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Extent of phytate degradation in breads and various foods consumed in Saudi Arabia

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Abstract

The extent of phytate degradation in breads and various foods consumed in Saudi Arabia was followed after baking or cooking. Phytate phosphorus content in raw and baked or cooked food was determined by ion-exchange and colorimeteric methods. White bread containing soda, namely Tamees, had a lower degree of phytate degradation followed by pita brown bread, namely Burr, in comparison to pita, French and pan white breads not containing soda, namely Mafrood, Samouli and Toast, respectively. The phytate content in breads ranged from 0.11 to 0.2 8%. Wheat-based food made from whole wheat flour, namely Margoog, had a lower degree of phytate degradation in comparison to other wheat-based foods made from bulgur, grits and partially debranned grains, namely Kibbah, Gerish and Harees, respectively. The phytate content in these foods ranged from 0.08 to 0.25%. Rice-based foods made from parboiled rice, namely Kabsa, or not drained from steeping or cooking water, namely Saleeg, had a lower phytate degradation than rice drained from steeping or cooking water, namely Baryani or Rus Abiedh. The phytate content in these foods was lower and ranged from 0.04 to 0.1%. Similarly, faba beans-based food not drained from cooking water, namely Food Jerra, had a lower degree of phytate degradation than faba bean or chick pea-based foods drained from cooking water, namely Foul Mudames, Falafe and Balila. The phytate contents in these foods ranged from 0.11 to 0.4%. Food recipes and baking conditions or cooking procedures are the main factors that affect the extent of phytate degradation. To avoid adverse effects on mineral nutrients, reduction in the phytate content of the phytate-rich foods such as Burr bread, Margoog and Foul Jerra foods, is recommended.

1. Introduction

Many widely-consumed foods in Saudi Arabia are made mainly from cereals, legumes and oilseed crops. These foods are good sources of proteins, minerals and vitamins for humans and they can make a significant contribution to meeting the nutritional requirement of populations, particularly to those of low income (FAO, 1987). Unfortunately, most of these foods may contain phytate as an antinutritional factor. This is an undesirable compound in foods because it may cause mineral deficiencies in humans, especially the high risk groups, i.e., children, pregnant and lactating women and the elderly (Davies, 1979). In processed foods, phytate would have the capacity to bind proteins and/or minerals such as iron, calcium and zinc to form insoluble complexes (Lasztity, 1990) which would decrease their bioavailability (Juliano, Hussaun, Resurreccion & Bushuk, 1991). An estimate of daily phytate intake in Saudi Arabia is unknown, but the consumption of phytate-rich foods is expected to be high. Although, the chemical composition and nutritive value of the widely-consumed foods in Saudi Arabia have been determined, no other data on phytic acid or phytate content in raw, baked or cooked traditional foods have appeared in the literature. The term phytic acid, phytate and phytin refers, respectively, to the free acid, the phosphorus salt and the calcium/magnesium salt. Phytic acid in the free form is unstable, decomposing to yield orthophosphoric acid, but the dry salt form is stable. The salt form, phytate (myo-inositol 1, 2, 3, 4, *5,* 6-hexaxis inositol dihydrogen phosphate), accounts approximately for 50–85% of the total phosphorus stored in many raw cereals and legumes (Ravindran, Ravindran & Sivalogan, 1994). Phytate content in foods made from cereals and legumes depends on the concentration of phytate in original raw materials and the final products to be prepared. It can be significantly

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degraded and the extent of degradation is influenced by several factors, such as type and extraction rate of milled products, type and quantity of leavening agent in bread doughs, activation rate of phytase enzyme, and cooking procedures of cereals and legumes, such as soaking, germination and fermentation.

The traditional cereals and legume-based foods form an important part of the diet of people in Saudi Arabia. They are greatly different in their recipes, processing methods, baking conditions and cooking procedures. Accordingly the objective of this investigation was to determine the extent of phytate degradation in different types of bread and other types of wheat, rice, faba beans and chick pea-based traditional food.

2. Materials and methods

2.1. Food samples:

The study included 17 types of common wheat, rice, chick peas and faba bean-based food. These foods are described in Tables 1, 3, 5 and 7. Raw and baked or cooked samples, approximately 1 kg in size, and their baking or cooking details, were collected from 10–15 local bakeries and restaurants around Riyadh city in November, 1998.

Samples were dried at 100°C in an oven, to constant weight, and ground in a Wiley laboratory mill to pass through a 60 mesh sieve. The ground samples were stored at room temperature in air-tight containers prior to chemical analysis. All samples were assayed in triplicate for moisture by AACC-Method 14-18, a two stage air-oven method (American Assocation of Cereal Chemists [AACC], 1983).

