# STUDY ON PHYTIC ACID CONTENT IN SOME ROMANIAN CEREAL SEEDS

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**Abstract.** The phytic acid content of the flour and bran from seeds, belonging to four cereal species, as well as the effect of thermal treatment on this acid was the purpose of this paper. The biological material was represented by dried seeds (moisture content 10%) of twelve Romanian cultivars (c), belonging to four cereal species: wheat (3 c), rye (3 c), oat (3 c) and maize (3 c). The seeds of each species were ground to get integral flour and bran. The phytic acid content was analyzed, using Garcia-Villanova method, in the flour and bran, before and after thermal processing (180°C for 50 minutes). They also determined pH values of the integral flour and bran in the four cereal species. Analyzing the phytic acid in integral flour and bran of raw samples, the highest and close values were in rye and maize, and the least ones in wheat and oat. Thermal processing of the both products (flour and bran) led to highest and significant reducing percent of phytic acid in rye, followed by oat and wheat samples with close values, the least reducing percent of phytic acid being in maize samples.

## INTRODUCTION

Phytic acid (myo-inositol hexakisphosphate, InsP6) is an organic compound present in plant seeds and grains *(Rose, 1912; Averill and King, 1926; Harland and Oberleas, 1987; Reddy et al., 1989*), roots and tubers (*Harland and Oberleas, 1987; Wolters et al., 1993; Ravindran et al., 1994*), fruits and vegetables (*Harland and Oberleas, 1987; Wolters et al., 1993; Ravindran et al., 1994*), nuts (*Harland and Oberleas, 1987; Wolters et al., 1993*, cited by *Reddy, 2002*) and in other vegetable sources.

Phytic acid is a strong chelator of divalent minerals such as copper, calcium, magnesium, zinc, and iron (*Sathe and Reddy, 2002*), and studies on animals and humans highlighted that phytates decrease mineral bioavailability by forming complexes with these minerals (*Reddy et al., 1989; Krebs, 2000*).

According to some authors (*Cheryan, 1980; Thompson*, *1993*) phytic acid can also form complexes with proteins as phytate-protein and phytate-mineral-protein, adversely influencing protein digestion and bioavailability. With starch, phytate can bind either directly, by hydrogen bonding, with a phosphate group or indirectly, through the proteins (*Rickard and Thompson, 1997*), which may result in a decrease of starch solubility and digestibility (*Sathe and Reddy, 2002*).

Food phytates have not only negative effects, as mentioned before, but also beneficial effects including lowering of serum cholesterol and triglycerides, and protection against certain diseases such as cardiovascular diseases, renal stone formation, and certain types of cancers (*Thompson, 1993; Rickard and Thompson, 1997; Zhou and Erdman, 1995; Shamsuddin et al., 1997; Grases et al., 2000; Urbano et al., 2000; Graf, 1983,* cited by *Sathe and Reddy, 2002*).

In this paper, the phytic acid content of the flour and bran from seeds, belonging to four cereal species, was studied, as well as the effect of the heat treatment on this compound.

## MATERIALS AND METHODS

**Research materials.** The biological material, coming from the last year crop, was represented by seeds of twelve romanian cultivars (c) belonging to four cereal species: wheat (3 c), rye (3 c), oat (3 c) and maize (3 c). The seeds were dried (moisture content 10%), and after that they were ground to get integral flour and bran, for each species.

**Procedure and research methods.** The phytic acid content was analyzed in integral flour and bran, before and after the thermal processing of the same materials, in oven at 180°C for 50 minutes. They also determined pH values of the integral flour and bran in the four cereal species.

The phytic acid was determined using Garcia-Villanova method (*Bordei et al., 2007*). They weighed 2 g of flour or bran, added 40 ml of HCl-$Na_2SO_4$ solution and leaved to stand for 90 minutes, stirring intermittently (to extract phytic acid). They filtered and collected 25 ml of the filtrate, which were placed in a stoppered tube, then added 20 ml of HCl-$Na_2SO_4$ solution, 20 ml hydrochloride solution of ferric chloride, and 20 ml of 20% sulfosalicylic acid solution. It boiled water in the closed tube for 15 minutes on a water bath, then cooled under a stream of water. It formed the ferric filtrate precipitate which was separated by filtration. From the clear (obtained) filtrate, it took 25 ml, placed in an Erlenmeyer flask, added about 175 ml of distilled water, and then adjusted the pH to 2.5 ± 0.5 with glycine. The mixture obtained was heated to 70°C and was titrated the excess of $Fe^{3+}$ (which has not precipitated with phytic acid), with 0.15M EDTA solution until the color shifted to bright yellow. The result was expressed in g phytic acid per 100 g product (%). Four replicates for each determination were used to get the data of experiments.

