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QUALITY OF POTATOES GROWN IN VARIOUS REGIONS OF SERBIA AS INFLUENCED BY HEAVY METAL AND PESTICIDE RESIDUES CONCENTRATIONS

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Abstract: It is possible to decompose starch into monosaccharides by the method of acid starch hydrolysis. By applying appropriate chemical procedure, a main solution is obtained, from which aliquots are taken after filtration to determine of the present glucose according to Luff-Shoorlu method.

The analysed potatoes of cv. *Desiree*, grown on various sites in Serbia, have starch content that corresponds to available literature data. The highest starch content is found in potatoes from Ivanjica and Novi Pazar, i.e. from the areas where climate factors, air temperature, and land relief are favourable for potato growing. Lower starch contents are found in potatoes grown in flat areas with warmer climate and drier periods. Those are sites in PKB-Belgrade, Smederevo, Dobanovci and Mrčajevci areas, where the values obtained by experimental procedure are very similar. The lowest starch content is found in potatoes from Belegiš and Guča sites, where starch content is lower than normal from literature values, which may be explained by some special causes (climate, location, irrigation).

On the basis of heavy metal contents in potato samples, it may be concluded that potatoes originating from sites famous for potato production are contaminated with Cd the content of which exceeds concentrations permitted by regulations. The presence of Cd in potato samples may also be explained by the application of phosphate fertilizers in higher (or recommended) rates. However, the soil itself should also be investigated, especially concerning the content of Cd and pH value. Thus, the influence of the soil itself should be established compared to fertilizer application in the current season. Presence of Cd in potatoes, on the

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other hand, is highly unfavourable because it prevents its utilization in nutrition, but also as a raw material for further processing of products based on potatoes: chips, etc.

Also, Cd presence in foods is strictly controlled by EU, which prevents possible export of products based on potatoes containing Cd.

Analyses of *lindane* and *bensultap* (Bancol) pesticides indicate that they are not within critical values, nor in such quantities to affect human health, so, from this aspect, the analysed potato samples from all sites are absolutely suitable for consumation.

Key words: potato, heavy metals, potato starch, Lindane-γHCH, Bancol 80-WP (Bensultap), cadmium.

Introduction

Potato (*Solanum tuberosum L.*) belongs to the family *Solanaceae*, genus *Solanum*. It is considered to be one of the most intensively grown and most profitable crops and is recognized as a very important agricultural and food product.

Potato is a good source of energy, starch, C, B, E and K (which helps water elimination from human body, decreases swellings and heals burns) vitamins, mineral substances, organic acids, etc. Potato has an important therapeutic function in human body (Bugarčić, 2000).

From the aspect of population nutrition, potato is a very important crop in Serbia. Average annual consumption per person is 65 kg. Potato is grown on 90-100,000 ha in Serbia. Average yield is 8-9 t/ha, which is far behind European and global yields, contrary to some other crops (Narančić, 1989; Grupa autora, 1986; Harris, 1982; Fabiani and Vavasori, 1982; Метлицкий и сар., 1972).

During last 50 years over 1000 new cultivars of potato have been selected and bred in the world. Some commonly grown cultivars produce yields of 70 t/ha. Up to the year 2000, there were 3 domestic and 54 introduced potato cultivars in the cultivar list of Serbia. It should be mentioned that over 30 foreign cultivars have been accepted during last ten years, but only half of them have been tested through a wider production. Domestic cultivars *Dragačevka*, *Jelica* and *Univerzal* do not have any commercial significance, so the production is based on introduced cultivars such as: *Desiree, Jaerla, Kondor, Cleopatra* and *Kennebec* and another 10 cultivars which are grown on smaller areas. Cultivar *Desiree* is most widely spread and comprises about 80 % of total production of mercantile potato.

Weeds may cause a lot of harm to potato crop. They decrease the yield because they "steal" nutrients and water, they shade potato plants, they induce longer maintainance of dew and appearance of *rust*, they can fell the plants (field bindweed), bore into tubers (couch grass and broomcorn) etc. Besides mechanical measures of weed control, a high degree of efficiency is achieved by applying chemical preparations - *pesticides* (*herbicides, fungicides, insecticides*, *rodenticides* etc.). Combined mechanical - chemical control of weeds gives excellent results and decreases the need for high application rate of preparations, and is thus favourable for the environmental protection.

