FOOD SCIENCES

EFFECT OF SELENIUM ON THIAMINE, RIBOFLAVIN AND PANTOTHENIC ACID CONTENT IN DIFFERENT GRAINS

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Abstract

The effect of selenium on the content of thiamine (vitamin B_1), riboflavin (vitamin B_2), as well as pantothenic acid (vitamin B_5) in wheat (*Triticum aestivum* L), hulless barley (*Hordeum vulgare* L.) and hullless oats (*Avena sativa* L.) grains during germination were investigated.

The winter wheat grain variety 'Zentos', hulless barley and hulless oats were used for study. Grains were soaked for 120 hours totally in solutions containing selenium from 10 to 200 mg l^{-1} in the form of sodium selenate (Se^{+6}). Grains with moisture content of 43%-44% were let to sprout at ambient temperature of 18±2 °C. The content of B_1, B_2 and B_5 vitamins in germinated grains were determined using standard methods.

Laboratory studies showed that changes in vitamin B_1, B_2 and B_5 content depend on selenium concentration and kind of grains.

Selenium additives promote biochemical activity of vitamin B_1 and content of this vitamin decreases after 5 days' germination in all investigated grains at all applied selenium concentrations. Selenium concentrations of 10 and 25 mg l^{-1} promote forming of vitamin B_2 in wheat, barley and oat grains. The changes in vitamin B_5 content depend on selenium concentration and kind of grains.

Keywords: selenium, wheat, barley, oats, germination, B vitamins.

Introduction

Whole grains are universally recommended as an integral part of the diet. They are an important source of nutrients that are in short supply in our diet, including digestible carbohydrates, dietary fibre, resistant starch, trace minerals, certain vitamins, and other compounds of interest in disease prevention, including phytoestrogens and antioxidants (Slavin, 2004).

The major constituents of different kinds of cereals are fairly uniform. Noteworthy variations are the higher lipid content of oats and lower starch content in barley and oats. Wheat, barley and oats also differ in vitamin B content. Oats are the richest in thiamine ($\sim$ 7 mg kg^{-1}) and pantothenic acid ($\sim$ 14 mg kg^{-1}), the content of riboflavin is higher in barley (Belitz, Grosch, 1986).

Wheat grains are high in dietary fibre, low in fat, have $\sim$ 7–20 g 100 g^{-1} protein, and are concentrated sources of starch, high in vitamins (especially B vitamins), and good source of minerals (Kulp et al., 2000).

The practice of sprouting is widely used to improve the nutritional value of grains. It is known that germination increases the level of amino acids, some vitamins, and minerals (Lintschinger et al., 2000). Germination has an important effect on the water-soluble vitamin composition, and sprouted grains usually contain different levels of some vitamins (ascorbic acid, thiamine, riboflavin, niacin and pantothenic acid) compared to levels in the corresponding dry grains. These changes depend on the type of grain and sprouting conditions, such as time, temperature, the presence or absence of light during sprouting process or the composition of soaking and rinsing media (Yang et al., 2001).

Using selenium-containing solutions for grain soaking during germination it is possible to fortify grains with this microelement (Lintschinger, 1997). Selenium (Se) is an essential trace element for man and its biological functions are carried out by selenoproteins, several of which are parts of the antioxidant enzymes that protect cells against the effects of free radicals (Ganther, 1999).

Because of the good nutritional source for protein, vitamins as well as microelement selenium from grains, the present study investigates the effect of selenium additives on changes in thiamine, riboflavin and pantothenic acid content during germination of wheat, barley and oat grains using solutions with different selenium concentrations.

Table 1

Tiamine, riboflavin and pantothenic acid content in grains before germinating

Type of grains	Vitamin concentration, mg kg^{-1}±SD		
	Thiamine	Riboflavin	Pantothenic acid
Wheat	3.80 ± 0.03	1.17 ± 0.01	41.93 ±0.04
Barley	3.66 ± 0.05	1.75 ±0.02	48.33 ±0.04
Oats	7.22 ±0.01	1.51 ±0.06	17.23 ± 0.01

Materials and Methods

The research was performed at the Laboratories of the Department of Chemistry at the Latvia University of Agriculture and at the Laboratory of Biochemistry and Physiology of Animals at the Institute of Biology of University of Latvia.

The winter wheat grain variety 'Zentos', hulless barley and hullless oat grains were germinated for 5 days. Grains (100 g) were soaked in 500 ml of solutions containing 10, 25, 50, 100 and 200 mg l^{-1} of selenium in form of selenate at ambient temperature of 18±2 °C for 6 h and shaken every 30 min. The solution was then drained off and samples were germinated for 5 days under natural light conditions at 18±2 °C. Every 24 h the grains were moistened with corresponding solution and carefully shaken.

