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MONITORING OF RESEARCH ON THE CHEMICAL COMPOSITION OF WHITE ROOT CROPS

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Abstract. Recently, there has been an increase in demand for white root crops due to their dietary properties. The problem that is being solved in this work is to determine the possibility of overcoming the deficiency of essential substances in nutrition through the use of white root vegetables, namely parsley, celery and parsnips. The methodology adopted for this study is based on the analysis and synthesis of data from literary sources (articles in scientific publications, monographs, etc.). The research results into the chemical composition of white root crops by many scientists of the universe are given. It is shown that they are a source not only of easily digestible carbohydrates, ballast and mineral substances, but also of functional ingredients – phytosterols, phenolic compounds, phytoalexins, phthalides, bioactive aliphatic polyacetylenes. Thanks to this, white root crops have very good medicinal properties – from a positive effect in obesity, neuroses to the treatment of atherosclerosis, prostate adenoma. They have antibacterial, antimicrobial, anti-inflammatory, anti-cancer and antioxidant effects. The problem of accumulation of contaminants by white root crops, which have a toxic effect on the human body, is considered. The species, variety, and morphological specificity of the accumulation of contaminants by white root crops, as well as the influence of the area of their cultivation, the type of crop and its variety, as well as the tissue specificity of the accumulation of all chemical elements on this process are shown. Data on the high content of oxalic acid and its salts, nitrates and salts of heavy metals in white root crops are presented. The necessity of conducting scientific research on the search for new, more effective methods of processing raw materials has been proven. The prospect of using white root crops for the production of special purpose products after their detoxification has been proven.

Keywords: white root vegetables, parsley, parsnip, celery, contaminants, chemical composition.

Introduction. Formulation of the problem

Healthy nutrition of Ukrainians is one of the most important social problems of today, which shapes the health and well-being of the nation as a whole. The main risk factors for the health of the population in this direction include: unbalanced diet, deficiency of certain essential nutrients, contamination of food products with contaminants.

An important role in overcoming the nutritional deficiency of essential nutrients belongs to products of plant origin, in particular to those cultures that have a dietary and preventive effect. Such crops include white root crops, namely: parsley, parsnip, celery. The need of the population and the food industry of Ukraine for this valuable raw material is insufficiently met. This is due to the fact that, until recently, these vegetables were classified as uncommon, not sufficiently studied, and were grown in limited quantities. But recently, scientists have paid great attention to the study of the chemical composition of white root crops and their medicinal properties. And thanks to the popularization of these studies, there is an increase in demand for white root crops among the population and food industry enterprises. In this regard, the development of the domestic production of white root crops is of particular importance. These crops are used in many branches of the food industry, but they have not been fully used in the production of special purpose products. But of course, white roots have a beneficial effect on metabolism in the body, the cardiovascular and nervous systems, hematopoietic processes, have diuretic, mild laxative, antiseptic, anti-inflammatory and wound-healing properties, increase the overall tone of the body, physical and mental performance, are used in treatment of obesity [1-6]. In addition, there is practically no information in the available sources of Ukraine regarding the chemical composition of white root crops of local varieties, their properties and further directions of processing. That is why the analysis of the latest research by scientists on these issues will provide opportunities to expand knowledge about these vegetables, which will contribute to their more active use for the production of special purpose products.

The methodology adopted for this study is based on the analysis and synthesis of data from literary sources (articles in scientific publications, monographs, etc.).

The purpose of the work is to analyse the studies of the chemical composition of white root crops that are zoned in different parts of the world.

The **objectives** of research are:

- **s**tudy the characteristics of the accumulation of chemicals in parsley, celery and parsnip and to emphasize the emphasis on those that determine the dietary and medicinal properties of root crops;
- analysis of the content of contaminants in white root crops.

Analysis of recent research and publications

White root crops belong to the botanical family of celery (Ariaceae) and are characterized by the presence of white, white-gray or yellowish-white fleshy and juicy root crops. They have been known in many countries since ancient times. Now widely cultivated in many European countries, especially in Ukraine, Bulgaria, Germany and Romania. The general chemical composition of white root crops per 100 g of the product is: water – 75–85% and 15–25% dry matter. Dry substances are represented by carbohydrates – 1.7–10.0%; proteins – 1.1–3.2%; fats – 0.4–0.8%; organic acids (in terms of malic) – 0.1%, ash – 0.8–1.8% [7].

Chemical composition of parsley. Parsley is one of the most valuable plants from the celery family. The roots are cylindrical or cone-shaped, white or yellowish-white in color with a spicy smell.

