FORTIFIED WHEAT GRAINS WITH MICROELEMENT SELENIUM

Māra Dūma, Daina Kārkliņa
Latvia University of Agriculture
e-mail:marad@inbox.lv

Abstract

Selenium (Se) is an essential microelement for human health, it is not synthesized in human body and cannot be substituted by any other element. Many health problems have a link with Se deficiency. People need to obtain all necessary amounts of selenium with food. Cereal products are important components of our diets and can contribute comparatively large part of the total dietary intake of Se. The wheat grains growing in Latvia contain comparatively small amount of selenium – on average 0.04 mg kg^{-1}.

The objective of this study was to investigate the possibilities of fortifying wheat grains with microelement selenium during soaking grains in selenium containing solutions. Wheat grains were soaked in sodium selenite and sodium selenate solutions with selenium concentration from 10 to 200 mg l^{-1}. Sprouting activity was determined after 24, 72 and 120 hours, the influence of selenium valence in compound was observed. Comparing the influence of Se^{+4} and Se^{+6}, it can be concluded that Se^{+4} does not promote sprouting activity of wheat grains in opposition to Se^{+6} which increases sprouting activity till selenium concentration 100 mg l^{-1}. Uptake of selenium in grains was studied by determination of total Se using atomic absorption spectroscopy method. Linear correlation between Se concentrations in applied soaking solutions and Se concentration in grains was observed. The content of total protein did not change significantly – it varied from 13.64% in the control sample to 13.87% in the wheat sample with the highest applied selenium concentration (200 mg l^{-1}).

Key words: selenium, wheat grains, sprouting activity.

Introduction

In areas such as Latvia where soils are low in bioavailable selenium (Se), its potential deficiencies can cause health risks for humans. Selenium is an essential nutrient for animals and humans, but it is toxic at high concentrations. It is not synthesized in human body and cannot be substituted by any other element. It is known that human body should contain 5-20 mg of Se (Combs, 2001).

Selenium was discovered by Swedish chemist Jons Jakob Berzelius in 1817. Klaus Schwarz established selenium as an essential nutrient for animals in 1957, but the first selenium function in humans was not discovered until 1973 (Rotruck et.al., 1973).

Se deficiency has been extensively studied in relation to Keshan and Kashin-Beck diseases in China (Foster et al., 1997). This nutrient is an important part of antioxidant enzymes that protect cells again the effects of free radicals that are produced during normal oxygen metabolism. Selenium is also important for normal functioning of the immune system and thyroid gland. Selenium may also protect the body against contaminants such as mercury, cadmium, silver and help speed the elimination of cancer cells, and slow tumor growth.

The best-known biochemical role of selenium is its function as part of the enzyme glutathione peroxidase which protects vital components of cells against oxidative damage (Standman, 1990).

Low selenium status may contribute to the aetiology of the disease process but in some cases it may be an outcome of the condition itself and may exacerbate disease progression (Rayman, 2002).

The maintenance dose is 55-70 μg day^{-1}, but a daily extra-dietary supplement of 200 ģg Se has been indicated to increase resistance to viral infections and reduce cancer risk (Schrauzer, 2002).

The consumption of food provides the principal route of Se intake for population. Cereal products are important components of our diets and can contribute comparatively large part of the total dietary intake of Se.

Wheat (*Triticum aestivum L*) is the most important of all wheat species as well as one of most suited to bread making. It contains useful amounts of several of the B vitamins including thiamine, riboflavin and niacin, and also vitamin E. Wheat also contains the minerals potassium and zinc as well as trace elements such as selenium. The selenium content in wheat will depend on the amount of selenium in the soil which it is grown in.

Wheat is a good source for bioavailable selenium and many studies have been performed to enrich selenium in wheat by selenium fertilization of the soil (Eurola et al., 1990).

Several studies show that selenium-rich wheat products are able to significantly enhance selenium blood levels and glutathione peroxidase activity (Barkclay et al., 1992).

Summarizing above mentioned information, the present study was to investigate the possibilities of fortifying wheat grains with microelement selenium during soaking grains in selenium containing solutions. Germinating sprouts might be used directly for food or for supplementing of different diets. Sprouting was used because it is known that it additionally improves the nutritional value of grains due to better quality of protein, a more favourable distribution of amino acids, a higher content of polyunsaturated fatty acids, and higher content of vitamins (Lintschinger et al., 1997).

