

THE PHYTIC ACID-TOTAL PHOSPHORUS RELATIONSHIP IN BARLEY, OATS, SOYBEANS, AND WHEAT

G. M. LOLAS¹, N. PALAMIDIS¹, and P. MARKAKIS¹

ABSTRACT

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The following correlation coefficients were found between phytic acid content and total P content of four seed types: 0.9612 for barley, 0.9103 for oats, 0.9852 for soybeans, and

0.9682 for wheat. This high correlation may be used for the estimation of phytic acid content through the simpler total P determination.

Phytic acid, which is myo-inositol 1,2,3,4,5,6-hexakis (dihydrogen phosphate), has attracted considerable attention in recent years as it interferes with the intestinal absorption of certain minerals, especially zinc, and thereby causes nutritional deficiencies (1). In a previous communication (2) the observation was made that the phytic acid content of dry beans is highly correlated with their total P content. A similar relationship was sought in this paper for several other seeds. Should such a relationship exist, the relatively simple determination of total P could be used to estimate phytic acid content, as the direct determination of the latter is rather tedious and time-consuming.

MATERIALS AND METHODS

The following seeds were used: 15 cultivars of soybeans, 19 cultivars of oats, 18 cultivars of barley, and 38 cultivars of wheat, the names of which are given in Table I. The samples (1-2 lb each) of soybeans, oats, and barley were provided by the Michigan Agricultural Experiment Station and those of wheat by both the Michigan and Kansas Agricultural Experiment Stations. Five samples of wheat mill bran were also analyzed.

The moisture of the samples was determined by the vacuum-oven method (3). Allen's (4) colorimetric method was used for the determination of total P after perchloric acid digestion. The phytic acid content was measured by a combination of two methods. The extraction and precipitation of phytic acid as ferric phytate was conducted according to Wheeler and Ferrel (5), and the iron of the precipitate was determined by Makower's method (6).

RESULTS AND DISCUSSION

The results of the analyses (duplicate or triplicate samples), expressed on a dry weight basis, are shown in Table I.

The total P and the phytic acid contents of the seeds studied were found to be related by the following linear regression equations:

¹Department of Food Science and Human Nutrition, Michigan State University, East Lansing, MI 48824. This paper has received Michigan Agricultural Experiment Station Journal Article No. 7512.

TABLE I
Total Phosphorus and Phytic Acid Contents of Seeds Studied

Varieties	Total P % Dry Weight	Phytic Acid % Dry Weight	Phytic Acid P as % of Total P
Soybeans			
Wells Ont.	0.583	1.13	54.6
Corsoy Mi.	0.559	1.05	52.9
Tracy S.R.L.	0.616	1.19	54.4
Kim IA.	0.532	1.00	52.9
Bragg S.R.L.	0.573	1.11	54.5
Swift Mi.	0.642	1.21	53.1
Davis S.R.L.	0.568	1.06	52.5
Hodgson Mi.	0.589	1.09	52.1
Beeson Ont.	0.574	1.09	53.5
Amsoy Ont.	0.559	1.03	51.9
Prize IA.	0.585	1.07	51.5
Reg XK 505	0.608	1.13	52.3
Hartwood Ont.	0.553	1.01	51.4
SRF Mi.	0.715	1.45	57.1
71-6234 S.R.L.	0.745	1.47	55.6
Oats			
Hudson	0.412	0.87	59.5
Scott	0.368	0.79	60.4
OA272DI	0.426	0.99	65.4
CLD64	0.432	0.94	61.3
Stout	0.431	0.93	60.8
PO61353B393	0.454	0.99	61.4
Jaycee	0.420	0.95	63.7
Noble	0.439	0.96	61.6
Ill. 69-745	0.412	0.89	60.8
Ill. 67-1514	0.391	0.84	60.5
Ill. 69-1644	0.438	0.98	63.0
Gopher	0.402	0.88	61.6
M 71101	0.445	1.01	63.9
NY 6083-1	0.418	0.90	60.6
DAL	0.442	1.00	63.7
Mackinaw	0.407	0.82	56.7
Wisx 2456-2	0.420	0.94	63.0
Mariner	0.410	0.86	59.1
Orbit	0.411	0.89	61.0
Barley			
Barbless	0.427	1.04	68.6
Manchuria	0.430	1.04	68.1
Traill	0.432	1.02	66.5
Larker	0.416	1.01	68.4
Prilar	0.428	1.03	67.8
H 379-2	0.437	1.06	68.3
Conquest	0.448	1.07	67.2
Bonanza	0.428	1.04	68.4
SD 69-1781	0.494	1.16	66.1
Manker M16	0.445	1.05	66.4
M 18	0.421	1.04	69.6