Recently, there has been an increasing interest in contamination of soil, water, air, and subsequently of food with *heavy metals*, the most dangerous of which are Cd, Pb, Cu and Zn (Stefanović, 1999). *Heavy metals* enter the soil mainly through anthropogenization. Mineral fertilizers and *pesticides* are considered to be the most prominent contaminants (pollutants) of the environment among chemical substances used for plant production. *Heavy metals* are introduced into soil, water and plants via *pesticides* and mineral fertilizers, reaching subsequently animal and human bodies. *Heavy metals* and their compounds reach the blood after resorption and are carried to the cells of various tissues and organs. Deposition of toxic substances depends on their physical and chemical properties, condition of cell membranes and other factors, so, in accordance with this, the rate of their deposition and accumulation is unequal.

Removal of harmful substances from the body is performed in several different ways, primarily through respiratory organs, salivary glands (Pb, Hg, Cd), through skin, sweat and sebaceous glands (Pb, As, Hg, Fe), urogenital organs and excrements. Secretion rate of *heavy metals* and their compounds from the body depends on numerous factors, some of which are: physicochemical properties of the compound, its concentration, condition and functioning of the organ through which the secretion is performed. Elimination from the body may last between few hours and few days or even several years. If *elimination* is slower than *resorption*, there occurs accumulation (deposition) of *heavy metals* in the body - they have cumulative properties.

All metabolical processes are not equally susceptible to the influence of heavy metals, but, on the other hand, many heavy metals do not induce only inhibition of enzymatic processes in the cell. There is a well known Schulz-Arndat law (*Schaltz Arnadt*), according to which low concentrations of metals stimulate cell activities. However, it is almost impossible to predict always metal impact within a cell, considering the complexity and number of its functional systems. For that reason, it is hard to answer the question *where* metal-induced impairments occur on subcellular level. It is current opinion that cell membrane represents the primary site of action and impairment in poisoning the body with heavy metals, while enzymatic system inhibition within the cells occurs in most instances as a secondary event.

Mineral fertilizers may also be potential soil contaminants with heavy metals (Hg, Pb, Ni). Raw materials for fertilizer production may contain heavy metals (raw *phosphate,* potassium salts, *saltpeter* etc.). Soil pollution with Cd is a common occurrence (although Pb and Ni are also frequent) in phosphate fertilizer utilization. It has been found that in the last 30 years there have occurred a mild increase of average cadmium content by 0.053 mg/kg. Heavy metal impact depends on fertilizer rate, cadmium content in them, soil properties, especially pH value, plant species, etc. (Gajić and Đurović, 1999). At increased pH values (i.e. in calcareous soils), cadmium content in plant is decreased more than 6 times (Phosphorus&Pottassium, 1982).

For these reasons, the present paper includes an investigation of potato cultivar *Desiree*, the samples of which have been collected from various sites in the Republic of Serbia in order to establish the potato quality (content of starch) but also the degree of pollution of soils on which the potato was grown. This has been done in a suitable way, by determination of the residues of applied pesticides and of some heavy metal concentrations in the potatoes. The aim of the study was to find if we are consuming health food and whether the soil on which various crops are grown is contaminated or not. For these reasons, starch content in potato was determined by acid hydrolysis and the content of heavy metals in the potato was determined by atomic absorption spectrophotometry (AAS) and the presence of pesticides by the method of gas chromatography.

Materials and Methods

Plants of the potato cultivar *Desiree* used for this experiment have been collected from the following sites: sample 1.: Ivanjica (type of soil: *gray brown skeletoidal soil and flysche*), sample 2.: Mrčajevci (*alluvial smonitza-meadow soils*), sample 3.: Borča (*chernozem*), sample 4.: Guča (*parapodzol pseudogley*), sample 5.: Leskovac (*marsh black soil*), sample 6.: Belegiš (*chernozem*), sample 7.: Rajac (Gornji Milanovac) (*shallow back soil buavica on limestone*), sample 8.: PKB–Beograd (*chernozem*), sample 9.: Smederevo (*alluvium*), sample 10.: Dobanovci (*degraded chernozem in the process of browning*), sample 11.: Požarevac (*smonitza*), sample 12.: Novi Pazar (*ranker*) (Filipovski i Ćirić, 1969; Ćirić, 1991; Institute for Pedology and Agrochemistry: Pedological chart, 1959, 1964).