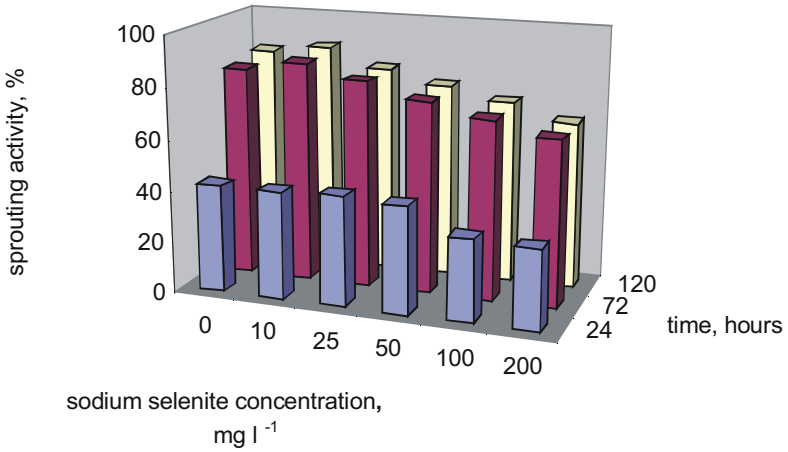

Figure. 1. Sprouting activity of wheat grains depending on the Se^{+4} concentration in solution and the sprouting time.

Materials and Methods

The winter wheat grain variety 'Zentos' was used in this study.

The germinating of wheat variety 'Zentos' was performed in different solutions containing different concentrations of selenium (from 10 to 200 mg l^{-1}) in forms of sodium selenite (Se^{+4}) and sodium selenate (Se^{+6}). In all, 50 g of wheat grains were soaked in 500 ml of corresponding solutions for total of 120 hours. Grains with moisture content 43-44% were let to sprout at ambient temperature (19-20 °C). Sprouting activity was determined after 24, 72, and 120 hours. Grains soaked in deionised water were used as controls (using cationite Amberlite 252 NA layer). After germination the soaked grains were washed 3 times with 500 ml of deionized water to prevent the sprouts surface contamination with 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 experiments were performed in triplicates.

Visible germination rates were determined by measuring the number of sprouting grains. The protein content was determined by Kjeldhal method according to ISO 5983 standard method.

The concentration of selenium in the dry matter of analysing grains and sprouts was determined by the atomic absorption spectrometric (AAS) method using standard method AOAC 986.15.16th.Ed.1995.

The data given here are the mean values of the measurements.

Results and Discussion

Analysis of the obtained results shows that sprouting activity of wheat depends on selenium valence in applied

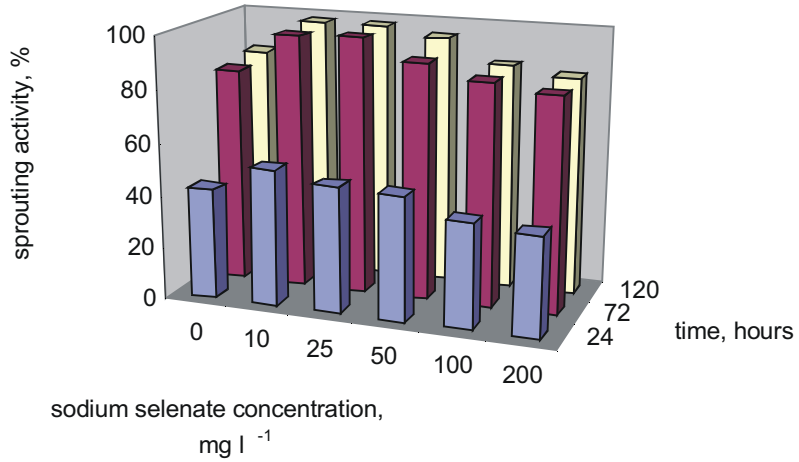

Figure. 2. Sprouting activity of wheat grains depending on the Q concentration in solution and the sprouting time.

