Phytate Content of Foods: Effect on Dietary Zinc Bioavailability

Nuzhat Chowdhury, M. Mostafizur Rahman, Sultana Sayeed*

Institute of Nutrition and Food Science, University of Dhaka, Dhaka-1000, Bangladesh

Abstract

Phytate and zinc contents of different varities of rice, wheat and legumes were analysed. Phytate content of rice (perboiled, milled) was found in the range of 92.12 ± 2.70 mg in Latisail to 225.29 ± 3.25 mg per 100g edible portion in BR-22. In legumes highest amount of phytate was found in Bengal gram (858.51 ± 2.50 mg /100g EP) with a range of 489.2 ± 1.50 to 858.51 ± 2.50 mg per 100 g EP.Wheat flour (whole) contained 720 ± 3.25 mg of phytate per 100 g EP while wheat flour (refined) contained only 146.46 ± 1.29 mg of phytate. Zinc content of different varities of rice varied from 0.58 ± 0.02 to 1.71± 0.09 mg per 100 g EP and in legumes it ranged from 2.31± 0.01 to 3.67 ± 0.05 mg per 100 g EP. Zinc content of wheat flour (whole) was found higher (2.65 ± 0.05 mg /100 g EP) than wheat flour (refined) (0.85 ± 0.09 mg/100 gm EP) Average phytate and zinc intake of Bangladeshi adult population was calculated on the basis of daily per capita food intake. Average per capita phytate and zinc intake was found to be 1036 mg and 8.0 mg respectively. Bioavailability of zinc of the diet was calculated on the basis of phytate-zinc molar ratio. Phytate - zinc molar ratio was found to be 12.77 which indicated that the bioavailability of zinc was in the range of 30% to 35%.

Key Words: Phytate, Zinc, Molar Ratio, Bioavailability.

Introduction

Phytate, myoinositol hexaphostate or IP6, is a naturally occuring compound found in all seeds. In its native state it complexes with protein as well as divalent cations and is consumed by humans and animals chiefly in cereal grains and legumes or food derived from them. One function of phytate in the seed is to serve as storage form of phosphorus[1]. During germination, phytase, which is present in most seeds, hydrolyzes phytate to release inorganic phosphate[2, 3]. Zinc deficiency, once thought to be non-existent, is now known to occur in several populations[4, 5]. Zinc deficiency is exacebrated by diminished dietary zinc bioavailability owing to formation of a relatively insoluble complex between zinc and phytate. An inverse relationship has been demonstrated between dietary phytate and zinc bioavailabilyty in

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* *Author for Correspondence*

several studies[6, 7]. On the basis of all of these experiments, there appears to be significant value in relating dietary phytate - zinc molar ratio to the bioavailability of zinc. These ratios may be used when the potential bioavailability of dietary zinc in human is asessed[8,9]. In this study, data are provided on the phytate and zinc contents of different varities of rice, legumes and wheat flour. Molar ratios of phytate to zinc were calculated to show the bioavailability of zinc. A dietary calculation was done to provide data on phytate and zinc contents of Bangladeshi diet and phytate - zinc molar ratio of the diet was also calculated to predict the bioavailability of zinc from the Bangladeshi diet.

Materials and methods

Collection of samples

Twelve samples of different varities of rice were collected for this study. Of the twelve samples, ten samples of rice (perboiled, milled) were certified samples of Bangladesh Rice research Institute (BRRI), Joydevpur. Other two samples of rice were collected from the open markets of Dhaka city. These were raw, milled rice and flavoured (polao) rice. Two samples of wheat flour (refined and whole) were collected from local market. Besides these, seven types of legumes were also collected from the local market of Dhaka city and were tested in this study.

Analytical technique

All the twelve samples of rice, two samples of wheat flour (refined and whole) and seven samples of legumes were used for analysis. The samples were grinded in a mechnical grinder. The moisture content was determined by drying the powder sample in an oven at 105°C for 5 h [10] and expressed on a percentage basis. Phytate content was determined according to the method described by E L Wheeler and R E Ferrel[11]. For the estimation of zinc, powdered sample (5 g) was wet ashed using a mixture of 18M H_2SO_4, 12M HCl and 16M HNO_3 (0.5: 1.0: 0.5 by volume) [12]. After dilution the concentration was determined by the use of an Atomic Absorption Spectrophotometer [13]. The millimole of phytic acid and zinc were calculated by dividing the mg of phytic acid by 660 (mol.wt. of phytic acid) and the mg of zinc by 65.4 (atomic wt. of zinc). The molar ratio of phytic acid to zinc was then calculated by dividing millimoles of phytic acid by millimoles of zinc.