Starch determination by acid hydrolysis

(Džamić, 1986 i 1988)

Acid hydrolysis is applied on samples containing high concentrations of starch and dextrin like potato, because other polysaccharides in natural products may also be hydrolyzed (pentosanes, galactanes) and give eventually false results of starch concentration.

Description of the applied procedure: From the whole, chopped sample, an aliquot is taken containing about 2.5-3.0 g of dry matter. The aliquot is transferred to a 100 cm^3 beaker, where about 50.0 cm^3 of distilled water is added. By one hour intensive mixing, all components soluble in cold water are extracted from the sample. Liquid is filtered, and the remnant is thoroughly washed with 250 cm^3 of cold distilled water. All starch remained in the precipitate is transferred into a - 500 cm^3 Erlenmayer flask and about 200 cm^3 of distilled water and 20.0 cm^3 of concentrated HCl (density 1.19 g/cm^3) is subsequently added. On the Erlenmayer flask a condenser with reflux is mounted which prevents later evaporation of the liquid. The flask is warmed up at moderate boiling for 2.5 hours during which time the starch is decomposed into monosaccharides. The content of the flask is cooled and neutralized with 30 wt.% solution of NaOH in the presence of lithmus. The content is transferred into a - 500 cm^3 flask and is filled with water to the mark. This is then a basic solution from which aliquots of 25.0 cm^3 are taken in order to determine reducing sugars, and the starch quantity is calculated when glucose percent is multiplied by 0.90.

Sugar content determination according to *Luff-Shoorl*

The method is based on the reduction of copper salts by reducing sugars in a warm alkaline solution and on indirect titration of the formed copper oxide by sodium thiosulphate solution.

Luff mixture: 25.0 g of $CuSO_4 \cdot 5H_2O$ is diluted in 100 cm^3 of water, 50.0 g of citric acid is diluted in 50.0 cm^3 of water and 388 g of $Na_2CO_3 \cdot 10\ H_2O$ is diluted in about 350 cm^3 of warm water. All these are transferred into a normal vessel which is then filled with water to the 1000 cm^3 mark.

Twenty five cm^3 of Luff's mixture is taken into a 300 cm^3 Erlenmayer flask, the same quantity of sugar is added (maximally 60 mg of reducing sugars should be present). Few glass beads are added and the mixture is warmed over flame burner making the mixture boil for 2 min. The flask is connected with a condenser and warming is continued for 8 minutes.

Determination of the quantity of remaining Cu^{2+}: After 2 min 10.0 cm^3 of 30 wt.% KI is added to the mixture and, as fast as possible, but carefully, 25.0 cm^3 of 25 wt.% H_2SO_4.

Produced free iodine is determined by titration with 0.005 mol/dm^3 sodium thiosulphate with the addition of 2.0 cm^3 1 wt.% solution of starch as indicator.

Control sample is analysed in the same except that instead of 25.0 cm^3 of sugar solution, 25.0 cm^3 of water is added, and the termination of the reaction is determined by the appearance of grey colour.

Calculation is carried out on the basis of difference in utilized sodium thiosulphate for experimental (main) and controle (blank) sample and, using appropriate tables, corresponding quantity of reducing sugars is determined.

Determination of heavy metals in potato samples

Heavy metals were determined by acid digestion procedure used for determining total and soluble metals by atomic absorption spectrophotometry (AAS) using flame technique and hydride generation technique (SW–846–*test* *methods for evaluation of solid waste*, *method* 3005A). Mercury was determined by atomic absorption spectrophotometry with the application of cold vapour technique (*Methods for Chemical Analysis of Water and Waste* EPA-600/4-82-55, *Methods* 245,1 *Mercury*, *Cold Vapour Technique*).

All analyses were performed by atomic absorption spectrophotometer, Varian, Australia, 1981, Atomic absorption spectrophotometer - flame, Spectra A1200, Sample preparation system SPS 5, PC AT 486 Varian 1981.

Ten g of chopped potato is burned on a heating plate and is then transferred into an oven for further mineralization at 450°C during 13 h. After cooling, 2.0 wt.% HNO_3 is added and the sample is quantitatively transferred to a 10.0 cm^3 normal vessel (for Pb and Cd determinations).

Mercury determination was carried out by wet procedure (acid digestion) by transferring of 10.0 g of chopped potato together with 20.0 cm^3 of concentrated HNO_3 onto a heating plate for decomposition. Subsequently, 10.0 cm^3 of hydrogen peroxide and 10.0 cm^3 of hydrochloric acid is added to eliminate HNO_3, and then the sample is transferred into a 25.0 cm^3 normal vessel (for As and Hg determinations).

