	0.74^{k}	±0.015	44
3	BWP-79	1.043^{ef}	±0.010	1.10^{cdf}	±0.001	5.1
4	Sandal	1.043^{ef}	±0.001	0.85^{ij}	±0.002	17
5	Aari-83	0.933^{g}	±0.017	0.83^{j}	±0.002	10
6	Lu-26	0.89^{ghi}	±0.002	1.053^{def}	±0.035	15
7	Indus-79	0.92^{g}	±0.035	1.0 03^{f}	±0.020	08
8	Punjab-81	0.86^{hij}	±0.012	1.210^{b}	±0.003	28
9	LYP-73	0.91^{gh}	±0.025	1.00 ^{f}	±0.004	09
10	Pak-81	1.103^{cd}	±0.002	1.100^{cdf}	±0.035	0.2
Variability (%) among varieties:			36 (%)		39 (%)	

*Values are mean±SD of three replications. *Means followed by same alphabets are non significant from one another for p = 5

Table 2: Phytic acid contents of wheat varieties used in breeding programs at NARC and Quetta

		Islamabad (NARC)		Quetta (Balochistan)		
S. No	Varieties	Phytic acid (%)	Standard Deviation	Phytic acid (%)	Standard Deviation	Variation (%)
1	Sonalika	0.80^{e}	±0.002	1.12^{c}	±0.001	28
2	Zarghoon	0.93^{d}	±0.015	1.10^{c}	±0.002	18
3	Pavon	0.90^{d}	±0.012	1.42^{a}	±0.025	36
4	Zamindar-80	0.86^{de}	±0.030	1.21^{b}	±0.015	28
Variability (%) among varieties:			14 (%)		22.50 (%)	

*Values are mean±SD of three replications. *Means followed by same alphabets are non significant from one another for p = 5

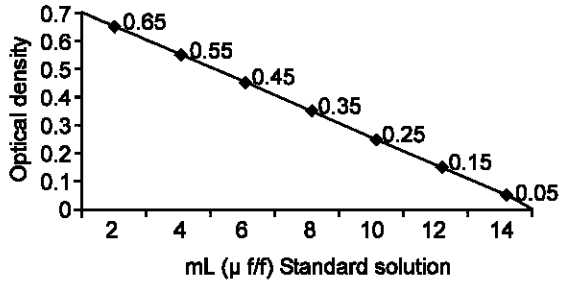

Fig. 2: Standard curve for phytic acid determination

Frontier Province (NWFP) and Balochistan) and northern areas. Wheat quality is greatly effect by these agro-ecological zones.

Phytic acid contents of wheat varieties used in breeding program at NARC (Islamabad) and AARI (Faisalabad): Comparison of overall range and mean values of phytic acid contents of wheat varieties grown at NARC and AARI was presented in Table 1. Phytic acid is between the range of 1.343-0.86% for Pari-73 and Punjab-81 respectively at NARC, Islamabad. Where as it is 1.21- 0.74% for Punjab-81 and Pari-73 respectively. Results also revealed that at one location (Islamabad), a variety (Pari-73) showing the highest value of phytic acid (1.343%) and at other location (Faisalabad), same variety showing the lowest phytic acid (0.74%). This maximum variability (44%) also indicated that there was significant effect of change in location on phytic acid contents of wheat varieties. It is mainly due to presence of available phosphorus reserves in soil as phytate has direct relation to soil phosphorus (Asada *et al*., 1969). Results also support the finding of kim *et al*. (2002) who described that Phytate contents was significantly correlated with total phosphorous concentration (r = 0.97, p<0.001). Harvest year also tends to influence the total phosphorous and phytate contents (p = 0.079 and p = 0.082), respectively.

Phytic acid contents of wheat varieties used for breeding programs at NARC (Islamabad) and Quetta (Balochistan): The results of the four varieties grown at two locations NARC (Islamabad) and Quetta (Balochistan) are shown in Table 2. The range of phytic acid was between 0.8-0.93% for Islamabad and 1.1-1.42% for Zargoon and Pavan at Quetta. Maximum variability was observed in Pavon (36%) having 0.90% phytic acid at NARC (Islamabad) and same variety showed highest levels of phytic acid (1.42%) at Quetta indicating location difference had significant effect on phytic acid contents. That was mainly because of change in soil conditions. Results are in line with (Bassirz and Nahapetian, 1976; Sattar *et al*., 1985). They have mention that variation in the environmental and organic factors has a greater influence on the concentration of various nutrients. Phytic acid and total phosphorous has great relationship with each other (Lolas *et al*., 1976).