2.2. Determination of phytate phosphorous:

Five grams of each dried sample were extracted for 24 h at room temperature with l00 ml of 0.667 N Hcl. The extract was filtered under vacuum and kept at 4°C. This extract was subjected to phytate determination. Phytate was determined by the ion-exchange method of Latta and Erskin (1980) as modified by Mameech and Tomar (1993). Four independent measurements of phytate were conducted with each sample of specific food. Data obtained were subjected to a statistical analytical process (Jeffery, Bassett, Mendham & Denney, 1987) using means±standard deviations of four determinations.

3. Results and discussion

3.1. Phytate degradation in various breads:

Changes in phytate levels and the extent of phytate degradation in various breads, expressed as percentage losses of the original phytate content in bread dough before fermentation are shown in Table 2. Tamees bread had the lowest phytate degradation degree, followed by Burr bread, and then other types of bread. Differences in bread susceptibility to phytate degradation

Table 1
Various wheat bread names, recipes and baking conditions[a]

Bread name	Bread type	Flour extraction rate (%)	Active yeast quantity (%) flour basis	Total dough fermentation time (h)	Baking soda quantity (%) flour basis
Mafrood	Pita white	75	0.55	1.75	–
Samoli	French white	75	0.55	1.30	–
Toast	Pan white	75	0.55	1.30	–
Tamees	Thick layer white	75	0.11	3.00	0.22
Burr	Pita brown	95	0.44	5.00	–

[a] Data were collected from 10–15 bakeries around Riyadh City for each type of bread.

Table 2
Changes in phytate levels and extent of phytate degradation in various wheat breads after baking

Bread name	Bread type	Phytate content in dough before fermentation mg/100 g[a] dry basis	Phytate content after baking mg/100 g[a] dry basis	Extent[b] of phytate degradation after baking
Mafrood	Pita white (pocket-like bread)	209±2.06	113±1.79	46
Samouli	French white	212±1.55	136±1.09	36
Toast	Pan white	213±1.85	141±1.07	34
Tamees	Thick layer white	210±2.22	187±1.88	11
Burr	Pita brown (pocket-like bread)	338±1.84	283±1.09	16

[a] Means ±S.D. of 4 determinations.
[b] Expressed as percent loss of the original phytate content in bread dough before fermentation.

Table 3
Various wheat-based foods names, recipes and cooking procedures[a]

Food name	Type of milled wheat[b] product	Procedure of cooking
Kibbah	Bulgur (parboiled crushed partially debranned grains)	Bulgur is steeped. Excess water is discarded after steeping. Rolls are made and then fried in deep oil
Harees	Partially debranned grains	Grains are steeped. Excess water is discarded after steeping. Grains are boiled in excess water
Gerish	Grits	Grits are steeped. Excess water is discarded after steeping. Grits are boiled in excess water.
Margoog	Whole flour	Flat rolls are made from a dough, then boiled in excess water

[a] Data were collected from 10–15 local restaurants around Riyadh City for each type of food.
[b] Original wheat was hard winter wheat, yecorarojo, grown in Saudi Arabia.

are likely related to differences in requirements of wheat breads prepared in Saudi Arabia (Table 1). Tamees is a thick-layer white bread which requires 0.22% baking soda and 11% active yeast (flour basis). Other white bread types, such as Mafrood, Samouli and Pan, do not require baking soda, but require 0.55% active yeast (flour basis). Baking soda at the 0.22% level (flour basis) is a likely responsible factor for the low phytate degradation in Tamees. Faridi, Finney and Rubenthaler (1983) explained that baking soda had a retarding effect on the hydrolysis of phytate. The elimination of soda as a leavening agent could significantly reduce the phytate content of breads and increase the availability of some minerals. Burr bread is a pita brown bread which requires brown flour of 95% extraction rate. Other white bread types require white flour of 75% extraction rate. A high flour extraction rate indicates a higher level of bran which contains a high amount of phytate (De Boland, Garmer & O'Dell, 1975). Bran is likely responsible for either the high phytate content (0.28%) or the low phytate degradation rate in Burr bread. Despite that yeast has been claimed to enhance phytate enzyme activity and thus enhance phytate degradation in bread (Harland & Harland, 1980), it had been observed in this study that neither yeast nor the longer fermentation time increased phytate degradation rate in Burr bread. This is consistent with observations of Tangkonchitr, Seib and Hoseney, (1981). Lolas, Palamides and Markakis, (1976) and Mameech et al. (1993) reported a high phytate level in bread made from whole wheat flour or flour containing a high rate of bran. Factors such as type and extraction rates of flour, type and amount of leavening agent and total fermentation time (Table 1) are likely responsible factors for the low phytate degradation rates in brown bread consumed in Saudi Arabia. Türk and Sandberg (1992) claimed that phytate content of whole flour wheat bread can be reduced by addition of phytase enzyme and by using fermented milk instead of whole milk as it has no inhibitory effect on phytate hydrolysis.

