EFFECT OF PHYTATE CONTENTS OF CEREALS ON BIOAVAILABILITY OF TOTAL PHOSPHORUS IN POULTRY

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ABSTRACT

Different cereals were examined for their total and phytate phosphorus contents along with bioavailability. Bioassay was conducted on 18 weeks old cockerels of White Leghorn breed. They were starved for 24 hours and were forced-fed 30 grams of prepared single feed stuff and droppings were collected at regular time intervals. Total phosphorus contents for rice (polished), wheat, barley, maize (red), maize (white) and sorghum (white) were 0.16, 0.28, 0.25, 0.24, 0.23 and 0.28 percent, respectively which contained 0.04, 0.18, 0.15, 0.17, 0.18 abd 0.24 percent phytate phosphorus, respectively. The bioavailability values for these feed stuffs were 66.41, 64.04, 61.25, 53.46, 47.06 and 41.26 percent, respectively. The phytate phosphorus contents were negatively correlated ($P<0.01$) with available phosphorus.

Key words: Bioavailability, phosphorus, phytate, cereals.

INTRODUCTION

Cost of production is considered to be a very important factor in raising commercial poultry. The major share in cost of production is contributed by feed only and thus it markedly influences the economics of meat and egg production (Singh and Panda, 1990). Preparation of an efficient quality feed needs information about the bioavailability of different nutrients because chemical analysis does not take into account the nutritive losses occurring during digestion (Maynard and Loosley, 1969).

Among minerals, the availability of phosphorus of plant sources is limited because much of the element present in cereal grains is in the form of phytates, which are salts of phytic acid, a phosphoric acid derivative (McDonald *et al*., 1999). Phytic acid is an undesirable dietary agent which binds certain minerals such as Calcium (Ca^{++}), Magnesium (Mg^{++}), Iron (Fe^{++}) and Zine (Zn^{++}), and renders them unavailable for their physiological functions by forming insoluble compounds in the intestine (Verma, 1997). Phytate is a normal constituent of almost all cereals constituting 1-3% by weight. About 30-90% of total phosphorus is in the form of phytate (Nelson, 1967; Nelson *et al*., 1968; McDonald *et al*., 1999).

The present study was undertaken to determine the effect of phytate contents on bioavailability of total phosphorus and to correlate the phytate contents with available phosphorus in poultry.

MATERIALS AND METHODS

Determination of total phosphorus, phytate contents and their bioavailability was conducted through an experiment in Animal Nutrition Department at University of Agriculture Faisalabad. The bioassay was made on 18 weeks old cockerels of White Leghorn breed. The experimental birds were housed in individual wire cages in an environmentally controlled room. Clean and fresh water was provided *ad libitum* and 12 hours light was provided each day. They were given stock diet for one week followed by feeding test feed stuffs after starving for 24 hours to ensure complete elimination of residue of previous feed from the elementary canal. Six prepared test feed stuffs. i.e. rice (polished), wheat, barley, maize (red), maize (white), and Sorghum (white) were allotted to 18 test birds at random in such a way that each feed stuff was forced-fed to 3 birds (Sibbald, 1976). Dry matter contents of feed samples were also analyzed at the same time (A.O.A.C., 1984). Four birds served as negative control for the estimation of endogenous and metabolic losses. The excreta voided during subsequent 48 hours were collected in collection trays separately, freeze-dried and then weighed. The excreta and samples of test material were analyzed for total (A.O.A.C., 1984) and phytate phosphorus contents (Wheeler and Ferrel, 1971). The bioavailability was calculated (Sibbald, 1982) as under:

$$\text{Bioavailability} = \{ Ip (Ep - Cp) \div Ip \} \times 100,$$

Where Ip = Intake of phosphorus
Ep = Excreta phosphorus
Cp = Excreta phosphorus of control birds

RESULTS AND DISCUSSION

Phytate contents

The data in Table 1 reflects that rice (polished) has the lowest phytate contents while sorghum (white) contained the highest. The phytate contents of rice (polished) in the present study (25% of the total phosphorus) were lower than those (51% of the total phosphorus) reported by other workers (Asada and Kasai, 1962; Resurreccion *et al*., 1979). This low phytate percentage of rice (polished) in the present study may be due to the provision of more irrigation which tends to increase the total phosphorus contents of cereal grains and the increase occurs in the inorganic portion only and the phytate contents remain the same (Greaves and Hirst, 1929) so phytate percentage decreases in polished rice.

Wheat contained 64.29% phytate contents which fall within the range (63-74% and 60-80%) investigated by Lolas *et al*. (1976) and Singh and Reddy (1977), respectively. The Phytate contents in wheat (72.79%) reported by National Research Council (1994) are also comparable with the results of the present study.

The phytate contents of barley (60%) in the present study are somewhat lower than the values (66 and 72%) reported by Lolas (1976) and National Research Council (1994), respectively. This variation might be due to the difference in method of chemical analysis, as extraction grades differ for different grains (Wheeler and Ferrel, 1971). Maize (red) contained 70.83% phytate contents which is close to 66% reported by National Research Council (1994). The value of phytate (78.26%) for maize (white) was higher than the value for maize (red) in the present study. Sorghum (white) contained 85.71% phytate contents which are comparable to those (71-89.9%) reported by Radhakrishnan and Sivaprasad (1980) and Reddy and Salunkhe (1981).