Investigation of pesticide traces by gas chromatography method

Determination of *Lindane*–γHCH

For pesticide traces determination, a gas chromatograph equipped with EC detector (63 Ni) was used: *Hewlett Packard* 5890 *Series II* (Advised condition: *Column*: capillary length: 5 x 0.53 mm x 2.65 nm film thickness with HP–1 (Methyl Silicone Gum). *Oven temperatures*: 140°C (1 min), rate 2°C/min, 185°C during 10 min. *Carrier gas*: helium 10.0 cm^3 /min).

A quantity of 20.0 g of potato sample, well chopped, was mixed with 40.0 cm^3 of acetone, and then the mixture was homogenized in Ultra Turrax centrifuge for 30 sec. Dichlor methane (40.0 cm^3) and petrol-ether (40.0 cm^3) were added and the mixture was homogenized for 30 sec, at 4000 rpm. Then the upper (organic) phase was separated. The remnant was warmed and evaporated to dryness in a rotation evaporator in a bath at the temperature of 40°C. Light petrol-ether (5.0 cm^3) was added and the sample was completely dried again. Dry remnant was diluted in light petrol-ether in such way that the solution contains 2 g/cm^3.

The extract and evaporated sample were then transferred to a graduated vessel and 6 cm^3 of H_2SO_4 was added. The mixture was mixed on a rotation mixer for 1 h, and then the determination on a gas chromatograph was performed (Analytical Methods for Pesticide Residues in Food Stuffs, 1996).

Determination of *Bancol* 50–WP (*bensultap*)

Potato samples were divided for the purpose of analytical measurement into two composite samples for each treatment. They were kept in a deep-freezer (at = -18°C).

Sample preparation, extraction and derivatization of *bensultap* into *nereistoxine-oxalate* was performed according to a modified method (Analytical Methods for Pesticide Residues in Food Stuffs, 1996; Mojašević et al., 1995). Derivatization was carried out with *cysteine* and nickel-chloride. *Nereistoxine* content was performed by gas chromatography on the instrument *Shimadzu (*model 8A) with FPD/S detector. Analytical procedure efficiency (*recovery*), one of the indicators of analytical measurement quality, was estimated on the basis of control samples added in known quantities of *bensultap* at two "saturation levels", in quantities that correspond to the range of *bensultap* between 0.25 and 1.00 mg/kg. The detection limit of the method was estimated on the basis of the analysis of control potato samples during various phases of technological maturity, according to the criteria given by the manufacturer.

Method of analysis of *bensultap* remnant is a modified analytical method for determination of *kartap* (Nishi et al., 1974; Grujić, 1996). Determination of *bensultap* remnants in various substrates (plants and soil) is based on thiosulphonate reaction with thiols that form disulphides. In a homogenized sample, *bensultap*, that contains thiosulphate moiety, reacts with *cysteine (CySH*) in acid environment and forms *nereistoxine disulphide* (NTXO). In the presence of *cysteine* in excess and in alkaline environment, disulphide is easily hydrolysed and oxidized to *nereistoxine* (NTX). It is then extracted with appropriate solvent and determined by gas chromatography on FDP/S.

Results and Discussion

Starch is a polysaccharide synthesized by plants and is present in grains and roots of some plant species. There is starch in cereals, potato, in other tuberous plants as well as in hazelnut, almond, chestnut, walnut etc. From the aspect of human nutrition, starch is the most important polysaccharide, because it has high energy value. People meet about 40% of their energy needs by starch.

Starch is a complex homopolysaccharide, i.e. it consists of monomeric units of the same type of α-D-glucose. In nature, starch is found in the form of starch grains, granules, which have characteristic form and size in dependence of starch origin. Starch grain contains two components - *amylase* and *amylopectin* built from α-D-glucopyranose moieties. In *amylase* molecules, glycoside bonds are established by condensation of glycoside moiety of the last and alcoholic moiety on C atom of each next α-D-glucopyranose.

Amylopectin has a forked structure, its molecules are composed of moieties of α-D-glucopyranose bound by α (1→4) glucoside bond, but at the sites of branching, glucoside bonds are formed by condensation of alcoholic moieties on C_6 atoms of α-D-glucopyranoses from side chains (Rikovski, 1979; Arsenijević, 1998).

