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ESTIMATION OF HEALTH RISK INDEX DUE TO PRESENCE OF HEAVY METALS IN FOOD OF KYZYLORDA CITY (KAZAKHSTAN)

Abstract. This article presents the estimation of health risk index due to presence of heavy metals in food of Kyzylorda city. The main heavy metals (zinc, copper, cadmium, lead and manganese) were analyzed in some most commonly used locally produced food products of Kyzylorda city by atomic absorption spectrometry. The decomposition of food samples was done by mixture of sulfuricand nitricacidsin a ratio of1:1 without boiling to complete oxidation.The obtained data were used for the health risk index calculation.

The results showed the highest content of zinc in rice (93.8 mg/kg); lead – in cabbage (61.2 mg/kg); cadmium – in peels of onion (14.7 mg/kg); manganese – in peels of carrot (38.7 mg/kg); copper – in peels of onion (33.2 mg/kg).

Health risk index due to content of zinc and lead in potato and zinc in rice is high. Consumption of carrots, onions, cabbages and apples produced in Kyzylorda region has insufficient influence on health of local people, but the content of heavy metals in potato and rice is recommended to be controlled.

Keywords: heavy metals, food, Kyzylorda city, health risk index, estimation, atomic absorption spectrometry.

Introduction. The main problem of heavy metals in comparison with organic pollutants is their disability to be easily decomposed because of their non-degradable characteristics. As a result, heavy metals are accumulated into the food chain, resulting to health of the local population [1]. Heavy metals are regarded as the most dangerous pollutant to food security [2]. Serious systemic health problems would develop in human body as a result of excessive dietary intake of heavy metals such as Cd and Pb into human body [3]. Exposure to high concentration of Cd had been linked to human lung, prostate and renal cancer [4]. Pb was also deemed to have carcinogenic potential in humans, and do some adverse effects on human health such as cardiovascular, nervous system, blood and bone diseases [5, 6].

Although Cu is an essential trace element, its excessive concentration can threaten human health [7, 8]. Previous studies also showed that Cu toxicity could induce changes in cellular activities, such as regulation of lipid metabolism, neuronal activity, gene expression and resistance of tumor cells to chemotherapeutic drugs [9].

This study included investigation of content of main heavy metals (zinc, lead, cadmium, manganese and copper) in main food products of Kyzylorda city market. The most commonly used food products by local population for this

investigation were chosen. Among them are potato, carrot, onion, cabbage and apple. As in [10-12] high concentrations of heavy metals, especially cadmium and lead in rice were reported, rice from Kyzylorda city market was also included in this research.

MATERIALS AND METHODS

Object description. Kyzylorda region is characterized by a number of features, among which are socioeconomic conditions, low level of life quality in rural areas, lack of drinking water quality, and poor environmental situation due to Aral Sea issues (the processes of desertification, soil salinity over large areas, pesticide and herbicide pollution, heavy metal contamination) [13, 14].

At the territory of Kyzylorda region significant amount of mineral resources, such as zinc, lead, uranium, vanadium, gas and petroleum are located [15]. These mining activities have certainly increased the dispersal of toxic elements in Kyzylorda region. The presence of elements such as cadmium, copper, lead and zinc in soil and water samples obtained from Kyzylorda region was reported in [15].

Samples and sample pre-treatment description. The food samples were purchased at the local market of Kyzylorda city. The samples were washed with tap and distilled water. Peels of potato, carrot and onion were removed and were analyzed separately as individual samples. From apples, cores were removed and analyzed separately. The wetmaterial was dried in an oven at 30-40 ºC and grinded.

Determination of heavy metals. The weighed mass was decomposed by wetashingina Kjeldahl flask of 300 ml. For this purpose tothe test samplea mixture of sulfuricand nitricacidsin a ratio of1:1 was added and gentlyheated without boiling to complete oxidation (i.e.cessation of the releaseof colored vapors of nitrogen oxides).The contents of the flask quantitatively was transferred toa 25 ml flask, diluted with distilled water. The obtained solution was filtered. The measurements of content of heavy metals wasdoneby atomic absorptions pectrometry [16].

Health risk index. The health risk index (HRI) was calculated by following formula (1):

$$HRI = DIM/R_{fd}, \quad (1)$$

where DIM is daily intake of heavy metals, mg/person/day; R_{fd} is the oral reference dose, mg kg^{-1} body weight d^{-1}. R_{fd}value for Zn, Pb, Cd, Mn and Cu is 1,5; 0,004; 0,001; 0,033; 0,04, respectively [17]. The health risk index values greater than one for human health were not considered safe [1].

