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CHANGES IN HEAVY METALS CONTENT IN WINTER WHEAT GRAIN AND FLOUR UNDER RIGHT-BANK FOREST-STEPPE CONDITIONS

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The article presents data on the contamination with heavy metals of winter wheat grain grown under intensive farming conditions. The decrease in heavy metals content during grinding of winter wheat grain into different fractions of flour: high-grade, first-grade, second-grade and bran was investigated.

According to the results of the conducted research it was established that grinding of winter wheat grain into different fractions of flour allows to reduce the lead content in high-grade flour by 71,8 %, first-grade flour – by 51,5 %,compared to the lead content in grain; cadmium content in high-grade flour decreases by 75,0 %, first-grade – by 50,0 %, second-grade – by 25,0 %, but increases in bran by 60,0% compared to the cadmium content in grain; the copper content in high-grade flour is 72,0 % lower, first-grade flour – 52,0 % lower, second-grade flour – 47,4 % lower, but at the same time higher in bran by 50,7%, compared to the copper content in grain; zinc content in high-grade flour decreases by 95,9 %, first-grade flour – by 54,6 %, second-grade flour – by 51,7 %, but at the same time increases in bran by 68,2 %, compared to zinc content in winter wheat grain.

***Keywords:** grain, winter wheat, flour, contamination, heavy metals.*
Tab. 1. Lit. 12.

Introduction. Wheat is one of the main energy sources for humans on Earth. Its value is constantly growing, because it's a useful and economically viable food crop that can be grown under fairly wide and varied conditions [1].

A significant amount of flour is produced and consumed all over the world, especially wheat flour. Wheat flour is an important product of world trade and it's important for human nutrition. Nowadays, great attention is paid to the quality and expansion of the range of its products, due to the fact that successful promotion of the product on the consumer market and its ability to compete with similar products of other manufacturers depend on above-mentioned things. Equally important is the fact that the milling industry purpose is reoriented: it's important to create a product that would not only feed a person but also be of maximum benefit and quality for the consumer. That is, the problem of grain quality and flour today is more urgent than ever [2].

Alimentary products and raw materials safety is one of the main factors that determines the health of the population of Ukraine and its gene pool conservation. More than 70% of all contaminants get into the human body with food. The results of the food quality control show the high levels of contamination of the products with

toxic chemical compounds, biological agents and micro-organisms. Overall, 1.5–10 % of food samples in Ukraine contain heavy metals, including lead, cadmium, copper, zinc, of which 2,5 to 5 % are in concentrations exceeding the limit [3].

Heavy metals enter the human habitat as a result of not only natural processes, but also mainly due to intensive development of industry, irrational use of natural resources, agriculture and urbanization of society [3, 4].

Once in contact with living organisms, heavy metals are stocked in certain tissues. Reaching a certain concentration into the body, they begin to influence on it harmfully. In particular, by interacting with the thiol groups of different macromolecules of the body, their blocking occurs, which in turn leads to the loss of many reactions by proteins as well as to the metabolic disorder. In the blood heavy metals are combined with albumin, which increases their accessibility to the body's cells [3, 4, 5].

Contamination of grain products with heavy metals is an extremely important and urgent problem. Among the variety of heavy metals, lead, cadmium, copper, and zinc present the largest amounts of their inflow with chemical products [6, 7].

Analysis of recent research and publications. The problem of production of flour of high nutritional value and quality is covered in scientific works of I. P. Bondar, H. V. Deinychenko, N. V. Vereshko, V. A. Morhun, I. T. Merko, V. O. Morhun, T. A. Bakuridze, B. M. Maksymchuk, O. I. Maksymchuk, I .O. Shvetsova, N. P. Kozmina, L. I. Puchkova, R. D. Polandova, I. V. Matveieva, V. I. Drobot, L. Y. Arseniieva, O. B. Shydlovska and other scientists.

Heavy metals entering the human body may cause a number of metabolic disorders, mainly redox processes. Chemical compounds of metals with different cell components may cause membrane damage as well as inhibition of the activity of different enzymes [8].