Table 1. Content of phytate and zinc in different varities of rice (*Oryza sativae*) and wheat (*Triticum aestivum*), and calculated amount of zinc available for absorption[a]

Varities	Moisture (g%)	Phytate (mg/100gEP)	Zinc (mg/100gEP)	Phytate:Zinc molar ratio	Absorbable Zn (mg/100g)[b]
Perboiled, milled.					
BR- 1	12.12±0.11	138.64±3.40	0.71±0.02	21.0	0.71
BR-10	12.14±0.15	119.05±2.39	1.71±0.09	6.92	0.53
BR-11	12.05±0.05	118.98±1035	0.8 ±0.11	14.75	0.24
BR-12	12.07±0.01	135.62±2.20	1.03 ±0.05	12.73	0.31
Br-22	11.09±0.04	225.29 ±3.25	1.17 ±0.03	19.10	0.12
Purbachi	11.0±0.03	150.49 ±3.05	0.58 ±0.02	28.37	0.06
Nizersail	12.31±0.08	208.96 ±1.25	0.82 ±0.04	25.28	0.08
Paijam	11.07±0.07	129.41±3.38	0.75 ±0.05	17.08	0.08
Latisail	12.25±0.04	92.12 ±2.70	0.65 ±0.03	14.04	0.20
Rajasail	11.71±0.03	173.23 ±1.29	1.25 ±0.02	14.04	0.38
Raw, milled.					
Kali jira	12.25±0.09	91.99 ±1.05	1.09 ±0.01	8.37	0.33
Paijam	11.71±0.011	176.67 ±2.01	1.10 ±0.01	15.95	0.11
Wheat flour(whole)	12.±0.08	720.0±3.25	2.65±0.05	27.25	0.27
Wheat flour(refined	13.3±0.06	146.5±1.29	0.88±0.09	12.45	0.26

a. Results were expressed as mean ± SD of triplicate determination.
b. Amount of zinc available for absorption calculated as 45%-55% if phytate:zinc (P:Z) molar ratio < 5, and 30%-35% if P:Z = 5-15, 10%-15% if P:Z > 15.

Dietary Calculation

Average food intake of Bangladeshi adult population was taken from Nutrition Survey of Bangladesh (1996) [14]. Average phytate and zinc contents of the diet was calculated using the data of phytate and zinc contents of cereals and legumes from this study and values for other foods were taken from litaratures.[15,17]

Results

Phytate and zinc contents of different varieties of rice and wheat are presented in Table 1. BR-22 variety of rice was the highest in phytate content (225.29 ± 3.25 mg / 100 g EP). Highest zinc content was found in BR-10 (1.7 ± 0.09 mg/ 100g EP). Phytate- zinc molar ratios ranged from 6.92 in BR-10 to 28.37 in Purbachi. Asorbable zinc was found highest in BR-1 variety of rice. Phytate and zinc contents of wheat flour (whole) were found higher than that of wheat flour (refined). Phytate-zinc molar ratio was also found higher in wheat flour (whole). Phytate and zinc contents of wheat flour (whole) were found to be 720 ± 3.25 mg and 2.65 ± 0.5 mg per 100 g EP respectively. Phytate-zinc molar ratio was found to be 27.25 (Table-1). Absorbable zinc was found same in both types of wheat flours. Among different types of

legumes analysed, highest amount of phytate and zinc were found in green gram (694.13 ± 2.1 mg of phytate /100g EP) and lentil (3.67 ± 0.5 mg of zinc /100g EP) respectively (Table 2). Phytate - zinc molar ratios ranged from 13.01 in lentil to 27.23 in Red gram and absorbable zinc was found highest in lentil. Daily per capita food intake of Bangladeshi population was shown in Table 3. Phytate and zinc contents of the foods were calculated. Daily per capita average phytate and zinc intake were also calculated and were found to be 1036.93 mg and 8.0 mg respectively and phytate - zinc molar ratio was found to be 12.77. Calculated amount of zinc available for absorption was found 2.4 mg assuming 30% absorption.

Table 2. Content of phytate and zinc in legumes, and calculated amount of zinc available for absorption [a]

Names of Legumes	Scientific name	Moisture (g%)	Phytate (mg/100gEP)	Zinc (mg/100gEP)	Phytate: zinc molar ratio	Absorbable Zn [b] (mg/100g)
Lentil	*Lens esculenta*	12.4 ±0.90	489.20 ±1.50	3.67 ±0.05	13.0113.01	1.1
Green gram	*Phaseolus aureus rox b*	10.1±0.50	694.13 ±2.10	2.89 ±0.02	23.86	0.29
Bengal gram	*Cicer arietinum*	9.9 ±0.09	858.51 ±2.50	3.28 ±0.03	26.00	0.33
Khesari	*Lathyrus sativas*	10.0 ±0.02	499.23 ±1.22	3.37 ±0.02	15.12	0.34
Peas	*Pisum sativum*	12.4 ±0.05	614.46 ±1.33	3.48 ±0.02	17.50	0.35
Red gram	*Cajanus cajan*	13.4 ±0.07	632.76 ±2.00	2.31±0.01	27.37	0.23
Black gram	*Phaseolus mung rox b.*	10.9 ±0.08	550.52 ±1.98	2.82 ±0.05	19.39	0.28

a Results were expressed as mean ± SD of triplicate determination.

b. Amount of zinc available for absorption calculated as 45%-55% if phytate:zinc (P:Z) molar ratio < 5, and 30%-35% if P:Z = 5-15, 10%-15% if P:Z > 15.