Control samples without selenium additives were prepared for comparison of obtained results.

After germinating all grains, which were soaked in selenium-containing solutions, 3 times were washed with 500 ml deionized water to prevent contamination of the surface of grains with the solution containing selenium. After that, the grains were put into plastic packs and stored at -18 °C in a freezer for 24 h, then dried and ground.

The amounts of B_1, B_2 and B_5 vitamins were determined by standard methods – AOAC Official Standard Method 986.27, AOAC Official Standard Method 970.65 and AOAC Official Standard Method 961.14 respectively. For comparing obtained results during germination and for evaluation of selenium influence on B vitamins content, the concentration of B1, B2 and B5 vitamins were determined in grains before germinating.

The germination was performed in duplicate and analysis was carried out in triplicate. The data given here are the mean values of the measurements ± standard deviation (SD).

The data was analyzed statistically using SPSS for Windows and MS Excel for Descriptive Statistics (mean values, standard deviation) and for Correlation and Regression Analysis.

Results and Discussion

The results obtained indicated that germination modified the nutritional composition of grains, which was dependent on the type of grains.

The content of B_1, B_2 and B_5 vitamins in grains before germination are showed in Table 1.

The research data on changes in thiamine content in wheat, barley and oat grains after 5 days' germination, using solutions with different selenium concentrations as well as control solution without selenium additives is presented in Figure 1.

It is known that during germination the content of thiamine decreases, because it is an essential constituent of all cells since it is a cofactor for two enzyme complexes involved in citric acid cycle – pyruvate dehydrogenase and α-ketoglutarate dehydrogenase (Belanger et al, 2004).

Comparing the content of vitamin B_1 in grains before soaking and in grains germinated in control solution we found that it decreased by 12.11% in wheat grains, by 66.94% in barley, and by 28.19% in oats. Figure 1 shows that selenium additives have influence on thiamine content in all investigated grains after 5 days' germination. After soaking grains in solution containing selenium of 10 mg l^{-1}, the content of vitamin B_1 decreases by 53.9% in wheat grains, by 69.7% - in barley, and by 35.6% - in oats comparing with B_1 vitamin content in grains before soaking. With increased concentration of selenium in solution, the content of B_1 vitamin decreases. The highest decreasing is obtained using solution with selenium concentration of 200 mg l^{-1}: after 5 days' germination the content of B_1 vitamin decreases by 97.4% in wheat grains, by 99.7% - in barley, and by 67.2% - in oats comparing with vitamin content in grains before soaking.

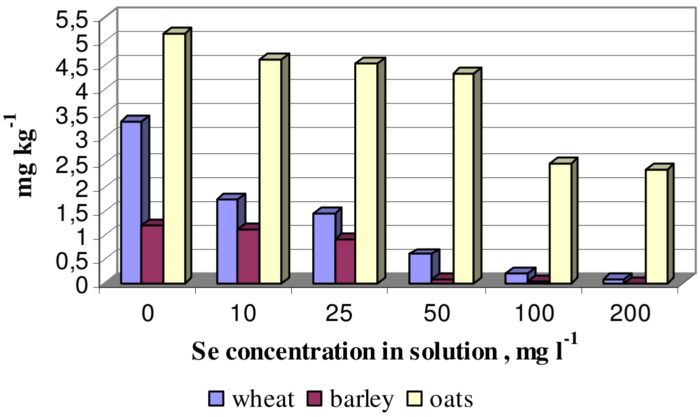

Figure 1. Thiamine concentration in germinated grains.

Linear correlations, i.e., $y = -0.0124x+2.0372$ ($R^2 = 0.59$), $y = -0.006x + 0.9462$ ($R^2 = 0.62$), and $y = -0.0146x + 4.8612$ ($R^2 = 0.84$) for wheat, barley, and oats respectively, which allowed defining the correlation of vitamin B_1 content and selenium concentration in solution, have been estimated.

We can conclude that microelement selenium has influence on thiamine concentration in germinated grains and it depends on type of grain and on the concentration of selenium.

The changes in riboflavin and pantothenic acid content in germinated grains depending on selenium concentration in soaking solution are showed in Figures 2 and 3.

The obtained results conform to the results described in literature on the changes in vitamin B_2 content during germinating (Zielinski et al., 2005).