Determination of pH was made with a digital pH meter supplied by Hanna Instruments.

**Statistical analysis.** The experimental data were statistically processed using SAS Version 8.02 (*SAS Institute, 2005*). To analyze the significance of differences among samples, generalized linear model analysis was carried out, and for multiple comparisons, Duncan's multiple range test ($P$<0.05) was used.

## RESULTS AND DISCUSSIONS

In the Table 1 are rendered the values of phytic acid and pH in samples coming from four cereal species, before and after thermal processing.

**Table 1. Phytic acid content mean values (±SD) and pH in flour and bran of cereal seeds**

| Cereal samples | Raw samples | | | | Thermal processed samples | |
|---|---|---|---|---|---|---|
| | Flour | | Bran | | Flour | Bran |
| | pH | Phytic acid (%) | pH | Phytic acid (%) | Phytic acid (%) | Phytic acid (%) |
| W1 | 5.3 | 1.22±0.5**FG***| 5.2 | 3.17±0.9**AB** | 0.96±0.03**GH** | 2.54±0.7**C** |
| W2 | 5.4 | 1.16±0.7**FG*** | 5.3 | 2.98±0.4**AB** | 0.89±0.08**H** | 2.42±0.8**CD** |
| W3 | 5.2 | 1.07±0.6**G** | 5.3 | 2.83±0.5**B** | 0.83±0.05**H** | 2.33±0.5**D** |
| R1 | 4.6 | 1.20±0.8**FG** | 4.7 | 3.17±0.5**AB** | 0.81±0.04**H** | 2.27±0.4**D** |
| R2 | 4.7 | 1.45±0.4**F** | 4.7 | 3.34±0.4**A** | 0.92±0.05**GH** | 2.34±0.6**D** |
| R3 | 4.6 | 1.27±0.7**FG** | 4.8 | 3.28±0.7**A** | 0.81±0.07**H** | 2.35±0.3**D** |
| O1 | 5.4 | 1.08±0.6**G** | 5.2 | 3.10±0.5**AB** | 0.82±0.06**H** | 2.48±0.5**CD** |
| O2 | 5.4 | 1.12±0.9**G** | 5.3 | 2.78±0.8**BC** | 0.83±0.04**H** | 2.27±0.8**D** |
| O3 | 5.3 | 1.18±0.7**FG** | 5.3 | 3.04±0.6**AB** | 0.91±0.02**GH** | 2.40±0.9**CD** |
| M1 | 5.8 | 1.17±0.4**FG** | 5.7 | 3.10±0.3**AB** | 0.97±0.06**GH** | 2.62±0.6**C** |
| M2 | 5.8 | 1.31±0.5**F** | 5.5 | 3.29±0.7**A** | 1.07±0.8**G** | 2.80±0.5**BC** |
| M3 | 5.7 | 1.25±0.2**FG** | 5.6 | 3.24±0.6**A** | 1.03±0.05**G** | 2.72±0.2**BC** |

SD=standard deviation; W1-3=wheat cutivars; R1-3=rye cultivars; O1-3=oat cultivars; M1-3=maize cultivars;
*Means with the same letters within a column are not statistically diferent ($P$<0.05)

As seen from Tab. 1, the pH values of cereals flour ranged between 4.6 (rye) and 5.8 (maize), and pH of cereals bran between 4.7 (rye) and 5.7 (maize).

Analyzing the phytic acid in integral flour of raw (unprocessed) samples, the highest values were in rye (1.45%) and maize (1.31%) with close values, and the least ones in wheat (1.07%) and oat (1.08%) with close values too ($P$<0.05).

According to some authors (*Lolas et al, 1976; Eechkhout and Depaepe, 1994; DeBoland et al., 1975; Kikunaga et al., 1985; Harland and Prosky, 1979*), cited by *Reddy N.R.* (*2002*), the phytic acid content of some cereal grains ranges between the following limits: 0.39%-1.35% (wheat), 0.54%-1.46% (rye), 0.42%-1.16% (oat) and 0.75%-2.22% (maize).

In the bran of raw samples, the phytic acid registered the highest and close values in rye (3.28% - 3.34%) and maize (3.24% - 3.29%), and the least one in oat (2.78%) and wheat (2.83%).

As seen, the phytic acid content in bran was higher then in flours, because, according to *Reddy (2002)*, in most cereals phytate is concentrated in the germ and aleurone layers (pericarp) of the grain cells. In maize 88% of phytate is concentrated in the germ portion of the grain (*O'Dell et al., 1972*).