TABLE I *continued*
 Total Phosphorus and Phytic Acid Contents of Seeds Studied

Varieties	Total P % Dry Weight	Phytic Acid % Dry Weight	Phytic Acid P as % of Total P
<i>Barley, continued</i>			
Beacon B140	0.457	1.08	66.5
ND 231	0.432	1.04	67.8
ND 718	0.458	1.08	66.4
X 1664-1	0.408	0.98	67.6
M 23	0.426	1.05	69.4
ND 1218	0.447	1.06	66.8
X 1894-11	0.397	0.97	68.8
Wheat			
Genesee	0.432	1.19	77.6
Yorkstar	0.402	1.08	75.6
Arrow	0.436	1.17	75.6
Ionia	0.453	1.22	75.8
Fredrick	0.453	1.16	72.1
Tecumseh	0.476	1.35	79.9
UO 915	0.399	1.12	79.0
Arthur	0.436	1.09	70.4
MO 250	0.441	1.19	76.0
ABE	0.438	1.10	70.7
Oasis	0.442	1.15	73.3
Logan	0.450	1.15	72.0
A 7170	0.473	1.20	71.4
A 9094	0.440	1.21	77.4
A 9096	0.408	1.10	75.9
BO 270	0.446	1.18	74.5
Yamhill	0.454	1.14	70.7
UO 912	0.428	1.09	71.7
UO 847	0.461	1.24	75.7
UO 788	0.437	1.18	76.0
Kaw 61 Lancer	0.332	0.80	67.8
69-313 Omaha	0.362	0.88	68.4
Gage 67-324	0.434	1.05	68.1
Apache	0.283	0.62	61.7
Chanute	0.387	0.93	67.7
Centurk	0.317	0.75	66.6
Moto Parker	0.354	0.87	69.2
Monon Woosten	0.396	1.03	73.2
Thorne #73407	0.468	1.23	74.0
Blueboy #73424	0.414	1.02	69.4
Yorkstar #73425	0.404	0.98	68.3
Avon #73408	0.445	1.09	69.0
Burt	0.289	0.66	64.3
Club	0.294	0.73	69.9
Durum	0.302	0.68	63.4
Amber Durum	0.365	0.91	70.2
Chris	0.524	1.33	71.5
Soft Red Winter	0.406	1.03	71.4

TABLE II
Total Phosphorus and Phytic Acid Contents of Wheat Mill Bran

Varieties	Total P % Dry Weight	Phytic Acid % Dry Weight	Phytic Acid P		% Diff.
			as % of Total Phosphorus	% Phytic Acid from Formula	
X 932-1	1.504	4.59	85.9	4.69	2.2
Wisc. 265	1.778	5.52	87.4	5.61	1.6
Ill. 69-1	1.497	4.74	89.2	4.67	1.5
Purdue 67137 B3-6	1.643	5.11	87.6	5.16	1.0
MO W8135	1.559	4.73	85.4	4.88	3.2

Soybeans: $Y = 0.133 + 0.410X$

Oats: $Y = 0.153 + 0.291X$

Barley: $Y = -0.092 + 0.504X$

Wheat: $Y = 0.096 + 0.300X$

where Y is the percentage content in total P and X is the percentage content in phytic acid. The correlation coefficients (r) and the standard errors of estimate ($s_{y,x}$) were:

Soybeans: $r = 0.9852$ $s_{y,x} = 0.008\%$

Oats: $r = 0.9103$ $s_{y,x} = 0.007\%$

Barley: $r = 0.9612$ $s_{y,x} = 0.009\%$

Wheat: $r = 0.9682$ $s_{y,x} = 0.014\%$

The mathematical formula, derived for the phytic acid estimation in wheat, can be used for the estimation of phytic acid in wheat bran, as well. Table II shows that the percentage difference between the results of the actual analysis of bran and those derived through the total P determination using the mathematical expression is small. Wheat bran contains most of the total P and phytic acid of the seed and it should not be surprising that the actual results of phytic acid determination agree with the estimated results when the same formula is used. The oat cultivars were all dehulled; cv. Orbit, however, was also available with the hulls on. The total P content of the nondehulled Orbit was 0.472% and that of phytic acid was 1.08% (dry weight basis); based on the general equation for oats, the phytic acid content of hulled Orbit would have been 1.096%, a difference from the analytical value of less than 1.5%.

The above relations may be useful to the investigator who wishes to determine phytic acid in a number of grain varieties of the same species, and it may also be of use to the plant physiologist.

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Literature Cited

- OBERLEAS, D. Phytates, in toxicants occurring naturally in foods. Nat. Acad. Sci.: Washington, D.C. (1973).

2. LOLAS, G. M., and MARKARKIS, P. Phytic acid and other phosphorus compounds of beans (*Phaseolus vulgaris* L.). *J. Agr. Food Chem.* 23: 13 (1975).
3. ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. Methods of analysis. The Association: Washington, D.C. (1970).
4. ALLEN, R. J. L. The estimation of phosphorus. *Biochem. J.* 34: 858 (1940).
5. WHEELER, E. L., and FERREL, R. E. A method for phytic acid determination in wheat and wheat fractions. *Cereal Chem.* 48: 312 (1971).
6. MAKOWER, R. U. Extraction and determination of phytic acid in beans (*Phaseolus vulgaris*). *Cereal Chem.* 47: 288 (1970).

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