3.2. *Phytate degradation in various wheat-based foods*

Changes in phytate levels and the extent of phytate degradation in other wheat-based foods, before and after cooking are shown in Table 4. Margoog had a lower phytate degradation degree than Kibbah, Harees and Gerish. Differences in wheat-based food susceptibility to phytate degradation are likely related to differences in requirements of wheat-based foods prepared in Saudi Arabia (Table 3). Margoog is made from unfermented whole flour dough. The procedure of cooking requires boiling the product in excess water but does not require the discarding of excess water which likely contains soluble phytate. Kibbah is made from bulgur, which is parboiled crushed partially-debranned grains. Cooking involves a steeping step, then excess water is discarded. Furthermore, a dough is made and fried in deep oil. It is likely that a large amount of phytate in Kibbah is lost due to leaching of soluble phytate during the steeping and frying steps. Factors, such as type of milled wheat product and procedure of cooking (Table 3), are likely responsible for the low phytate degradation rates in some types of wheat-based foods consumed in Saudi Arabia. Fredlund, Asp, Larrsson, Marklindev and Sandberg (1997) concluded that cereals with reduced phytate content and good hygienic quality can be developed and produced using hydrothermal treatment of whole grains.

3.3. *Phytate degradation in rice-based foods*

Changes in phytate levels and the extent of phytate degradation in rice-based foods before and after cooking are shown in Table 6. The lower phytate content of milled rice before cooking was due to the separation of bran layers during the polishing process. Over 80% of phytate in the rice grain is present in the outer bran layers and aleurone layers of the kernel (De Boland et al., 1975). The extent of phytate degradation after cooking ranged from 11% in Kabsa to 65% in Baryani. Differences in rice-based food susceptibility to phytate degradation are likely related to differences in requirements of rice-based foods prepared in Saudi Arabia. Rice-based foods are made from different varieties of imported milled rice and require different procedures of cooking (Table 5). Kabsa is made from parboiled Indian or American variety raw material and it is cooked in a minimal amount of water (1:2 w/w), but excess water is only discarded after steeping. Baryani is made from unparboiled Basmaty variety and it is cooked in excess water, but excess water is discarded after either the steeping or cooking step. Despite that Saleeg is made from unparboiled grain, it has a lower phytate degradation rate. This is likely because rice is not steeped and it is cooked in excess water so that excess water remains. These results are in accordance with those reported by Toma and Tabekia (1979) and by Mameech and Tomar (1993). They reported that all the phytate content remains in the cooked rice when excess cooking water is not drained from the rice. Factors such as variety of milled rice and procedure of cooking (Table 5) are likely responsible for the differences in the extent of phytate degradation in types of rice-based foods consumed in Saudi Arabia.

3.4. Phytate degradation in legume-based foods

The phytate degradation in some legume-based foods before and after cooking are shown in Table 8. The various raw foods were found to have a high phytate content ranging from 0.26% in Falafel to 0.58% in Foul Mudames. Similarly, Ravindrin et al. (1994) found a high level of phytate in raw legumes. After cooking, phytate content ranged from 0.11% in Falafel to 0.39% in Foul Jerra. Cooking reduced the phytate level as much as 70% in Foul Mudames. Several workers have reported a reduction in phytate content after cooking legumes (De Boland et al., 1975; Mameech & Tomar,

Table 4
Changes in phytate levels and extent of phytate degradation in various wheat-based foods

Food name	Appearance of food after cooking	Phytate content before cooking mg/100 g[a] dry basis	Phytate content after cooking mg/100 g[a] dry basis	Extent[b] of phytate degradation after cooking
Kibbah	Brown small ovoid wheat rolls	400±1.41	82±1.72	80
Harees	White porridge	397±1.33	153±1.75	61
Gerish	Brown porridge	410±2.00	184±1.78	55
Margoog	Non-fermented small flat wheat rolls	420±1.50	2.48±1.80	41

[a] Means±S.D. of 4 determinations.
[b] Expressed as percent loss of the original content in food dough before cooking.