Starch is hydrolysed either by acids or in the presence of enzymes. By acid starch hydrolysis, D-glucose is produced, and by plant *amylase* catalyzed hydrolysis, *maltose* is produced. Results of starch determination in the analysed potato *Desiree* samples taken from various sites are presented in Table 1.

Tab. 1. - Results of the analyses of heavy metal contents (in mg/kg) in potato cultivar *Desiree* samples

Potato samples	**Pb**	**Cd**	**Ni**	**Cr**	**Mn**	**Fe**	**Hg**	**As**	**Starch (in wt.%)**
sample 1	< 0.1	< 0.05	0.27	< 0.10	1.90	> 4	< 0.01	< 0.005	19.16
sample 2	< 0.1	< **0.06**	0.24	0.13	> 2	> 4	< 0.01	< 0.005	13.46
sample 3	< 0.1	< 0.02	< 0.10	< 0.10	1.60	3.60	< 0.01	< 0.005	14.86
sample 4	< 0.1	< 0.03	0.28	< 0.19	1.33	> 4	< 0.01	< 0.005	12.09
sample 5	< 0.1	< **0.07**	0.15	< 0.10	1.30	> 4	< 0.01	< 0.005	16.14
sample 6	< 0.1	< 0.02	< 1.00	< 0.10	1.85	4.30	< 0.01	< 0.005	11.35
sample 7	< 0.1	< **0.07**	0.19	< 0.10	1.60	> 4	< 0.01	< 0.005	12.83
sample 8	< 0.1	< 0.02	< 0.10	0.13	1.00	> 4	< 0.01	< 0.005	14.48
sample 9	< 0.1	< 0.02	< 0.10	< 0.10	1.34	4.15	< 0.01	< 0.005	15.50
sample 10	< 0.1	< 0.05	0.21	< 0.19	> 2	4.30	< 0.01	< 0.005	14.35
sample 11	< 0.1	< 0.02	< 0.10	< 0.10	1.30	4.30	< 0.01	< 0.005	15.37
sample 12	< 0.1	< 0.02	< 0.10	< 0.10	1.10	> 4	< 0.01	< 0.005	18.37
MAC*	1	0.05	-	-	-	-	0.02	0.3	16,10-18.90

*MAC, *Maximum Allowable Concentration* (in mg/kg) (Službeni list SRJ, 1992).

According to Luff's method, applied in this study, starch content was successfully determined in the potato *Desiree* grown on various sites. According to Kroner and Wolksen, carbohydrates represent over 80 wt.% of dry matter of potato tuber and starch comprises nearly 90 wt.% of carbohydrates. Starch content in fresh potato tuber amounts to 17.5 wt.% with the variations between 8.0 and 29.4 wt.%, i.e. between 16.1 and 18.9 or 12.355 and 22.645 wt.%.

Obtained results show that the lowest starch content was determined in the sample 6 (which comes from Belegiš) - 11.35 wt.%, and the highest one in the sample 1 (from Ivanjica area) - 19.16 wt.%. All other samples contain starch within permitted limits (except sample 4, from Guča) - 12.09 wt.%.

Determination of heavy metals content

Heavy metals, considering their effect on plants, may be divided into those necessary for development and those unnecessary for normal biological processes. In this study, the second group metals were analysed, among which the most important are: Pb, Ni, Cd and Cr. Uranium content was not determined in the potato because it was found, on the basis of the available data (Stojanović et al., 2001), that uranium content in potato is not dominant. After uranium determination in leaves, fruit coat and peeled fruit, it was found that uranium content is even 10 times higher in fruit coat and leaves than in peeled fruits. The highest uranium content was in potato peels, which is very important, knowing it is not utilized for human nutrition, but great care must be applied in domestic animals' nutrition.

Cadmium as a heavy metal is not necessary for plants and its presence induces their impairment. Lead and chromium, although they do not belong to essential elements, may act stimulatively at lower rates.

Uptake of heavy metals by plants depends on many factors which include: pH values of soil, CEC, redox-potential, mode of fertilization, % of organic matter, soil texture, some other ions, plant species.

A problem by itself within the whole problem of soil pollution is heavy metal pollution in acid soils both naturally acid and those which have become acid by mineral fertilizers utilization, or because of acid rains, etc.