Bioavailability of total phosphorus

The available phosphorus contents of rice (polished), barley and sorghum (white) were 0.11, 0.15 and 0.12% in the present study which are comparable to those (0.09, 0.16 and 0.10%, respectively) reported by Hubble (1989). Whereas the values (0.18, 0.13 and 0.11%) for wheat, maize (red) and maize (white) in the present study are somewhat higher than the values (0.15, 0.08 and 0.07% respectively) reported by Hubble (1989) and 0.10, 0.10% and nil, respectively, reported by Boltan and Blair (1973). The reason may be that these scientists might not have taken into account the phytate phosphorus availability as it is evident from the fact that the findings of these scientists regarding available phosphorus are equal to non-phytate phosphorus of National Research Council (1994) which is considered to be available completely.

Table 1. Average total and available total phosphorus (P) and phytate phosphorus (%) along with their bioavailability and correlation

Sr. No.	Ingredients	Total P	Phytate P	Phytate P %age	Available		Bioavailability		Correlation	
					Total P	Phytate P	Total P	Phytate P	R_1	R_2
1	Rice (polished)	0.16	0.04	25.00	0.11	0.02	66.41	50.50	0.90	-0.88
2	Wheat	0.28	0.18	64.29	0.18	0.08	64.04	45.09	0.99	-0.99
3	Barley	0.25	0.15	60.00	0.15	0.05	61.25	33.92	0.90	-0.90
4	Maize (red)	0.24	0.17	70.83	0.13	0.06	53.46	33.56	0.99	-0.84
5	Maize (white)	0.23	0.18	78.26	0.13	0.06	47.06	36.35	0.97	-0.99
6	Sorghum (white)	0.28	0.24	85.71	0.12	0.07	41.26	31.18	0.90	-0.90

R1 = Correlation between total phosphorus and its bioavailability
R2 = Correlation between phytate contents and total phosphorus availability

Effect of phytate contents on total phosphorus availability

Table 1 shows that as the phytate contents of cereals, commencing from polished rice to sorghum (white) increase, the respective bioavailability decreases accordingly except wheat. There was a downward trend of bioavailability values as compared to the upward trend of phytate contents of the cereals shown in Table 1. However, the bioavailability of total phosphorus from wheat was somewhat higher than barley inspite of the fact that wheat contained higher amount of phytate than barley. The reason of this change in overall trend of phytate effect on bioavailability of total phosphorus was that wheat contains phytase enzyme which increases the availability of phytate (McDonald *et al.*, 1999).

The phytate contents were correlated with bioavailability of phosphorus in cereals (Table 1). A negative correlation was found between them and it ranged between -0.84 and -0.99, with an average value of -0.92. The significant negative correlation coefficient found between phytate and available phosphorus contents of cereals indicated that when the phytate contents of cereals are increased gradually, the available phosphorus is decreased accordingly. Similar negative correlation between phytate contents and bioavailability of total phosphorus was found by Qi *et al.* (1984) and Ishtiaq (2002). This high negative correlation between phytate contents and bioavailability of total phosphorus is reflected in Figure 1.

Conclusions

1. The phytate contents of cereals have negative effect upon bioavailability of total phosphorus.
2. The phytate contents of cereals ranged between 25.0 to 85.71 per cent of the total phosphorus while the bioavailability of total phosphorus in adult poultry ranged between 41.25 to 66.41 per cent.
3. Bioavailability of total phosphorus in cereals can be increased for poultry by increasing the availability of phytate contents from the diet in the body through enzyme treatment.

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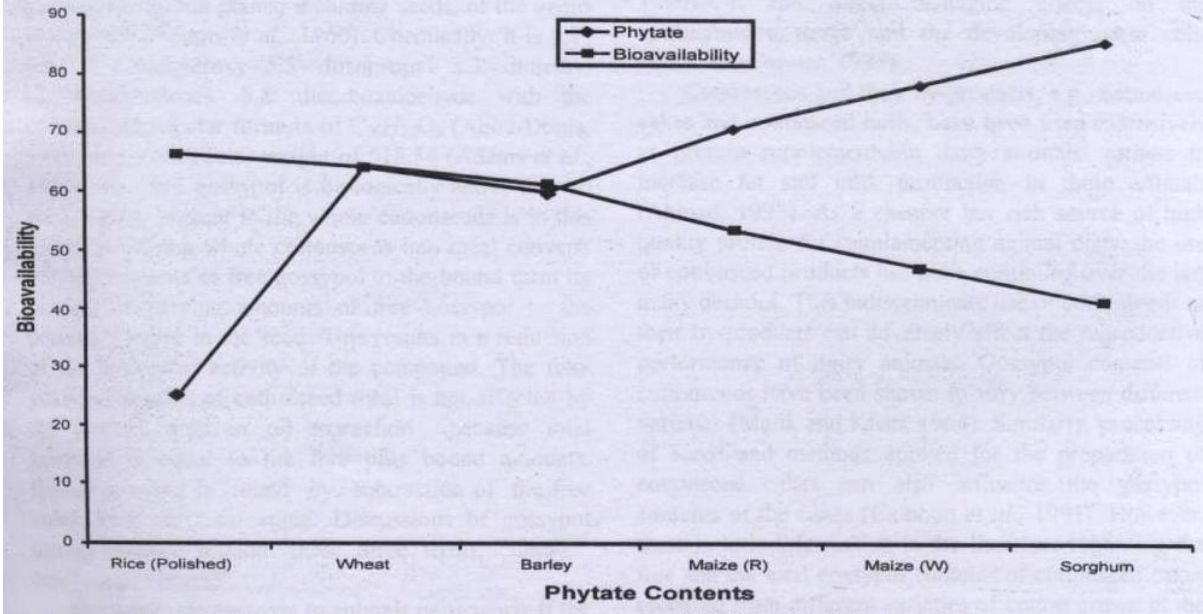

Fig. 1. Effect of phytate contents of cereals on bioavailability of total phosphorus

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