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THE INFLUENCE OF THE HYDROTHERMIC TREATMENT ON THE SOLUBLE PHOSPHORUS CONTENTS IN MILLING STREAMS PRODUCTS

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Abstract

The bran has a high content of bioelements which, unfortunately, are complexes by phytic acid. The hydrothermic treatment, under conditions which allow the phytase activity, was found to be an efficient process which reduces the quantity of the phosphor-ester in the favor of soluble phosphor. Whole meal rye and the bran obtained from hydrothermal treated rye can be used as sources of fibers with a reduced content of phytates. Depending on flour quality, they can be used as supplements, within 20-25%, for bread manufacturing. The aim of this study was to evaluate the way in which the parameters of hydrothermic treatment influence the decrease of the phosphor ester-content and transform it in soluble compounds. Our results show that a temperature of 550ºC and o concentration of the acid solution and o concentration of the acid solution used for rye soaking of 1.5% lead to higher contents of soluble phosphor.
Keywords: *hydrotermic treatment, soluble phosphorus, rye*

Introduction

A large part of the phosphorus in cereals (between 50 and 80%) is to be found under the form of phytine, calcium salt and magnesium of the phytic acid. In wheat grains, the phytine is unevenly distributed: 85 % is found in the aleuronic layer, 13% in the germ and 2% in the endosperm.

The content of phytic acid is 8.18mg/m in the rye, 3.44%mg/g in the rye flour according to Fretzdorff and Weipert (1986), and 4.48 mg/g in the wheat, according to Kim (2000).

It is known that the husk has a high content of bioelements – calcium, magnesium, zinc, iron. Unfortunately, they are under the form

of salts of the phytic acid. Through hydrothermic treatments, some optimal conditions of the phytasis action on the phytine can be created, releasing bioelements (Bergman, 2001).

The whole rye, the husk obtained from the rye hydrothermic treated can be used as a source of food fibers with reduced contents of phytates. They can be used as adding to the bread making in quantities up to 20...25%, depending on the quality of the wheat flour.

Experimental

We have used the Gloria variety, cultivated for its grains. The plant is ranked as semi-tall (120…125 cm). The ear is long, measuring about 11.0 cm, it is dense, prismatic, sometimes stretched prismatic, with well-formed and spread aristae, and it is dark-yellow when mature. The grain is oblong, medium to big, and it is greenish. The mass of 1000 grains is about 38…40 g and the hectolitrical mass is 65...70 kg/hl. It is a semi-precocious variety, resistant to frost and wintering.

The experiments have been held in two stages.

Firstly, we have analyzed the effect of the concentration of the acid solution used in dipping the rye, the temperature conditions having been constantly maintained

Secondly, we have applied a compositional experimental plan of the IInd order. The two parameters of the hydrothermic treatment had three levels (1, 0, +1).

The basic levels for x/temperature and y/the concentration of the citric acid solution have been

$$x^0 = \frac{x^{-1} + x^{+1}}{2} = 50^\circ C \ , \ y^0 = \frac{y^{-1} + y^{+1}}{2} = 0.75\% ,$$

and the encoded values

$$x/encoded = \frac{x - 50^0}{5} = \pm 1 \ , \ y/encoded = \frac{y - 0.75}{0.75} = \pm 1 .$$

Twelve experiments have been held.

In order to mathematically describe the hydrothermic treatment results, we have used a polynomial of the IInd order having the form of:

$$z = a + b \cdot x + c \cdot y + d \cdot x^2 + e \cdot y^2 + f \cdot x \cdot y$$

where:

z is the response variable (the quantity of soluble phosphorus existent after the application of the hydrothermic treatment);

x, y – the parameters of the hydrothermic treatment: the concentration of the citric acid, temperature;

a, b, c, d, e, f – parameters of the model (a – the free term, b, c, d, e, f – the regression coefficient).

Determining the regression coefficient and the analysis of the experimental results dispersion, in order to evaluate the contribution of the elements of the I^{st} order (a, b, c) and of the II^{nd} (d, e, f), but also to establish the degree of adequacy of the model, have been achieved through the programme Windows Statistics version 4.3.

The adequacy of the model, that is the hypothesis that the experimental data belong to the response surface generated by the regression equation, and the extent to which the correlation suggested by this equation is real, can be globally evaluated on the basis of the coefficient of this correlation. The closer to 1 it is, the better the model fits the experimental data, a very close relationship existing between the variables admitted in the study.

The hydrothermic treatment applied to the rye is made up of the following stages:

- ✓keeping the rye for 1 hour at temperatures between 45 and 55ºC in solutions of citric acid of concentrations between 0 and 1.5%; the relation between the rye and the acid solution was 1:2;
- ✓drying it for 5 h at 55ºC;
- ✓keeping it for 1 h at temperatures between 45 and 55ºC in citric acid solutions having a concentration between 0 and 1.5%, the relation between the rye and the acid solution was 1:2;
- ✓drying it for 15 h at 55ºC, drying it for 8 h at 50ºC, 2 h at 60ºC, 6 h at 80ºC.