The results show that the content of vitamin B_2 increases after 5 days‘ germinating and selenium additives influence the content of vitamin B_2 in grains. The content of vitamin B_2 increases in wheat, barley and oats after soaking grains in solutions with selenium concentration of 10 and 25 mg l^{-1}. The highest increase we observed with wheat grains – by 41.9% comparing with vitamin B_2 content in grains before soaking. After this research selenium concentration and vitamin B_2 content correlations in different grains have been estimated and linear equation obtained,

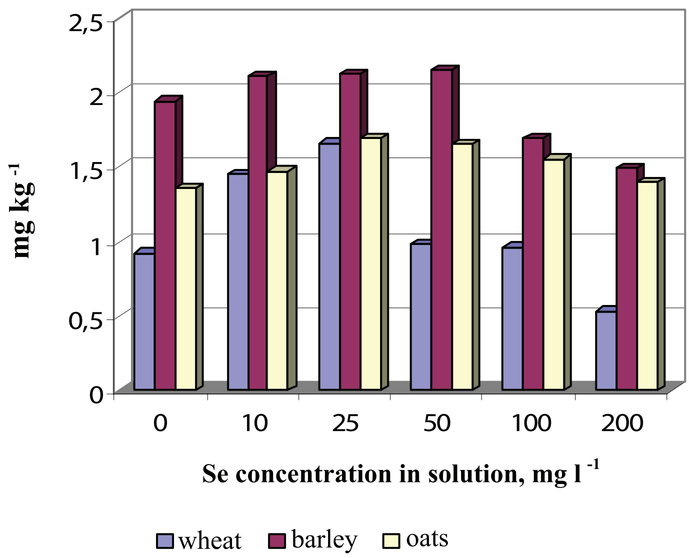

Figure 2. Riboflavin concentration in germinated grains.

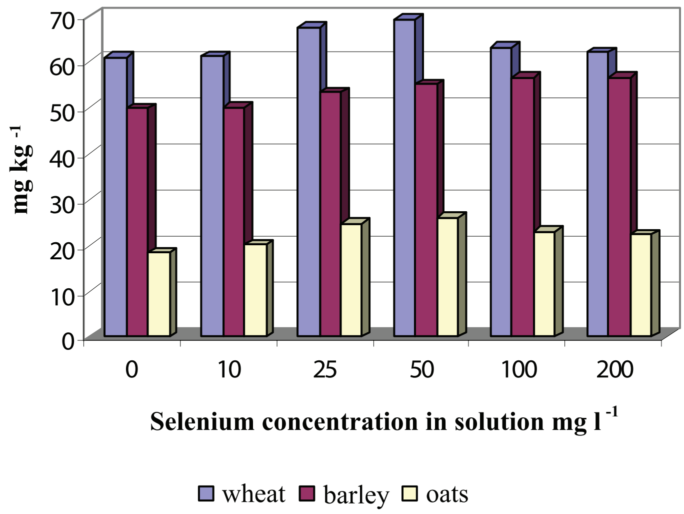

Figure 3. Pantothenic acid concentration in germinated grains.

i.e., $y = -0.0039x+1.3382$, $y = -0.0034x+2.1355$ and $y = -0.0004x + 1.5415$ for wheat, barley, and oats respectively. The strong positive correlation between selenium concentration in solution and B_2 vitamin content in wheat ($R^2 = 0.51$) and barley grains ($R^2 = 0.76$) have been determined.

Figure 2 shows that changes in vitamin B_2 content depend not only on selenium concentration, but also on the kind of grains. It can be explained with the different chemical composition of wheat, barley, and oat grains.

The content of panthotenic acid in different grains is higher than content of thiamin and riboflavin. The obtained results show that during germination the content of B_5 vitamin increases by 45.2%, 3.2% and 7.1% in wheat, barley and oat grains after soaking in solution without selenium additives. Analyzing the obtained data statistically, we found linear equations: $y = -0.0056x + 64.411$, $y = -0.034x + 51.359$, and $y = 0.0088x + 21.877$ for wheat, barley, and oats respectively. The strong positive correlation between selenium concentration in solution and B_5 vitamin content in barley have been determined ($R^2 = 0.66$).

Figure 3 shows that the highest increasing in vitamin B_5 content is observed in wheat and oat grains (65.4% and 52.0% respectively) at selenium concentration of 50 mg l^{-1}. All applied selenium concentrations promote forming of vitamin B_5 in barley (totally by 17.3%).

Conclusions

1. Microelement selenium has influence on thiamine content in germinated grains, which is dependent on type of grain. Selenium concentration of 200 mg l^{-1} gives the highest decrease – after 5 days‘ germination the content of B_1 vitamin decreases by 97.1% in wheat grains, by 99.2% - in barley and by 54.4%- in oats.
2. Selenium additives of 10 mg l^{-1} and 25 mg l^{-1} promote forming of riboflavin in wheat, barley, and oat grains.
3. The content of pantothenic acid increases during germination, and selenium additives promote increase in vitamin B_5 content in wheat and oat grains at selenium concentrations of 10, 25 and 50 mg l^{-1} but prevent increasing of this vitamin content in these grains at higher selenium concentrations 100 and 200 mg l^{-1}.
4. All applied selenium concentrations promote increase in pantothenic acid content in barley.

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