In general, pH decrease leads to an increase in heavy metal mobility, and thus to their higher accumulation in plants. Heavy metal uptake is always higher in acid than in neutral or alkaline soils. So, various procedures for acidity decrease influence favourably heavy metal uptake inducing its decrease. Especially positive effect is exerted by *calcination*.

Problem of interaction of heavy metals with other ions is very complex. There is a characteristic interaction between Cd and Zn. Cd addition increases Zn concentration and uptake in plant tips. However, with toxic rates of Cd there occurs a decrease in Zn uptake even to a critical level (Khan and Franhland, 1983). These results indicate a competition between Zn and Cd for protein receptors during transport through cell membrane, and also in metaloenzymes containing Zn (Grupa autora, 1997). Higher concentrations of Mn induce depression of Cd. Cd induces deficiency of Fe, Ca, Mg and Ni, and Se and Ca may induce decreased uptake of Cd. Also, heavy metals interact mutually: Cd and Pb have toxic properties each for itself, but if they are present together their toxic effect is still more powerful (*sinergistic action*).

Plant species is one of the most important factors that determine the quantity of absorbed heavy metals, and also the toxicity and accumulation in plant tissues. Heavy metals do not accumulate in all plant parts equally. In most investigations, in most plant species, the highest concentrations of heavy metals have been noted in roots, somewhat lower concentrations were in stems and leaves, and the lowest ones in generative organs and fruits. Taking potato as an example, the differences in accumulation of Cd (ppm) may be seen, in absorbtion of different Cd rates: potato-tip (0.58; 3.46; 7.35), potato-tuber (0.18; 0.89; 1.06) with Cd introduction (in mg/kg, as $CdCl_2$: 800, 1600, 3200, respectively) (Stefanović, 1999).

In addition, there are some not less important factors that influence mobility and uptake of heavy metals, which include, for instance: soil temperature, soil type, soil mineralogic composition, mode of fertilization.

Toxicity of individual heavy metals differs and is represented below (Tošković i Rajković, 2000; Greninger et al., 1974):

$$Cd > Cu > Co \approx Ni > As \approx Cr > Zn > Mn \approx Fe = Pb$$

Intensity of toxicity, besides being different for different elements, depends on the salt type of a heavy metal in soil, i.e. on valence number of the heavy metal in the salt, and depends also on plant species.

Individual plant species are differently susceptible to heavy metals. Sequence of plants from the most susceptible to the most tolerant is as follows:

onion > potato > spinach > sugar beet > summer wheat > tomato

The most toxic of all metals is cadmium, even in much lower concentrations than others. Available data show that Cd is even 20 times more toxic than Pb (Khan and Franhland, 1983). The toxicity depends both on Cd concentration and on plant species.

Symptoms of Cd toxicity are Fe-chlorosis, neurosis, withering, red-orange colour of leaves and an overall growth decrease. There also occur a photosynthesis disturbance, water deficiency in the system for transport, inhibition of mineral nutrition with nitrogen and phosphorus.

The results of heavy metal content analyses in potato samples taken from various sites in the Republic of Serbia are shown in Table 1.

Obtained results show that in the potato samples different concentrations of heavy metals are present. It may be said that Pb, Cr, Fe, Hg and As (except in sample 5) are present in approximately similar concentrations which are below the upper limit permitted by regulations. Mn content varied between 1.00 (sample 8) and 1.90 mg/kg, which is also below the upper limit permitted by regulations.

However, observing cadmium contents, the most conspicious seem samples 5 and 7 with the values above the one permitted by regulations (0.07 mg/kg against 0.05 mg/kg), sample 2 with 0.06 mg/kg and samples 1 and 10 with the values on the very upper limit - 0.05 mg/kg. There is also an interesting correlation with nickel concentration, because in these samples the highest nickel concentration was also observed. It should be stressed that these samples were taken from areas famous for potato production: sample 1 - Ivanjica, sample 2 - Mrčajevci, sample 5 - Leskovac, sample 7 - Rajac (Fig. 1).