Discussion.

In this study, phytate and zinc contents of different varities of rice wheat and legumes were analysed and the values were found with close agreement with that of other studies. Phytate content of different varieties of perboiled, milled rice were found in the range of 91.12 ± 2.70 to 225.29 ± 3.25 mg per 100g EP. Juliano[16] reported phytate content of different varities of rice (perboiled, milled) in the range of 72 to 250 mg per 100g EP. Another study from India [17] reported a value of 298.8 mg of phytate per 100g EP for perboiled, milled rice. Phytate and zinc contents of wheat flour, both whole and refined, found in this study, were very similer to that reported by Indian researcher [17]. In this study, phytate content of legumes were found in the range of 489.2 ± 1.5

to 858.51±2.50 mg per 100g EP. Phytate content of legumes as reported in Nutritive value of Indian foods ranged between 300 to 892.8 mg per 100g EP. Cereals and legumes have intermediat level of zinc (0.5 to 3.2 mg/100 gm EP). In the present study, zinc content of cereals and legumes were found in the same range as reported by other studies [17,18].

Table 3. Content of phytate and zinc in per capita food consumed by Bangladeshi adult population[a], and calculated amount of zinc available for absoption

Food	Amount (g)	Phytate (mg)	Zinc (mg) [b]	Phytate: zinc Molar ratio	AbsorbableZn[d] (mg)
Rice	408.0	612.0	3.91		
Wheat	18.0	129.6	0.32		
Pulses	11.0	68.17	1.34		
Roots and tubers	72.0	81.0	0.29		
Leafy vegetables	23.0	26.68 [c]	0.21		
Non-leafy vegetables	89.0	103.24 [c]	0.50	12.84	2.4
Fruits	14.0	16.24 [c]	0.27		
Meat	9.0	0.0	0.22		
Fish	33.0	0.0	0.56		
Milk and milk products	15.0	0.0	0.33		
Eggs	4.0	0.0	0.05		
Fats and oils	8.0	0.0	0.0		
Sugar	7.0	0.0	0.0		
Others	7.1	0.0	0.0		
Daily total		1036.93	8.0		

a. Ref no-14, b. Ref no-15, c. Ref no-17.
d. Amount of zinc available for absorption was calculated as 30% of intake.

Daily per capita average phytate intake of Bangladeshi population was found to be 1036.93 mg (Table 4.) Average American consumed 750 mg phytate per day with the intake ranging from 300 mg to 1300 mg [19]. South East Asian diet contain on an average 2248 mg of phytate and East African diet was found to contain 2200 mg of phytate per day.[18] So, phytate content of Bangladeshi diet was found less than the average South East Asian diet

In this study, calculated mean zinc content of Bangladeshi diet was found to be 8.0 mg. Recommended daily allowance for zinc for adult male and female is 15 mg and 12 mg respectively according to National Recherch Council of America assuming 20% absorption [20]. So, Bangladeshi diet provides 50% and 66% of RDA for zinc for male and female respectively. Recent surveys in America indicated that American males consume 90% and females consume

81% of RDA for zinc [20,21]. Zinc consumption was found in the range of 7 mg to 9 mg per day in the poorer region of the world like South East Asia. Northern Africa, Eastern Mediterranean and Sub-Saharan Africa [18]. The zinc intake of Bangladeshi population was comparable to that of the poorer region of the world.

To estimate the likely absorption of zinc from a diet, a phytate-zinc molar ratio can be calculated. A particular phytate-zinc molar ratio of the foods may be useful for food selection, but total daily dietary ratio provides a more important index of zinc bioavailability. It is generally considered that diets with a phytate-zinc molar ratio greater than 15 have relatively poor zinc bioavailability, and 0those with a phytate- zinc molar ratio between 5 and 15 have medium zinc bioavailability and those with a phytate-zinc molar ratio less than 5 have relatively good zinc bioavailability [22]. WHO estimates that about 45% to 55% of the element is absorbed from a high bioavailability diet, 30% to 35% from a medium bioavailability diet, and 10% to 15% from a low bioavailability diet[22]. So, bioavailability of zinc from this diet is to be considered medium, that is 30% to 35% of intake. In this study, phytate-zinc molar ratio of Bangladeshi diet was found to be 12.7. Calculated amount of zinc available for absorption was found 2.4 mg assuming 30% absorption. The US recommendation considered only one level of zinc absorption from a mixed diet (20% of intake). US recommendations are generally consistent with the WHO recommendations for a diet with low to medium zinc bioavailability. The UK recommendations assumed a single figure of 30% absorption from the diet[18]. Hence, the estumated UK reference zinc intake of is generally less than US estimate and consistent with the WHO estimate for a medium bioavailablity diet. Bioavailability of zinc from Bangladeshi diet remains to be solved.

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