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THE INFLUENCE OF PROCESSING ON PHYTIC ACID CONTENT IN SOME WHEAT PRODUCTS

***Marcel AVRAMIUC[1]**

[1]*Faculty of Food Engineering, Stefan cel Mare University of Suceava, Romania*
avramiucm@fia.usv.ro
*Corresponding author
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Abstract. *The influence of wheat processing (milling, fortification, bread making) on phytic acid content in flour and bread was the purpose of this paper. The biological material was wheat (Triticum aestivum* L.*) flour of types 550, 680, 1350, fortified wheat flour (3 mg of ferrous sulfate per 100 g) from the same types, and bread made from these flours (simple and fortified ones). Wheat grains processing (milling, flour fortification with iron, and bread making) has influenced the phytic acid content in flour and bread. Of the three types of wheat flour (550, 680 and 1350), the flour with largest degree of extraction (type 1350) has recorded the highest value of the phytic acid. The phytic acid content in all three types of unfortified flour was higher than in fortified ones. As compared to unfortified versions, the biggest drop in phytic acid content was recorded in fortified flour type 550, followed by flour type 680, and flour type 1350. The highest content of phytic acid was recorded in the bread made with flour type 1350. In the case of bread made from fortified flour (with Fe), the phytic acid content has increased with flour extraction degree rising. The phytic acid content in all bread samples made from unfortified flour was higher than in bread made from fortified ones. One can notice that during bread making, the phytic acid content of flour has decreased in all cases reaching much lower within fortified bread coming from flour with lower degree of extraction.*

Keywords: phytic acid, wheat, iron, fortified flour, bread

1. Introduction

The phytic acid (inositol hexaphosphate or phytate) is a major component of all plant seeds and has been an important dietary component for humans since ancient times [1,2]. In cereal grains, most of the minerals form salts with phytic acid that act as a storage compound of phosphorous [3]. Phytate is deposited in globoids from the aleurone cell layer of the grain [4]. Phytic acid can exist as free acid, phytate, or phytin depending on the physiological pH and the metal ions presen [5,1]. According to Casey and Walsh (2004), the phytases are enzymes that catalyses the degradation of phytate to lower inositol phosphates and free inorganic phosphorous is formed depending on extend of the enzyme activity. Cereal phytase is present with varying activity in all unprocessed cereal grains, and the activity in rye is high compared to other cereals [7,3]. Some operations of cereals processing, such as grains soaking at temperatures over 45°C (full meal, flours with different extraction degrees, bran), under optimum conditions for the specific phytase, e.g. pH 6 for rye grains phytase [8,3] can result in a strong hydrolysis of phytate and a significant increase in the bioavailability of mineral elements. Phytate hydrolysis occurs in all different stages of bread preparation, and depends on the type of bread that is prepared [9].

In this paper it has investigated the influence of some wheat processing (milling, fortification, bread making) on phytic acid content in flour and bread.

2. Experimental

2.1. Research materials

In this paper, the biological material was wheat (*Triticum aestivum* L.) flour of types 550, 680, 1350, and fortified wheat flour from the same types; bread made from flour of types 550, 680, 1350 (simple and fortified). For the fortification process there were used 3 mg of ferrous sulfate per 100 g flour with continuous mixing for 15 minutes. Afterwards, the obtained mixture was kept for 5 hours in a sealed container at a temperature of 30ºC. The recipe for preparing a bread sample was: 150 g flour (simple or fortified by case), 6 g of yeast, 125 ml of water and 1 g of salt. The fermentation temperature was 32ºC, the dough pH was adjusted to 4.5, and the fermentation time was 2 hours.

2.2. Research methods

The phytic acid determination (mg/100 g) was done using Garcia-Villanova method, based on treating the sample with a ferric salt and titration with sulfosalicylic acid (in the presence of EDTA solution as an indicator) of Fe^{3+} ions precipitated along with phytic acid [10]. Four replicates for each determination represented the data of experiments, which were statistically processed, the analysis of variance being used to calculate differences between results. The differences at $P < 0.05$ were considered significant.

3. Results and discussion

In the Table 1 are reproduced the phytic acid values in analyzed wheat flour samples.

Table 1

The phytic acid concentration in unfortified and fortified wheat flour with different degrees of extraction

Samples Test	WF type 550	WFF type 550	WF type 680	WFF type 680	WF type 1350	WFF type 1350
Phytic acid (mg/100 g)	578±15.3	542±4.8	605±12.2	573±13.1	658±8.9	630±11.2

WF=wheat flour; WFF= wheat flour fortified (3 mg $FeSO_4$ per 100 g flour)

As seen in the Table 1, in the unfortified flour types the highest content of phytic acid (inositol phosphates) was recorded in flour type 1350, ie with 13.8% more than flour type 550, and with 8.8% more than flour type 680 ($P<0.05$). The obtaining way of the flours has directly influenced the phytic acid values, so the flour with largest degree of extraction has recorded the highest value of this biochemically index too. The phytic acid content is higher in whole grain and whole meal flour compared to flour with low extraction rate [11].