It was established that 30 - 60 wt.% of Cd, incorporated in plants, comes directly from the atmosphere, and 40 - 70 wt.% from the soil (Grujić, 1996). There is a possibility of naturally increased concentrations of some heavy metals in soils, depending on geological composition of the underlying substrate. In this study, the increased heavy metal content was mostly connected with acid soils. In lithogenic soils, natural contamination (increased concentrations of Cd) is possible. On the basis of the Pedological chart of Serbia (Institute for Pedology and Agrochemistry: Pedological chart, 1959, 1964), the soils with the highest noticed Cd contents are of *smonitza* (samples 1. and 2.), *pseudogley* (sample 5.) and *black soil type* (sample 7). As the sample 12 originates from a typically acid soil (*rankers*) and Cd content has not been increased in it (< 0.02 mg/kg), the assumption is confirmed that the increased Cd content in potatoes is more a result of anthropogenization, than of natural Cd content in soil but, in any case, the influence of the soil type must not be excluded.

One of the ways for cadmium to be introduced into soil are artificial (mineral) fertilizers, which are produced by decomposition of raw phosphates by mineral acids (Phosphorus&Pottasium, 1982).

Cadmium quantity in phosphate fertilizers is variable and depends mostly on the type of raw phosphate utilized for fertilizer production (with the time, the quality of raw phosphates decreases, i.e. the ratio (in wt.%) of P_2O_5 decreases, and the content of impurities increases), as well as on the production process of a fertilizer. Arable soil already contains three times more Cd than a hundred years ago. Thus, during only two generations, Cd quantity in human body increased five times, expecially in kidneys. Absorbed Cd reaches the liver by blood, and then nerves and kidneys. As it is eliminated very slowly from the body, it is a cumulative toxine. Its biological halflife is about 40 days in blood and 20 and more years in liver and kidneys. Main toxic effects induced by cadmium are neuropathological problems and kidney distrophy as well as cancer

Fig. 1. - Sites from which the potato cv. *Desiree* samples were taken, represented by Cd contents (u mg/kg)
o – concentrations of Cd below 0.02 mg/kg;
• – concentrations of Cd between 0.02–0.05 mg/kg;
☠– concentrations of Cd above those permitted by regulations values (> 0.05 mg/kg)

The ratio between available concentration of Cd in soil and plants and the one introduced into soil through artificial fertilizers is very important for establishing the upper permitted limit of cadmium concentration in arable soil (Phosphorus&Pottassium, 1984; Aulett, 1979; Chizhikov, 1966; Shacklette, 1972).

All samples, out of the zone of high potato production on the acid soils, according to their heavy metal contents are far below the upper limit values permitted by regulations, and it may be said that sample 12 (from Novi Pazar) is of best quality, considering all the indicators.

Considering that *lindane* is used because of its insecticide properties as a prevention for the protection of plant crops, in this study the investigation was carried out of its presence, when it was found that its presence is in concentrations lower than 0.002 mg/kg of *Lindane*-γ HCH in all samples, which is the limit of detection of the method.

Preparation Bancol 50-WP (with the active component *Bensultap*) is used because of necessarily expressed efficiency against potato beetle (0.5 kg/ha is applied) due to a contact and digestive action.

It was impossible to determine *bensultap* deposition in potato samples because of the foliar application on the aboveground plant parts (Mojašević et al., 1995; Kovačević, 1991). The fact that remnants of bensultap higher than control values (= 0.02 mg/kg) were not found in any potato tuber sample is absolutely expected due to poor possibility of translocation of the main compound through the plant and to its fast degradation (Sakai, 1984; Tomlin, 1994). These results are in accordance with reports on this compound (Sakai, 1982; Sakai, 1984; Tomlin, 1994), as well as with results obtained in the investigations of Mojašević et al. (Mojašević et al., 1995) and Inđić et al. (Indjić et al., 1993). In the case of possible finding of *bensultap* in potato tubers it may be said that meteorological conditions did not have any influence on transporting *bensultap* into plant fruits by evaporation through the soil.

In accordance with the Law of sanitary safe of foods and objects in common use (Official gazette SFRJ, 1991), Regulations on quantities of pesticides and other toxic substances, hormones, antibiotics and mycotoxines that may be present in foods (Official gazette SRJ, 1992), the analysed pesticides in the potato samples are within the limits permitted by the Law.

Conclusion

It is possible to decompose starch into monosaccharides by the method of acid starch hydrolysis. By the application of appropriate chemical procedure, the main solution is obtained from which aliquots are taken after filtration to determine the present glucose according to Luff-Shoorlu method.

The analysed potatoes of cv. *Desiree*, grown on various sites in Serbia, has starch content that corresponds to available literature data.