Table 5
Various rice-based foods names, recipes and cooking procedures[a]

Food name	Variety of imported milled rice	Procedure of cooking
Baryani	Long grain (Basmati Indian)	Excess water is discarded after steeping and cooking
Rus Abiedh	Long grain (Basmati Indian)	Excess water is discarded after steeping. Rice is cooked in a minimal amount of water (1:2 w/w)
Saleeg	Short grain (Egyptian or Australian)	Rice is cooked in excess water
Kabsa	Parboiled (Indian or American)	Excess water is discarded after steeping. Rice is cooked in a minimal amount of water (1:2 w/w)

[a] Data were collected from 10–15 restaurants around Riyadh City for each type of food.

Table 6
Changes in phytate levels and extent of phytate degradation in various rice-based foods

Food name	Appearance of food after cooking	Phytate content before cooking mg/100 g[a] dry basis	Phytate content after cooking mg/100 g[a] dry basis	Extent[b] of phytate degradation after cooking %
Baryani	Well-separated yellow and white kernels	135±1.68	48±1.05	65
Rus Abiedh	Well-separated white kernels	135±1.68	85±1.72	37
Saleeg	White porridge	103±1.30	90±0.94	12
Kabsa	Well-separated red kernells	113±183	101±1.49	11

[a] Means±S.D. of 4 determination.
[b] Percent loss of the original phytate content in food before cooking.

Table 7
Various legume-based food names, recipes and cooking procedures[a]

Food name	Grain legumes name	Procedure of cooking
Falafel	Chick peas	Kernels are steeped. Excess water is discarded after steeping. Rolls are made and fried in deep oil
Foul mudames	Faba beans	Kernels are steeped and cooked in excess water. Excess water is discarded
Balila	Chick peas	Kernels are steeped and cooked in excess water. Excess water is discarded
Foul Jerra	Faba beans kernels and debranned grits	Beans are steeped. Excess water is discarded after steeping only. Beans are cooked in excess water

[a] Data were collected from 10–15 restaurants around Riyadh City for each type of food.

Table 8
Changes in phytate levels and extent of phytate degradation in various legume-based foods

Food name	Appearance of food after cooking	Phytate content before cooking mg/100 g[a] dry basis	Phytate content after cooking mg/100 g[a] dry basis	Extent[b] of phytate degradation after cooking %
Falafel	Small spherical brown rolls	262±1.95	113±1.72	57
Foul Mudames	Whole kernels	576±2.30	171±1.98	70
Balila	Whole kernels	262±1.95	177±1.49	32
Foul Jerra	Brown porridge	420±1.33	390±1.04	7

[a] Means±S.D. of 4 determination.
[b] Percent loss of the original phytate content in food before cooking.

1983; Reddy, Balakristian & Salunkhe, 1978). Differences in the extent of phytate degradation rates after cooking legume-based foods are likely related to differences in requirements of legume-based foods prepared in Saudi Arabia (Table 7). Foul Jerra is a brown porridge made from whole and debranned faba bean grits. The cooking procedure requires discarding of water after the steeping step, but does not require discarding of water after cooking because the product is boiled in excess water so that food becomes a brown porridge and excess water remains. Foul Mudames is made from whole faba beans. Beans are steeped and cooked in excess water. Excess water is discarded after steeping and cooking. Falafel and Balila are made from chick peas, but phytate degradation degree in Falafel is higher than in Balila because Falafel requires a frying step. Factors, such as type of legume and procedure of cooking (Table 7), are likely responsible for the low phytate degradation rates in some types of legume-based foods consumed in Saudi Arabia. It is suggested that legume, prior to consumption should be soaked, dehulled or germinated before cooking, in order to substantially reduce their phytate contents and increase their nutritional quality (Deshphande, Sathe, Salunkhe & Cornforth, 1982; Igbedioh, Olugbemi & Akpopunium, 1994).

4. Conclusions

Types of bread consumed in Saudi Arabia, such as white bread containing baking soda, namely Tamees, and brown pita bread, made from a high extraction rate-wheat flour, namely Burr, are less susceptible to phytate degradation than white pan, local Samouli breads or white pita bread, namely Mafrood. Food made from whole wheat flour, namely Margoog has a higher phytate content than other types of foods, and it is less susceptible to phytate degradation than other wheat-based foods made from bulgur, grits and partially debranned grains, namely Kibbah, Gerish and Harees, respectively.