Lead is a dangerous toxicant of global importance. In oral administration, lead, depending on the compound, is absorbed by adults by 10 % and children by 20 %. The maximum allowable dose for the human body should be within 0.0004… 0.005 mg/kg. In case of lead intoxication, both general and specific abnormalities can be noted in the human body, which are expressed in neurology and encephalopathy changes [8].

Cadmium is a toxicant with a high capacity to be accumulated in tissues. The withdrawal period of this metal from the body is 13–40 years, with the lethal dose for the human body of 150 mg/kg. The main source of soil contamination with cadmium is industrial water, wastewater, as well as the use of mineral fertilizers and pesticides in agriculture [8].

Copper as a bio microelement is involved in tissue respiration and hematopoiesis. When fed with food, about 30% of copper is absorbed in the gut. For humans, a single dose of 10… 20 mg/kg body weight causes nausea, vomiting and other symptoms of copper intoxication. The daily intake of the element can be no more than 0.5 mg/kg (up to 30 mg/kg into the diet) with normal dietary content of molybdenum and zinc, physiological copper antagonists [8].

Zinc stimulates cell division and healing of the affected tissues, but at the same time promotes the formation of cancer cells. Cardiovascular diseases can occur due to the imbalance of zinc content into the body. For nutritional products, the following levels of zinc are recommended: meat up to 20 mg, beverages up to 5 mg, fruits and vegetables up to 100 mg/kg [9, 10].

Purpose of the research was to determine the reduction of heavy metals content during grinding of winter wheat grain into different fractions of flour: high- grade, first-grade, second-grade and bran.

Main research material presentation. The studies were conducted during 2016–2018 on a winter wheat grain grown under intensive farming conditions and its flour under right-bank forest steppe conditions.

Laboratory analysis of grain and flour were carried out at a certified Scientific and Measuring Agrochemical Laboratory of Vinnitsa National Agrarian University, where the content of heavy metals was determined by grinding winter wheat grain into different fractions of flour: high-grade, first-grade, second-grade and bran.

Intensive chemicalization of technological processes of winter wheat growing causes the introduction of high standards of mineral fertilizers and pesticides. These agents contribute to the accumulation of heavy metals in grain and flour [11].

Flour is a product that is obtained by grinding the grain into cereal powder or legume seeds. It is an important component of our daily diet, as it is widely used in cooking, baking, pasta and other food industries [11].

Wheat flour is the most popular in Ukraine, which is extracted from grains of soft or soft with solid impurities of wheat. They produce the high-grade, first-grade, second-grade flours and bran [12].

An important technological operation for the production of flour is the grinding of grain. It can be one-time and repeated. In the first case, the flour is obtained by one-time passing the grain through the grinding machine. However, commercial flour is not produced in this way. When grinding again, the flour is produced by repeated and sequential grain and its parts passing through the grinding machines [11].

According to GOST 30178-96 MPC of heavy metals in winter wheat grain is as follows: lead – 0,5 mg/kg, cadmium – 0,1 mg/kg, copper – 10,0 mg/kg, zinc – 50,0 mg/kg.

Results and discussion. When the lead content in winter wheat grain was 1,03 mg/kg, which was 2,1 MPC, the lead content in bran amounted to 2,68 mg/kg, which was 5,4 MPC and 61,6 % more than its content in grain. In second-grade flour, the lead content was lower by 47,6 % and amounted to 0,54 mg/kg, corresponding to 1,1 MPC. In first-grade flour, the lead content was lower by 51,5 % compared to the winter wheat grain and amounted to 0,50 mg/kg, which corresponded to MPC. High-grade flour was characterized by the lead content of 0,29 mg/kg, which was 71,8 % less than in grain and amounted to 0,6 MPC. Therefore, when the lead content of winter wheat is 2,1 MPC, it’s possible to use high-grade flour for food purposed without any restrictions or first-grade flour with some restrictions (Table 1).