The DIM was calculated by following equation (2):

$$DIM = C_m * C_f * D_{FI} / \text{body weight}, \quad (2)$$

where C_m is concentration of heavy metal in plants, mg/kg; C_f is conversion factor, which convert the fresh vegetable weight to dry weight; D_{FI} is daily intake of vegetables/food, kg/d. According to the food basket of Kazakhstan, each

citizen of Kazakhstan eat the following amounts: apple – 0.07 kg d^{-1}; onion – 0.05 kg d^{-1}; carrot – 0.05 kg d^{-1}; cabbage – 0.07 kg d^{-1}; potato – 0.26 kg d^{-1}; rice – 0.02 kg d^{-1} [18]. Average adult weight for Kazakhstan was considered as 60 kg.

RESULTS AND DISCUSSION

The content of heavy metals in foodare presented in figure 1–5.

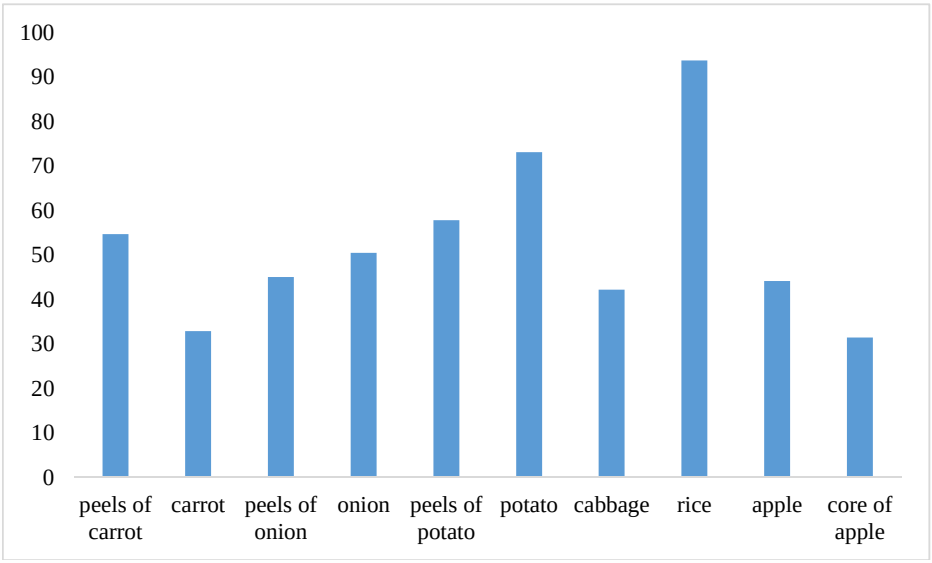


Figure 1 – The content of zinc in food, mg/kg

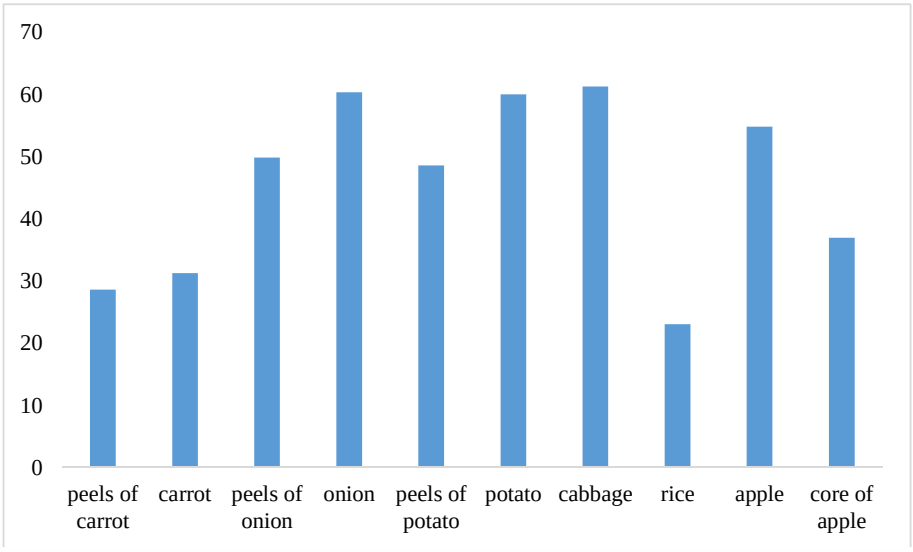


Figure 2 – The content of lead in food, mg/kg

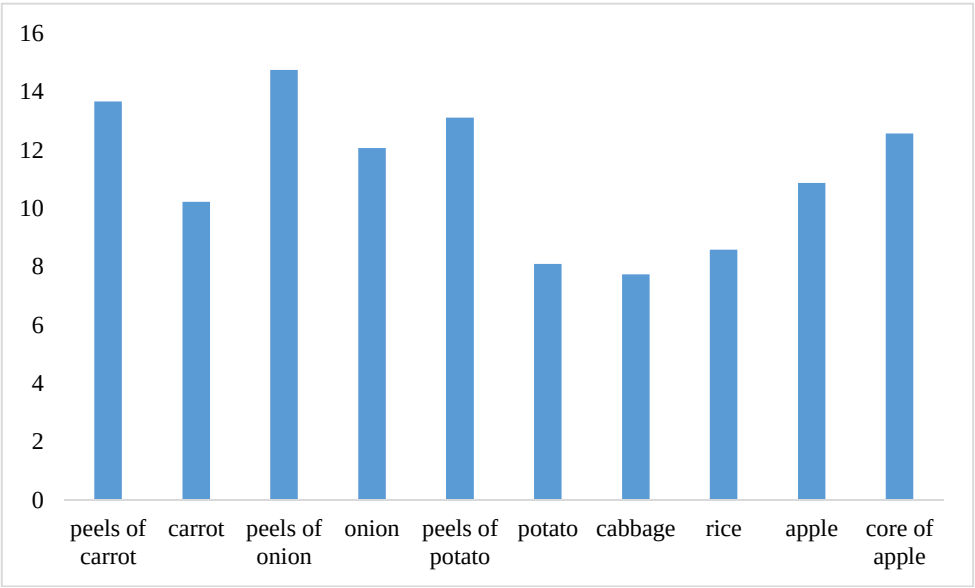


Figure 3 – The content of cadmium in food, mg/kg

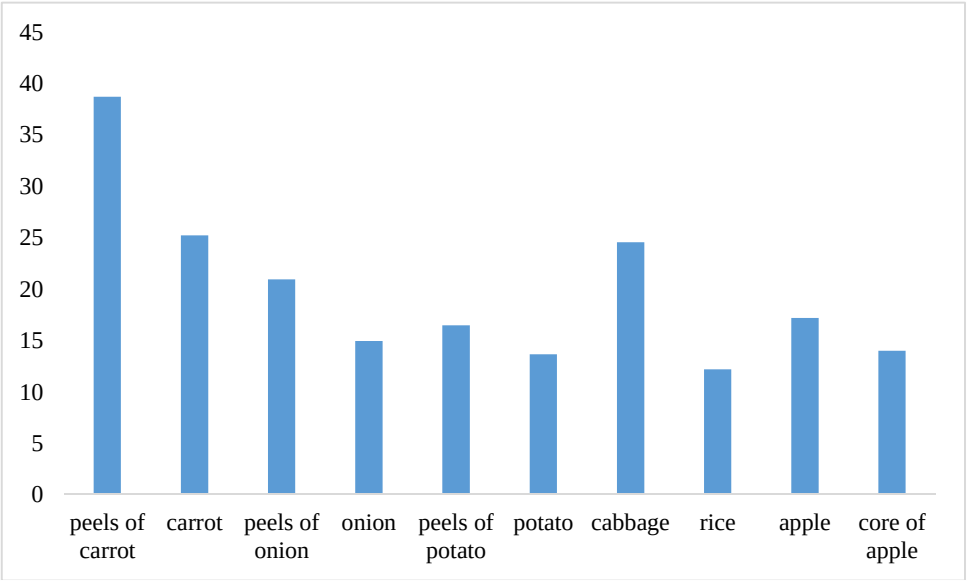


Figure 4 – The content of manganese in food, mg/kg

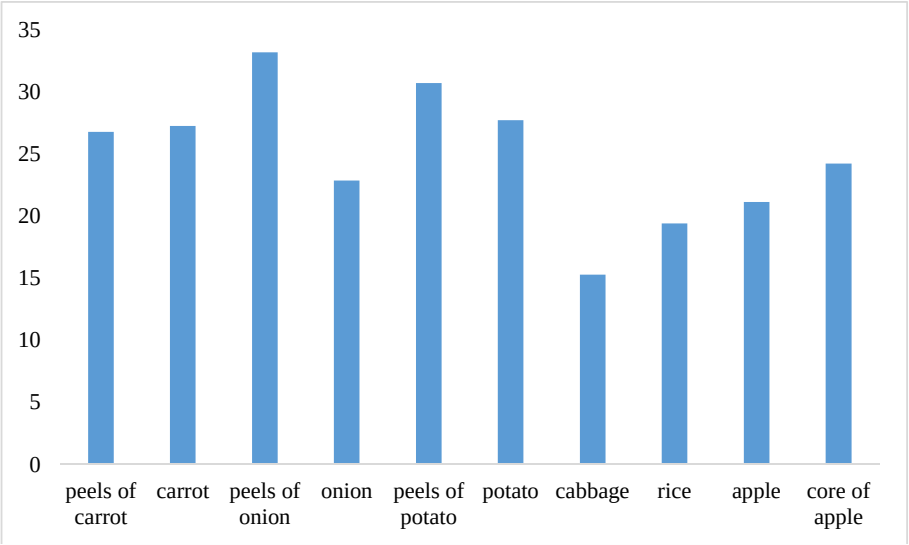
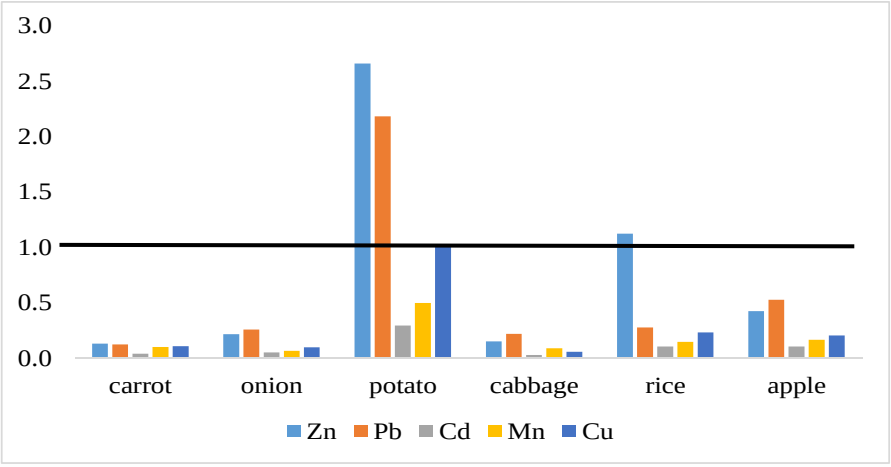


Figure 5 – The content of copper in food, mg/kg

