PHOSPHORUS DISTRIBUTION IN GRAINS [1]

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INTRODUCTION

In past years considerable attention has been given to the subject of nitrogen and carbohydrate fractionation of plant materials, and a vast sum of data has accumulated. Phosphorus and its compounds in plants have, however, been little studied. Recent advances in methods of study, especially of the phospholipin fraction, have directed attention to the phosphorus compounds in plants, and the writer has undertaken to make a rather complete study of changes occurring both in seeds and in green plants. As a preliminary step toward this end, a study of the phosphorus fractions in a group of seeds has been made and the results are reported in this article. Previous workers have made studies on certain of these fractions in grains, but none seems to have made a comprehensive fractionation.

REVIEW OF LITERATURE

Averill and King (*2*)[3] have determined the phytin content of several foodstuffs and give a discussion of the method and modifications they used. Their results are expressed as phytin. Rather (*8*) also has worked on the Heubner and Stadler method for phytin estimation and his procedure is the one followed in the present work. He reports some results for total and acid-soluble phosphorus as well as phytin, in plant materials. Collison (*3*) reports on the inorganic phosphorus content of several grains and also gives an improved method for its estimation, which method is the one used in this work.

The solubility and distribution of phosphorus compounds in seeds has also been studied by Koehler (*7*). His extensive work deals mainly with total, inorganic, and organic compounds in a few seeds, and a large part of his work is on methods.

Guerrant (*5*) has analyzed seeds of various kinds for their phospholipin content and discusses the relation of this fraction to various other constituents such as ash, fat, and protein. He finds no significant relationship. Other workers have made various phosphorus determinations on plant material, but the foregoing summarizes the more important recent publications.

EXPERIMENTAL METHODS AND DATA

The seeds used in the work here reported were all of the 1927 crop and were stored in half-gallon jars with p-dichlorobenzene added as a disinfectant. Openings, screened with fine copper gauze, were

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[3] Reference is made by number (italic) to "Literature cited," p. 125.

made in the caps to permit gas exchange. The seeds, before analysis, were so ground as to pass the finest mesh screen of the Wiley mill.

Two-gram samples of the finely ground seeds were dried overnight at 105° C. and weighed for moisture determination, after which the samples were ashed in a muffle furnace and weighed to secure the ash.

The fat percentage was obtained by the usual ether-extraction method run on dried samples.

Germination was made early in the fall and was intended to give some idea of viability, since it was thought that changes in viability might occasion certain phosphorus changes.

The determination of total phosphorus was made according to the official volumetric method (*1*) on samples digested, using H_2SO_4, K_2SO_4, and $CuSO_4$, as was done by Jones and Perkins (*6*).

Phospholipin phosphorus was determined by the microcolorometric method of Guerrant (*4*), modified only to the extent of using 50 c. c. of the alcohol-ether mixture per gram of material in place of the 25 c. c. which he recommends.

The determination of phytin phosphorus was carried out by the iron-titrametric method suggested by Rather (*8*).

Collison's improved method as given in the Journal of Biological Chemistry (*3*) was used without change for the determination of inorganic phosphorus.

The values of other phosphorus were secured by subtracting the sum of the various fractions from the total phosphorus figure. It necessarily follows that this figure is not of great value since it contains the errors of the other figures.

The figures in Table 1 are calculated to a dry-weight basis. In every case a sufficient number of determinations was made to secure closely checking and consistent figures, and wherever possible these were compared with published results in other articles.

TABLE 1.—*Analysis and percentage germination of seeds as related to the distribution of phosphorus*

Seeds analyzed	Percentage germination	Percentage of water	Analysis expressed in percentage of dry weight						
			Fat	Ash	Total phosphorus	Phytin phosphorus	Lipoid phosphorus	Inorganic phosphorus	Other phosphorus
Mung bean	100	8.94	0.77	3.77	0.5305	0.3418	0.0404	0.0239	0.1244
Soy bean	100	6.65	16.90	5.54	.5469	(a)	.0966	.0178	-------
Cowpea	95	8.84	1.73	3.28	.4736	.1438	.0459	.0282	.2557
Wheat	80	8.68	2.33	1.77	.4274	.3033	.0283	.0210	.0748
Barley	72	8.08	2.39	2.96	.3937	.1794	.0220	.0222	.1701
Common kafir	62	11.04	3.23	1.82	.3704	.2800	.0206	.0157	.0541
Yellow corn	98	8.48	5.25	1.50	.3468	.2865	.0352	.0124	.0127
Oats	98	8.23	4.94	3.99	.3453	.1905	.0290	.0149	.1109
White corn	94	8.79	5.85	1.48	.3194	.2443	.0485	.0156	.0110
Darso	64	10.65	3.57	1.49	.3117	.2714	.0227	.0158	.0018
Rye	75	8.79	1.99	1.87	.2947	.2059	.0325	.0197	.0366

[a] The solutions were so colored that no satisfactory results could be secured.

DISCUSSION

In discussing the data presented in Table 1, only one salient fact stands out: There seems to be no relation between the total phosphorus content of the seeds and that of any of the fractions, nor is

there any comparable variation found among the different fractions. It was thought that perhaps there would be some relation shown between the fat and phospholipin content, but such is not the case. While it is true that low germination appears to be associated with low phospholipin content, this is probably accidental. It was also thought that there might be some relation between the ash content and the inorganic phosphorus, but no constant relationship is apparent. Phytin phosphorus is, in nearly every case, the most important fraction; in only two instances does it constitute less than 50 per cent of the total and in Darso it represents 87 per cent. The inorganic phosphorus represents only a very small percentage of the total, as does also the phospholipin fraction in most instances.

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