When the content of cadmium in winter wheat grain was 0,04 mg/kg, which was 0,4 MPC, its content in bran amounted to 0,10 mg/kg, which was 1,0 MPC or more by 60,0 % than in grain. In second-grade flour, the cadmium content was 25,0% lower than in grain and amounted to 0,03 mg/kg, corresponding to 0,3 MPC. In first-grade flour, the cadmium content was lower by 50,0 % compared to winter wheat grain and was 0,02 mg/kg, which corresponded to 0,2 MPC. The high-grade flour was characterized by the cadmium content of 0,01 mg/kg, which was 75,0 % less than in grain, corresponding to 0,1 MPC. Therefore, with cadmium content in wheat grain of 0,4 MPC in winter wheat grain, flours of second, first and high grades may be used for food purposes, but bran use should be limited.

Table 1

Content of heavy metals in winter wheat grain and its flour, mg/kg (average farm data, 2016-2018)

Grain and its milling products	Pb		Cd		Cu		Zn	
	MPC	actual content	MPC	actual content	MPC	actual content	MPC	actual content
Winter wheat grain	0,5	1,03±0,1	0,1	0,04±0,01	10,0	17,44±0,5	50,0	26,50±1,6
Bran		2,68±0,2		0,10±0,2		35,34±1,4		83,20±,1,9
Second-grade flour		0,54±0,02		0,03±0,01		9,18±1,0		12,80±1,2
First-grade flour		0,50±0,02		0,02±0,01		8,38±1,0		12,05±1,1
High-grade flour		0,29±0,01		0,01±0,01		4,89±0,9		1,09±0,2

Source: based on own research

When the copper content in winter wheat grain was 17,44 mg/kg, which was 1,7 times higher than MPCм, the copper content of bran amounted to 35,34 mg/kg, which was 3,5 times higher than MPC and 50,7 % more than in grain. In second-grade flour, the copper content, compared to the grain, was 47,4 % lower and amounted to 9,18 mg/kg, which corresponded to 0,9 MPC. In first-grade flour, the copper content was lower by 52,0 % compared to winter wheat and amounted to 8,38 mg/kg, which corresponded to 0,8 MPC. High-grade flour is characterized by the copper content of 4,89 mg/kg, which was 72,0 % less than in grain, which corresponds to 0,5 MPC. Therefore, when the copper content in wheat is 1,7 MPC in winter wheat grain, for the food purposes flours of second, first and high grades can be used without any restrictions.

When the zinc content in winter wheat grain was 26,5 mg/kg, which was 1,9 times less than MPC, the zinc content of bran was 83,2 mg/kg, which was 1,7 times more than MPC. In second grade flour, the zinc content was 51,7% less than grain and amounted to 12,80 mg/kg, which corresponded to 0,3 MPC. In first-grade flour, the zinc content was 54,6 % lower than in winter wheat and amounted to 12,05 mg/kg, corresponding to 0,2 MPC. High-grade flour was characterized by the zinc content of 1,09 mg/kg, which was 95.9 % less than in grain, corresponding to 0,02 MPC. Therefore, when the zinc content of winter wheat is 0,5 MPC, it's possible to use second -, first - and high-grades flour for food purposes without restrictions, but it's prohibited to use bran. On the basis of conducted research the tendency of heavy metals content decreasing in winter wheat flour is traced in the

following sequence: 2 grade – 1 grade – high grade, but heavy metals content increasing in bran is also traced. Possible reasons for the significant increase in the content of heavy metals in bran is their greater concentration on the periphery of the seed, in particular on the coat. And due to the fact that the bran is mainly represented by the coats of the grain, their content of heavy metals significantly increases. The lowest content of heavy metals in high grade flour, as compared to second grade flour, is caused by the removal of the larger fractions of flour, and accordingly the dust of heavy metals in the fractions of lower quality flour.

Conclusions and prospects for further research. Thus, winter wheat grain grinding into different fractions of flour allows to reduce lead content in high-grade flour by 71,8 %, first-grade by 51,5 %, second-grade by 47,6 %, but at the same time it allows to increase lead content in bran by 61,6%, compared to the lead content of grain; cadmium content in high-grade flour decreases by 75,0 %, first-grade by 50,0 %, second-grade by 25,0 %, but increases in bran by 60,0 % compared to cadmium content in grain; copper content in high-grade flour is 72,0 % lower, first-grade by 52,0 %, second-grade by 47,4 %, but at the same time higher in bran by 50,7 %, compared to the copper content in grain; zinc content in high-grade flour decreases by 95,9 %, first-grade by 54,6 %, second-grade by 51,7 %, but at the same time it increases in bran by 68,2 %, compared to zinc content in winter wheat grain.