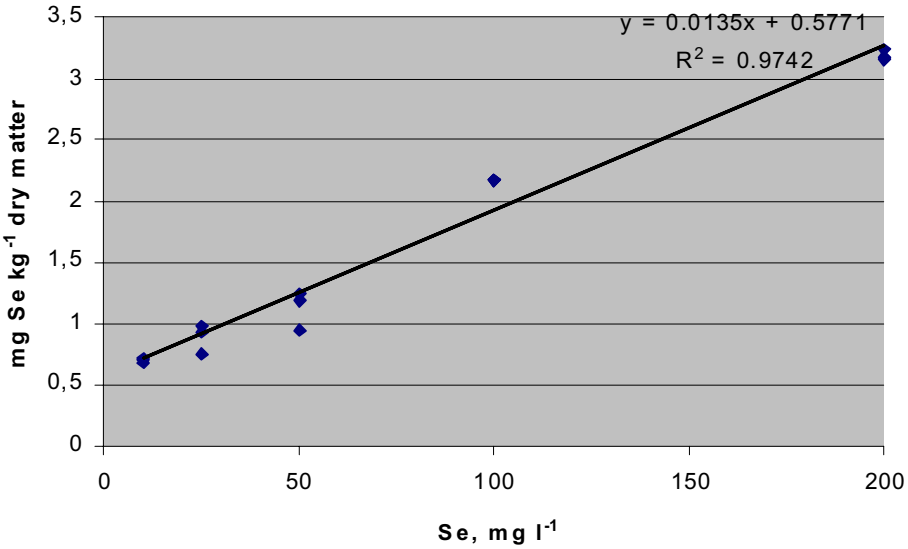

Figure. 3. Total Se concentration in grains depending on Se concentration in soaking solution.

salt solutions. Figures 1 and 2 represent these differences. Comparing the influence of Se^{+4} and Se^{+6}, we can conclude that Se^{+4} does not promote sprouting activity of grains. Only one Se^{+4} concentration of 10 mg l^{-1} gives small increasing of wheat grains sprouting activity, but all other applied concentrations decrease sprouting activity after 24, 72, and 120 hours. A different effect can be observed after wheat grains soaking in sodium selenate solutions. Investigated concentrations of sodium selenate increase the sprouting activity of wheat grains till Se^{+6} concentration of 100 mg l^{-1}. After 120 hours of germinating, the sprouting activity at Se^{+6} concentration of 200 mg l^{-1} is even lower than in the control. These differences certify the literature data that Se as selenate in opposition to Se as selenite is not reduced to elemental Se in the cultural solution and therefore uptake of selenium in the form of selenate is better (Lintschinger et al., 2000).

Since influence of sodium selenite was undistinguished, the further analysis was carried out with wheat grains soaked in different concentration solutions of sodium selenate.

The uptake rates were determined by measuring the total Se concentration in the sprouts after 5 days of germination in sodium selenate containing solutions, because it is known that selenium accumulation is more affected by root uptake than by imbibition (Lintschinger et.al, 1997). Therefore a long germination period is required for better enrichment.

The obtained results are shown in Figure 3. Data shows that wheat is active in selenium uptake during soaking. The content of selenium in the grains increases several times compared with selenium concentration in the grains before soaking. It could be explained by the high bioavailability of the wheat. The results suggest that the nutritional value of the grain can be increased by a reasonable addition of Se.

In Figure 3 the total selenium concentration of wheat grains as a function of the concentration of the applied Se solution are presented. Linear correlation can be observed: the correlation coefficient r=0.99, and determination coefficient R^2=0.974.

For comparing the changes in wheat nutritional value due to fortifying of grains with selenium, the content of total protein was determined. Analysis of the obtained results suggests that selenium additive does not influence the total protein significantly – the results vary from 13.64% in control sample to 13.87% in wheat sample with the highest applied selenium concentration (200 mg l^{-1}).

Conclusions

1. Fortifying of wheat grains with microelement selenium is possible during soaking of grains in sodium selenate solutions. The content of total selenium in grains increases 81.5 times after soaking grains in the highest concentration (200 mg l^{-1}) of sodium selenate solution.

2. Sprouting activity of wheat variety 'Zentos' depends on selenium valence and selenium concentration in applied salt solutions. Se^{+4} does not promote sprouting activity of wheat grains in opposition to Se^{+6} which increases sprouting activity till selenium concentration 100 mg l^{-1}.

3. Sodium selenate (Se^{+6}) promotes the germination process better than sodium selenite (Se^{+4}).

4. The content of total protein does not change significantly during soaking of wheat grains in selenium Se^{+6} containing solutions.

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