The results showed the highest content of zinc in rice (93.8 mg/kg); lead – in cabbage (61.2 mg/kg); cadmium – in peels of onion (14.7 mg/kg); manganese – in peels of carrot (38.7 mg/kg); copper – in peels of onion (33.2 mg/kg).The content of heavy metals in peels of carrot is higher than in carrot. The content of heavy metals in peels of onion is similar to the values in onion. The content of zinc and lead in peels of potato is lower than in potato, but for cadmium, manganese and copper is verse situation. The content of cadmium and copper in core of apple was higher than in apple, but for zinc, lead and manganese is verse situation.

Based on the obtained experimental data the health risk index was calculated and the obtained data are presented in figure 6.



Health risk index

According to [1] index values greater than one for human health are not considered safe. Figure 6 shows that the health risk index due to content of zinc and lead in potato and zinc in rice are high, so it is not recommended to use them.

Although the content of zinc in all investigated food products is high, the health rice index showed the influence only in case of potato and rice. The content of lead is also high, but the health risk index showed the hazard only for potato.

So, it can be concluded that usage of carrot, onion, cabbage and apple produced in Kyzylorda city has insufficient influence on health of local people, but the content of heavy metals in potato and rice is recommended to be controlled.

Conclusion. The results showed the highest content of zinc in rice; lead – in cabbage; cadmium – in peels of onion; manganese – in peels of carrot; copper – in peels of onion. The content of heavy metals in peels of carrot is higher than in carrot. The content of heavy metals in peels of onion is similar to the values in onion. The content of zinc and lead in peels of potato is lower than in potato, but for cadmium, manganese and copper is verse situation. The content of cadmium and copper in core of apple was higher than in apple, but for zinc, lead and manganese is verse situation.

Health risk index due to content of zinc and lead in potato and zinc in rice are high. Usage of carrot, onion, cabbage and apple produced in Kyzylorda city has insufficient influence on health of local people, but the content of heavy metals in potato and rice is recommended to be controlled.