The highest starch content is found in potatoes from Ivanjica and Novi Pazar, i.e. from the areas where climate factors, air temperature, and land relief are favourable for potato growing.

Lower starch contents are found in potatoes grown in flat areas with warmer climate and drier periods. Those are sites from PKB-Belgrade, Smederevo, Dobanovci and Mrčajevci areas, where the values obtained by experimental procedure are very similar.

The lowest starch content is found in potatoes from Belegiš and Guča sites, where starch content is lower from normal literature values, which may be explained by some special reasons (climate, location, irrigation).

On the basis of heavy metal contents in the potato samples, it may be concluded that the potatoes originating from sites famous for potato production are contaminated with Cd the content of which surpasses concentrations permitted by regulations. The presence of Cd in potato samples may also be explained by the application of phosphate fertilizers in higher (or recommended) rates. However, the soil itself should also be investigated, especially concerning the content of Cd and pH value. Thus, there should be established the influence of the soil itself compared with fertilizer application in the current season. Presence of Cd in potatoes, on the other hand, is highly unfavourable because it prevents its utilization in nutrition, but also as a raw material for further processing of products based on potatoes: chips, etc.

Also, Cd presence in foods is strictly controlled by EU, which prevents possible export of products based on potatoes containing Cd.

Analyses of *lindane* and *bensultap* (Bancol) pesticides indicate that they are not within critical values nor in such quantities to affect human health, so, from this aspect, the analysed potato samples from all sites are absolutely suitable for consumation.

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KVALITET KROMPIRA GAJENOG U RAZNIM PODRUČJIMA U SRBIJI S OBZIROM NA SADRŽAJ TEŠKIH METALA I OSTATAKA PESTICIDA

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R e z i m e

Metodom određivanja skroba kiselom hidrolizom moguće je razgraditi skrob do monosaharida. Primenom odgovarajućeg hemijskog postupka dobija se matični rastvor iz čijeg se filtrata uzimaju probe za određivanje prisutne glukoze po Luff–Shoorlu–ovoj metodi.

Ispitivani krompiri sorte *Desiree* gajeni na različitim lokalitetima Srbije imaju sadržaj skroba koji odgovara literaturnim vrednostima.

Najveći sadržaj skroba ima krompir sa lokaliteta Ivanjica i Novi Pazar, dakle sa onih područja kod kojih se klimatski uslovi temperatura–vazduh slažu sa reljefom zemljišta koje je pogodno za gajenje krompira.

Manji sadržaj skroba ima krompir koji je gajen u ravničarskim predelima sa toplijom klimom i sušnijim periodama. To su lokaliteti sa područja PKB–Beograd, Smederevo, Dobanovci, Mrčajevci, gde se vrednosti dobijene eksperimentalnim putem veoma malo razlikuju.

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Najmanji sadržaj skroba ima krompir sa lokaliteta Belegiš i Guča, u kojima je sadržaj skroba čak niži od literaturnih vrednosti, što se ne može objasniti nekim posebnim razlozima (klima, podneblje, navodnjavanje).

Na osnovu sadržaja teških metala u uzorcima krompira, može se zaključiti da je krompir koji potiče sa lokaliteta poznatih po njegovom gajenju kontaminiran sa Cd, čiji sadržaj prelazi Zakonom dozvoljene vrednosti. Prisustvo Cd u uzorcima krompira može se objasniti i korišćenjem fosfatnih đubriva u većim (ili preporučenim) količinama. Međutim, treba ispitati i samo zemljište, naročito u pogledu sadržaja Cd i pH vrednosti, pri čemu treba utvrditi kakav je uticaj samog zemljišta u poređenju sa novom primenom đubriva u toj godini. Prisustvo Cd u krompiru, sa druge strane, je izuzetno nepovoljno jer onemogućava njegovu upotrebu u ishrani, ali i kao sirovinu za dalju proizvodnju proizvoda na bazi krompira: čips i dr.

Takođe, prisustvo Cd u prehrambenim proizvodima je rigorozno kontrolisano od strane EU, tako da je onemogućen eventualni izvoz proizvoda na bazi krompira koji sadrže Cd.

Ispitivanje sadržaja pesticida *lindana* i *bensultapa* (Bancola) ukazuje da se oni ne nalaze u kritičnim količinama niti u količinama koje bi ugrozile zdravlje ljudi, pa sa te strane, ispitivani uzorci krompira sa svih lokaliteta su potpuno ispravni za ishranu.

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