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АНОТАЦІЯ

ЗМІНА ВМІСТУ ВАЖКИХ МЕТАЛІВ У ЗЕРНІ ПШЕНИЦІ ОЗИМОЇ ТА БОРОШНІ В УМОВАХ ЛІСОСТЕПУ ПРАВОБЕРЕЖНОГО

У статті наведені дані по забрудненню важкими металами зерна озимої пшениці, що вирощене в умовах інтенсивного землеробства. Досліджено зниження вмісту важких металів при розмелі зерна озимої пшениці на різні фракції борошна: вищого ґатунку, першого ґатунку, другого ґатунку і висівки.

За результатами проведених досліджень встановлено, що розмел зерна озимої пшениці на різні фракції борошна дозволяє зменшити вміст свинцю у борошні вищого ґатунку на 71,8 %, першого ґатунку – на 51,5 %, другого – на 47,6 %, але водночас збільшити у висівках – на 61,6 %, порівняно із вмістом свинцю у зерні; вміст кадмію у борошні вищого ґатунку зменшується на 75,0 %, першого ґатунку – на 50,0 %, другого – 25,0 %, але збільшується у висівках на 60,0 %, порівняно із вмістом кадмію у зерні; вміст міді у борошні вищого ґатунку на 72,0 % менше, першого ґатунку – на 52,0 %, другого – на 47,4 %, але водночас вищий у висівках на 50,7 %, порівняно із вмістом міді у зерні; вміст цинку у борошні вищого ґатунку зменшується на 95,9 %, першого ґатунку – на 54,6 %, другого – на 51,7 %, але водночас збільшується у висівках на 68,2 %, порівняно із вмістом цинку у зерні пшениці озимої.

Ключові слова: *зерно, пшениця озима, борошно, забруднення, важкі метали.*

Табл. 1. Літ. 12.

АННОТАЦИЯ
ИЗМЕНЕНИЕ СОДЕРЖАНИЯ ТЯЖЕЛЫХ МЕТАЛОВ В ЗЕРНЕ ПШЕНИЦЫ ОЗИМОЙ И МУКИ В УСЛОВИЯХ ЛИСОСТЕПИ ПРАВОБЕРЕЖНОЙ

В статье приведены данные по загрязнению тяжелыми металлами зерна озимой пшеницы, что выращенное в условиях интенсивного земледелия. Исследовано снижение содержания тяжелых металлов при размоле зерна озимой пшеницы на различные фракции муки: высшего сорта, первого сорта, второго сорта и отруби.

По результатам проведенных исследований установлено, что размола зерна озимой пшеницы на различные фракции муки позволяет уменьшить содержание свинца в муке высшего сорта на 71,8 %, первого сорта – на 51,5 %, второго – на 47,6 %, но одновременно увеличить в отрубях – на 61,6% по сравнению с содержанием свинца в зерне; содержание кадмия в муке высшего сорта уменьшается на 75,0 %, первого сорта – на 50,0 %, второго – 25,0 %, но увеличивается в отрубях на 60,0 % по сравнению с содержанием кадмия в зерне; содержание меди в муке высшего сорта на 72,0 % меньше, первого сорта – на 52,0 %, второго – на 47,4 %, но в то же время выше в отрубях на 50,7 % по сравнению с содержанием меди в зерне; содержание цинка в муке высшего сорта уменьшается – на 95,9 %, первого сорта – на 54,6 %, второго – на 51,7 %, но одновременно увеличивается в отрубях на 68,2 % по сравнению с содержанием цинка в зерне пшеницы озимой.

Ключевые слова: *зерно, пшеница озимая, мука, загрязнение, тяжелые металлы.*

Табл. 1. Лит. 12.

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