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Резюме

И. В. Матвеева, О. И. Пономаренко, А. Е. Дияров, Н. А. Нурсапина, Ш. Н. Назаркулова, А. Н. Гурин, В. И. Ким

ҚЫЗЫЛОРДА ҚАЛАСЫНЫҢ (ҚАЗАҚСТАН) АЗЫҚ-ТҮЛІК ӨНІМДЕРІНДЕГІ АУЫР МЕТАЛДАРДЫҢ БОЛУЫНА БАЙЛАНЫСТЫ ДЕНСАУЛЫҚ ТӘУЕКЕЛІ ИНДЕКСІН БАҒАЛАУ

Мақалада Қызылорда қаласының азық-түлік өнімдеріндегі ауыр металдардың болуына байланысты денсаулық тәуекелі индексін бағалау нәтижелері ұсынылған. Негізгі ауыр металдар (мырыш, мыс, кадмий, қорғасын және марганец) Қызылорда қаласының ең жиі қолданылатын жергілікті азық-түлік өнімдері құрамында атомдық-абсорбциялық спектрометрия әдісін қолдану арқылы талданды. Азық-түлік өнімдері үлгілерін ыдырату 1:1 қатынастағы күкірт және азот қышқылдарының қоспасымен қайнатусыз, толық тотығуға дейін жүзеге асырылды. Алынған нәтижелер денсаулық тәуекелі индексін есептеу үшін пайдаланылды.

Нәтижелер күріш құрамындағы мырыштың ең жоғары мөлшерін (93,8 мг/кг) көрсетті; қорғасын - қырыққабатта (61,2 мг/кг); кадмий - пияз қабығында (14,7 мг/кг); марганец - сәбіз қабығында (38,7 мг/кг); мыс - пияз қабығында (33,2 мг/кг).

Картоп құрамындағы мырыш пен қорғасынның, күріш құрамындағы мырыштың болуына байланысты жоғары денсаулық тәуекелі индексі анықталды. Қызылорда қаласында өндірілген сәбіз, пияз, қырыққабат және алма өнімдерін қолдану жергілікті халықтың денсаулығына айтарлықтай әсер етпейді, алайда картоп пен күріштің құрамындағы ауыр металдардың мөлшерін бақылауда ұстау ұсынылады.

Түйін сөздер: ауыр металдар, азық-түлік өнімдері, Қызылорда қаласы, денсаулық тәуекелі индексі, бағалау, атомды-абсорбциялық спектрометрия.

Резюме

И. В. Матвеева, О. И. Пономаренко, А. Е. Дияров, Н. А. Нурсапина, Ш. Н. Назаркулова, А. Н. Гурин, В. И. Ким

ОЦЕНКА ИНДЕКСА РИСКА ЗДОРОВЬЯ, ОБУСЛОВЛЕННОГО ПРИСУТСТВИЕМ ТЯЖЕЛЫХ МЕТАЛЛОВ В ПРОДУКТАХ ПИТАНИЯ ГОРОДА КЫЗЫЛОРДА (КАЗАХСТАН)

В статье представлена оценка индекса риска здоровья, обусловленного присутствием тяжелых металлов в продуктах питания города Кызылорда. Основные тяжелые металлы (цинк, медь, кадмий, свинец и марганец) были проанализированы в нескольких наиболее часто используемых местных продуктах питания города Кызылорда методом атомно-абсорбционной спектрометрии. Разложение образцов продуктов питания проводили смесью серной и азотной кислот в соотношении 1:1 без кипячения до полного окисления. Полученные данные были использованы для расчета индекса риска здоровья.

Результаты показали самое высокое содержание цинка в рисе (93,8 мг/кг); свинца - в капусте (61,2 мг/кг); кадмия - в кожуре лука (14,7 мг/кг); марганца - в кожуре моркови (38,7 мг/кг); меди - в кожуре лука (33,2 мг/кг).

Был установлен высокий индекс риска здоровья, обусловленного присутствием цинка и свинца в картофеле и цинка в рисе. Использование моркови, лука, капусты и яблок, произведенных в городе Кызылорда, оказывает незначительное влияние на здоровье местного населения, но содержание тяжелых металлов в картофеле и рисе рекомендуется контролировать.

Ключевые слова: тяжелые металлы, продукты питания, город Кызылорда, индекса риска здоровья, оценка, атомно-абсорбционная спектрометрия.