By some data, the phytic acid content of wheat bran ranges between 2.02% and 5.27% (*Harland and Prosky, 1979; Ellis and Morris, 1982; Harland and Oberleas, 1986; Kirby and Nelson, 1988; Lehrfeld and Wu, 1991; Eechkhout and Depaepe, 1994; Gualberto et al., 1997; Kasim and Edwards, 1998*) and the phytic acid of oat bran between 0.60% and 1.42% (*Frolich and Nyman, 1988; Gualbert et al., 1997; Kasim and Edwards, 1998*).

After thermal processing, the phytic acid of flour registered the highest value in maize (1.07%), and the least ones in rye (0.81%), oat (0.82%) and wheat (0.83%) with close values ($P$<0.05).

The highest phytic acid content of thermal processed bran was in maize (2.80%) and the least ones in oat, rye and wheat samples, with close values (2.27% - 2.33%).

Analyzing the average values of phytic acid in flour and bran it can be observed that in all cases they were reduced by thermal processing.

The table 2 highlights the reduction percentage of phytic acid in cereals flour and bran due to thermal processing.

**Table 2. Reduction percentage of phytic acid average values in flour and bran thermal processed, compared to raw**

| Cereal samples | Phytic acid reduction percents | |
|---|---|---|
| | Flour | Bran |
| W1 | −21.31% **d** | −19.87% **e** |
| W2 | −23.27% **cd*** | −18.79% **e** |
| W3 | −22.43% **cd*** | −17.66% **ef** |
| R1 | −32.50% **ab** | −28.39% **bc** |
| R2 | −36.55% **a** | −29.94% **b** |
| R3 | −36.22% **a** | −28.35% **bc** |
| O1 | −24.07% **cd** | −20.00% **e** |
| O2 | −25.89% **c** | −18.34% **ef** |
| O3 | −22.88% **cd** | −21.05% **de** |
| M1 | −17.09% **f** | −15.48% **fg** |
| M2 | −18.32% **e** | −14.89% **fg** |
| M3 | −17.60% **ef** | −16.05% **fg** |

W1-3=wheat cutivars; R1-3=rye cultivars; O1-3=oat cultivars; M1-3=maize cultivars; *Means with the same letters within a column are not statistically diferent ($P$<0.05)

Thus, compared to raw samples, the thermal processing of flour, at 180°C for 50 minutes, led to highest and significant reducing percent of phytic acid in rye (−36.55%), followed by oat and wheat samples with close values; the least reducing percent of phytic acid (−17.09%) was in maize samples ($P$<0.05).

Under the same conditions, the thermal processing of bran led to highest and significant reducing percent of phytic acid in rye (−29.94%), followed by oat and wheat samples with close values, the least reducing percent (−14.89%) being also in maize samples ($P$<0.05).

One can observe that thermal processing, at 180°C for 50 minutes, caused a higher reducing of phytic acid content in flour, compared to bran. It is possible that the presence of cellulose and lignin in the bran composition to partially protect the phytic acid from the harmful action of high temperatures.

Some of these results are consistent with observations and data reported by certain authors.

A significant percent of phytate hydrolysis can take place due to activation of endogenous phytases and acid phosphatases, during the early part of the cooking phase (*Sathe and Venkatachalam, 2002*).

According to some authors (*Reddy et al., 1989; Mckenzieparnell and Davies, 1986; Sathe and Venkatachalam, 2002*), the phytic acid content of cereals in reduced by fermentation and bread making with 8.9% in the whole-meal breads (unleavened) and with 66-100% in white breads.

It seems that pH and cooking temperature are important factors reducing the content of phytic acid, because in doughs with pH 4.3–4.6 phytic acid is more effectively reduced than in doughs with higher pH (*Fretzdorff and Brümmer, 1992*).

In our experiment the least pH values (4.6-4.7) were registered in rye samples, and also at these samples were recorded the highest reductions in the content of phytic acid by exposure to high temperature.

## CONCLUSIONS

The analyze of phytic acid content in the integral flour and bran of grains, belonging to four cereal species, evidenced some significant differences between species.

Thus, the highest phytic acid content of integral flour and bran was in rye and maize with close values, and the least one in wheat and oat with close values too.

In all analyzed samples, the phytic acid content of bran was significantly higher then of integral flours.

The thermal processing of flour and bran (180°C for 50 minutes) led to highest and significant reducing percent of phytic acid in rye, followed by oat and wheat samples with close values, the least reducing percent of phytic acid being in maize samples.

The thermal processing caused a higher reducing of phytic acid content in flour, compared to bran, probable due to the presence of cellulose and lignin in the bran composition, which partially protect this acid from the harmful action of high temperatures.

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