Rice-based foods made from parboiled rice, namely Kabsa, or made from rice not drained from steeping or cooking water, namely Saleeg, are less susceptible to phytate degradation than rice-based foods made from unparboiled rice drained from steeping or cooking water, namely Baryani or Rus Abiedh. Similarly, faba bean-based food not drained from cooking water, namely Foul Jerra, is less susceptible to phytate degradation than faba bean, or chick pea-based foods drained from cooking water, namely Foul Mudames, Falafel and Balila. It is expected that type and extraction rate of milled products, type and amount of leavening agent, fermentation time, type of legume and procedure of cooking are the main factors that affect the extent of phytate degradation in bread and other wheat, rice and legume-based foods consumed in Saudi Arabia.

To avoid adverse effects on mineral nutrients, reduction of the phytate content in the phytate-rich foods is recommended especially those made from whole wheat flour or faba bean kernels, namely Burr bread, Margoog and Foul Jerra foods. This could either be in the food processes and conditions used or through recipe formulations and cooking procedures.

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References

American Association of Cereal Chemists. (1983) *Approved methods of the AACC. Method 44-18*. St. Paul, MN: author.

Davies, N. T. (1979). Anti-nutrient factors affecting mineral utilization. *Proceedings of the Nutrition Society, 38*, 121.

De Boland, A. R., Garner, G. B., & O'Dell, B. L. (1975). Identification and properties of phytate in cereal grains and oil seed products. *Journal of Agricultural and Food Chemistry, 23*, 1186.

Deshpande, S. S., Sathe, S. K., Salunkhe, D. K., & Cornforth, D. P. (1982). *Journal of Food Science, 47,* 1846–1850.

FAO (1987). Promoting under-exploited food plants in Africa, Rome, Italy.

Faridi, H. A., Finney, P. L., & Rubenthaler, G. L. (1983). Effect of soda leavening on phytic acid content and physical characteristics of Middle Eastern breads. *Journal of Food Science, 48*, 1654–1658.

Fredlund, K., Asp, N. G., Larsson, M., Marklindev, I., & Sandberg, A. S. (1997). Phytate reduction in whole grains of wheat, rye, barley and oats after hydrothermal treatment. *Journal of Cereal Science, 25*, 83–91.

Harland, B. F., & Harland, J. (1980). Fermetative reduction of phytate in rye, white, and whole wheat breads. *Cereal Chemistry, 57*(3), 226–229.

Igbedioh, S. O., Olugbemi, K. T., & Akpopunum, M. A. (1994). Effect of processing methods on phytic acid level and some constituents in bambara groundnut (*Vigna subterranea*) and pigeon pea (Cajanus cajan). *Food Chemistry, 50*, 147–151.

Jefferey, G. H., Bassett, J., Mendham, J., & Denney, R. C. (1987). *Vogel's text book of quantitative chemical Analysis*. Harlow, England: Longman.

Juliano, B. O., Hussain, A., Resurreccion, A. P., & Bushuk, W. (1991). Interference of phytate with extraction of protein from brown rice using SM acetic acid. *Cereal Chemistry, 68*, 317–318.

Lasztity, R. (1990). Gluten-phytic acid interactions. In W. Bushuk, & R. Tkachuk, *Gluten proteins* (pp. 303–313). St. Paul, MN: American Association of Cereal Chemists.

Latta, M., & Erskin, M. L. (1980). A colorometric method for phytate determination. *Journal of Agricultural and Food Chemistry, 28*, 1313.

Lolas, G. M., Palamides, N., & Markakis, P. (1976). The phytic acid total phosphorous relationship in barley, oats, soybeans, and wheat. *Cereal Chemistry, 53*, 867.

Mameech, M. S., & Tomar, M. (1993). Phytate content of some popular Kuwaiti Foods. *Cereal Chemistry, 70*(5), 502–503.

Ravindran, V., Ravindran, G., & Sivalogan, S. (1994). Total and phytate phosphorous contents of various foods and foodstuffs of plant origin. *Food Chemistry, 50*, 133–136.

Reddy, N. R., Balakrishan, C. V., & Salunkhe, D. K. (1978). Phytate phosphorous and mineral changes during germination of cooking of black grain *(Phaseovlus mungo* L.) seeds. *Journal of Food Science, 45*, 540.

Tangkonchitr, U., Seib, P. A., & Hoseney, R. C. (1981). Phytic acid II. Its fate during breadmaking. *Cereal Chemistry, 58*, 229–234.

Toma, R. B., & Tabekhia, M. M. (1979). Changes in mineral elements and phytic acid content during cooking of three California rice varieties. *Journal of Food Science, 44*, 619.

Türk, M., & Sandberg, A. S. (1992). Phytate degradation during breadmaking: effect of phytase addition. *Journal of Cereal Science, 15*, 281–294.