Table 3: Phytic acid contents of wheat varieties used in breeding programs at NARC, Quetta and Pirsabak (NWFP)

		Islamabad (NARC)		Quetta (Balochistan)		Pirsabak (NWFP)		
S. No	Varieties	Phytic acid (%)	Standard Deviation	Phytic acid (%)	Standard Deviation	Phytic acid (%)	Standard Deviation	Variability
1	Sarhad-82	0.95^{d}	±0.002	0.99^{c}	±0.012	0.78^{k}	± 0.010	21 (%)
2	LYP-73	1.00^{cd}	±0.001	1.1b^{c}	±0.024	1.11^{bc}	± 0.014	10 (%)
3	Pak-81	1.00^{cd}	±0.025	1.21^{b}	±0.014	1.27^{b}	± 0.015	21 (%)
Variability (%) among varieties:				2.93 (%)		8.94 (%)		23.72 (%)

*Values are mean±SD of three replications. *Means followed by same alphabets are non significant from one another for p = 5

Table 4: Phytic acid contents of wheat varieties used in breeding programs at NARC and Tandojam

		Islamabad (NARC)		Tandojam (Sindh)		
S. No	Varieties	Phytic acid (%)	SD	Phytic acid (%)	SD	Variability (%)
1	Blue Silver	1.113^{c}	±0.001	1.22	±0.003	7%
2	Pavon	0.90^{d}	±0.001	0.87	±0.020	3%
3	Tj-83	0.99^{c}	±0.025	0.82	±0.001	17%
4	Za-77	0.86^{de}	±0.015	0.91	±0.010	5.5%
Variability (%) among varieties:			22 (%)		25 (%)	

*Values are mean±SD of three replications. *Means followed by same alphabets are non significant from one another for p = 5

Phytic acid contents of wheat varieties used in breeding programs at NARC, Quetta and Pirsabak: Phytic acid contents of three wheat varieties grown at three locations are listed in Table 3. Phytic acid ranged from 0.95-1% at NARC (Islamabad), 0.99-1.21% at Quetta (Balochistan) and 0.78-1.27% at Pirsabak (NWFP). Maximum variability was observed in varieties grown at Pirsabak (23.72%) followed by Quetta (Balochistan) (8.94%) and Islamabad (2.93%). Statistical analysis showed that neither variety nor location had a significant effect on phytic acid contents of the whole wheat but location mean showed that phytic acid level were slightly higher at Quetta than at Pirsabak and both had higher levels than Islamabad.

Phytic acid contents of wheat varieties used in breeding programs at Islamabad (NARC) and Tandojam: The results of the four varieties grown at two locations NARC Islamabad and Tandojam (Sindh) are shown in Table 4. The range of phytic acid was between 0.86-1.113% for Islamabad and 0.91-1.22% for Tandojam (Sindh) Maximum variability (25%) for varieties grown at Tandojam (Sindh) was observed while for Islamabad the variability was (22%). Blue Silver had highest phytic acid content (1.22%) from Tandojam (Sindh) and lowered values observed for TJ-83 (0.82%). Results showed that varietal difference had non-significant effect on phytic acid content but location had a significant effect on phytic acid levels. That was mainly because of change in soil conditions.

Conclusion: Environmental and varietal difference exerted great effect on phytate content, which is significantly correlated with total phosphorus concentration. Harvesting year tends to influence the total phosphorus in the soil and ultimately to phytate content of the wheat The varieties selected constantly used in our crop breeding and improvement programs due to certain special features. These special features are short duration or early maturity (Sonalika, Blue silver), good bread/chapatti quality (Indus-79, Pak-81, Sindh-81, Lyp-73, Sandal, Lu-26), drought tolerance (Zamindar-80, Zarghoon, ZA-77), salt tolerance (Lu-26), high protein content (SA-75), etc.

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