Also in the case of the fortified flours with Fe, the phytic acid content has increased with flour extraction degree rising. So, the flour type 1350 has recorded the highest value of the analyzed index, with 16.2% more than flour type 550 and with 9.9% more than flour type 680 ($P<0.05$). The phytic acid content in all three types of unfortified flours was higher than fortified ones, because the presence of iron ions in fortified flours has led to the phytin content increase, and correspondingly to the content reducing the of phytate (phytic acid). From the Table 1 it can see that, as compared to unfortified versions, the biggest drop in phytic acid content was recorded in fortified flour type 550 (6.2%), followed by flour type 680 (5.3%) and flour type 1350 (4.2%) ($P<0.05$).

One can notice that the flour fortification has led to a greater decrease in the phytates concentration. The lower extraction degree of fortified flour the greater decrease of phytates was.

In the Table 2 are reproduced the phytic acid values in bread samples.

Table 2

The phytic acid concentration in bread obtained from unfortified and fortified wheat flour with different degrees of extraction

Samples Test	Bread from WF type 550	Bread from WFF type 550	Bread from WF type 680	Bread from WFF type 680	Bread from WF type 1350	Bread from WFF type 1350
Phytic acid (mg/100 g)	201±3.8	68±0.7	398±9.3	248±2.5	627±11.7	530±10.1

WF=wheat flour; WFF= wheat flour fortified (3 mg $FeSO_4$ per 100 g flour)

As seen in the Table 2, in bread samples made with unfortified flours the phytic acid content was different depending on the type of flour. The highest content of phytic acid was recorded in the bread made with flour type 1350: ie with 212% more than bread made with flour type 550, and with 57.5% more than bread made with flour type 680 ($P<0.05$). In the case of breads made from fortified flours (with Fe), the phytic acid content has increased with flour extraction degree rising. So, the bread made from flour type 1350 has recorded the highest value of the phytic acid, with 826.5% more than flour type 550 and with 113,7% more than flour type 680 ($P<0.05$).

The phytic acid content in all bread samples made from unfortified flours was higher than breads made from fortified ones. From the Table 2 it can see that, as compared to unfortified versions, the biggest drop in phytic acid content was recorded in fortified bread coming from flour type 550 (195.6%), followed by bread from flour type 680 (60.5%) and bread from flour type 1350 (18.3%) ($P<0.05$).

The flour fortification has led to a greater decrease of the phytates concentration in bread samples. The lower extraction degree of flour the greater decrease of bread phytates was. Comparing the data from the two tables, it can be seen that during bread processing the phytic acid content of flours has decreased in all cases ($P < 0.05$), reaching much lower:with 187.5% in unfortified bread and with 697% in fortified one (the both made from flour type 550), with 52% in unfortified bread and with 131% in fortified one (the both made from flour type 680) and with 4.9% in unfortified bread and with 18.8% in fortified one (the both made from flour type 1350).

These data show that, compared with phytic acid, the phytin (formed by iron fortification) was hydrolyzed more intense by phytases (derived from wheat or yeast). The reduction of phytate content during bread making depends on phytase action, which is influenced by several factors: the degree of flour extraction, the proofing time and temperature, the acidity of the dough, the yeast, enzymes added to the dough and the presence of calcium salts [12,3].

In our experiments, the dough pH was 4.5, and the fermentation temperature was 32ºC. It seeems that during bread making, the pH would be the most important factor reducing the content of phytic acid because the phytic acid in doughs with pH 4.3–4.6 is more effectively reduced than in doughs with higher pH [13]. According to Garcia-Estepa et al. (1999), another factor that reduces phytic acid content in bread is baking temperature, since within roasted sliced French toast 86% of phytic acid was destroyed.

Fermentation and bread making reduce phytic acid content of cereals with percentages between 8.9% in the whole-meal breads (unleavened) and 66-100% in white breads [15,16,17].

4. **Conclusions**

The processing of wheat grains (milling, flour fortification with iron, and bread making) has influenced the phytic acid content in flour and bread.

The flours extraction degree has directly influenced the phytic acid values. Of the three types of wheat flour analyzed (550, 680 and 1350) the flour with largest degree of extraction (type 1350) has recorded the highest value of the phytic acid.

The phytic acid content in all three types of unfortified flour was higher than in fortified ones. As compared to unfortified versions, the biggest drop in phytic acid content was recorded in fortified flour type 550, followed by flour type 680, and flour type 1350. The lower extraction degree of fortified flour the greater decrease of phytates was.

In bread samples made with unfortified flour, the phytic acid content was different depending on the type of flour. The highest content of phytic acid was recorded in the bread made with flour type 1350. In the case of bread made from fortified flour (with Fe), the phytic acid content has increased with flour extraction degree rising. The phytic acid content in all bread samples made from unfortified flour was higher than in bread made from fortified ones.

The flour fortification has led to a greater decrease of the phytates concentration in bread samples. The lower extraction degree of flour the greater decrease of bread phytates was. One can notice that during bread making, the phytic acid content of flour has decreased in all cases reaching much lower within fortified bread coming from flour with lower degree of extraction.

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