The rye samples have been ground at the Buhler laboratory aggregate. For the flour and the husk resulted, we have determined the contents of soluble phosphorus.

The content of soluble phosphorus has been determined by extracting it in trichloracetic acid and by dosing it through the spectrophotometrical method with the ammonium phosphomolybdate.

The method is based on the property of the phosphoric acid to form the phosphomolybdate, in acid environment and with excessive quantity of ammonium molybdate. The phosphomolybdate is reduced according to the reaction:

$$H_3PO_4 + 12\ (NH_4)_2MoO_4 + 21\ HNO_3 \rightarrow (NH_4)_3H_4[P(Mo_2O_7)_6] + 21\ NH_4NO_3 + H_2O$$

in a complex of blue colour (molybdenum blue) (Liteanu, 1985). We have used the hydroquinone as a reducing agent. The intensity of the colour is proportional to the contents of the phosphoric acid in the solution.

Results and Discussions

The concentration of the acid solution varied between 0.3 to 1.5%, at constant temperature (50ºC), typical to the treatment applied to the rye grains.

The experimental results for the types of flours resulted through grinding the rye samples hydrothermic processed are shown in table 1, and those for the bran are shown in table 2.

In order to quantitatively evaluate the influence of the hydrothermic treatment parameters – temperature, *p*H, on the quantity of soluble phosphorus resulted through the action of the phytasis, we have calculated the coefficients of the regression equations corresponding to the IInd order module, based on the experimental results.

Table 1. The variation of the soluble phosphorus quantity in the flour obtained through grinding the rye hydrothermic treatment

No. experiment	The concentration of the acid solution, %	Soluble phosphorus, mg/g	% of increase toward bran obtained from rye untreated
1	0.30	1.28	2.5
2	0.75	2.11	4.1
3	1.20	2.36	4.6
4	1.50	2.48	4.9

Table 2. The variation of the quantity of soluble phosphorus in the rye obtained through grinding the rye hydrothermic treatment

No. experiment	The concentration of the acid solution, %	Soluble phosphorus, mg/g	% of increase toward bran obtained from rye untreated
1	0.30	8.52	2.80
2	0.75	12.76	4.20
3	1.20	13.88	4.61
4	1.50	13.98	4.64

The statistical processing has enabled to establish the significance level for each coefficient of the regression equation, but also to achieve the analysis of the model variance, pointing to the lack-of-fit.

The IInd order regression equation which influences the evolution of the phytate contents reduction and the formation of soluble phosphorus was:

$$z = -2.1329 - 0.0984 \cdot x + 16.0794 \cdot y + 0.00499 \cdot x^2 - 4.9877 \cdot y^2 - 0.0633 \cdot x \cdot y,$$

the correlation coefficient being 0.9896.

We have noticed the existence of a significant level for risk of 5% for the regression equation coefficient corresponding to the factor *p*H (y) of I order and for the coefficients of the factors *p*H (y^2) and the interaction of the factors *p*H and temperature (xy) of IInd order).

The data in table 3 show that the lack-of-fit is not significant. The variance of the model explained is 98.03%. Under the circumstances, we can say the model fits better the experimental data.

By calculating and annulling the derived function of the Ist order in order to reduce the phytate contents and to form soluble phosphorus (z) in relation to temperature (x) and *p*H, we have obtained optimal conditions for applying the hydrothermic treatment: temperature of 55ºC and the concentration of the acid solution used for dipping rye is 1.5%.

Table 3. The quantitative evaluation of the influence of the hydrothermic treatment parameters on the reduction of the phytate contents (the statistical processing)

Source of variation	Sum of square	Degrees of freedom	Mean square	F_{STAT}	P>F
Regression	110.7512	5	22.1502	114.08	0.0001
Error:	1.1649	6	0.1941	-	-
-lake fit	0.9295	3	0.3098	3.949	0.1444
-pure error	0.2354	3	0.0784	-	-
Total	111.9162	11	-	-	-

Conclusions

The hydrothermic treatment is an efficient process used to reduce the quantity of esterified phosphorus in favour to the soluble one if the parameters of this treatment allow the action of the phytasis. At 55ºC and the concentration of the acid solution used for dipping the rye of 1.5%, we have obtained significant increase of the soluble phosphorus. The rye entirely ground, the husk obtained from the rye hydrothermic treated can be used as sources of food fibers with reduced contents of phytates. The quantity left is low enough to significantly influence in a negative way the absorption of the Fe, Mg, Ca and Zn ions.

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