Work [8] investigated the carbohydrate composition of parsley roots, which is zoned in Spain. It was established that parsley roots contain the main sugars (per dry matter): fructose 11.2 mg/g; glucose 20.6 mg/g; sucrose 10.4 mg/g and minor sugars: traces of sedoheptulose; syllo-inositol 1.6 mg/g; myo-inositol 22.8 mg/g and mannitol 1.0 mg/g. Scylo-inositol and myo-inositol are stereoisomers of the vitamin-like cyclic alcohol inositol. Inositol is a biologically active substance that has a positive effect on human health and has membrane-protective, lipotropic, anti-sclerotic, antidepressant effects, and also affects the recovery of nervous tissues and sleep. In the plant, myo-inositol is not destroyed during storage or processing. Polyalcohol mannitol in parsley is involved in the regulation of osmotic pressure and, as evidenced by in vitro and in vivo studies, it has antioxidant and antifungal effects.

Parsley roots contain starch (0.4%), fiber (1.1–3.6%) and pectin substances. The amino acid and protein composition of parsley roots has not yet been sufficiently studied. In the literature, there are data that parsley contains up to 180 mg/kg of glutathione [9]. Parsley contains oxidoreductases and S-adenosyl-L-methionine: xanthoxol O-methyltransferase, flavone synthase I; palmitin CoA-hydrolase, lipoxygenase, peroxidase, catalase, esterase, 6-1,3-gluconase, cafeyl-coenzyme A 3-0-methyltransferase, malonyltransferase, protein kinase, carboxylase [10].

In the literature, there are data from studies of the fatty acid composition of the seeds of parsley root crops, but this has not been studied in the root crops themselves.

The quantitative content of phytosterols in parsley, which was zoned in the Castilla-la-Manche region, was reported in work [11]. Their total amount in 100 g of fresh substance is 7.4±0.4 mg, campesterol 0.2±0.1 mg, stigmasterol 2.3±0.1 mg, β-sitosterol 3.1±0.2 mg and unidentified phytosterols 1.8±0.1 mg.

Work [12] found that parsley roots contain (per dry matter) 2.5 mg/g of bioactive aliphatic C17-polyacetylenes: falcarindiol 2.32±0.02 mg/g, 8-O-methylfalcarindiol 0.35± 0.01 mg/g, panoxydiol 0.12±0.03 mg/g. Bioactive substances polyacetylenes are widely distributed in plants of the Apiaceae family. In vitro studies have established that they have antifungal, anti-inflammatory and phototoxic effects, and are also natural antibacterial components of plant cells [13]. Paper [14] shows that polyacitellins are biologically active substances that do not harm the development of healthy cells and act purposefully against diseased cells in the human body. They are able to inhibit the development of AIDS and, due to their cytotoxicity, have an anticancer effect.

Parsley organic acids include acetic, malic, butyric and oxalic acids [15].

Literature review has shown that many scientists were engaged in determining the mineral composition of parsley. It has been established that in the plant, mineral substances participate in the activation and inhibition of enzymes. Parsley is rich in potassium and contains from 262 to 342 mg in 100 g of product. Potassium is an important intracellular element that regulates the acid-alkaline balance in the blood, water exchange, activates the work of a number of enzymes, participates in the transmission of nerve impulses, activates metabolism, reduces blood pressure and the risk of kidney stone disease. In the part [7], it was found that found that the parsley root contains 8 mg of sodium, 57 mg of calcium, 22 mg of magnesium, 73 mg of phosphorus, and 0.7 mg of iron per 100 g of fresh material. In the part [16] determined the content of parsley N – 6000 (μg/g), P – 900 (μg/g), K – 15000 (μg/g), Ca – 10000 (μg/g), Mg – 3800 (μg/g), Fe – 260 (μg /g), Zn – 16 (μg/g), Cu – 12 (μg/g), Ni – 27 (μg/g).

The mineral composition of 15 varieties of root parsley, bred in the Czech Republic, Germany, the USA, the Netherlands, England and regionalised in the Czech Republic, was investigated. According to the result, it was established that the average content of minerals is: potassium 4690 mg/kg, calcium 124 mg/kg, magnesium 509 mg/kg and sodium 425 mg/kg in fresh matter [17]. A group of Swedish scientists found that the mineral composition of parsley varies depending on the place of cultivation and the composition of the soil. The content of Ba, Br, Cd, Co, Cr, Cu, Mg, Mn, Na, Ni, Rb, S, Se, Ti and Zn in parsley cultivated on acidic soils is significantly higher than in plants growing in an alkaline environment [18].

Slovak scientists found that parsley contains 0.7–3.2 mg/g of selenium [19].

Parsley roots have a high content of vitamin C, E and β-carotene. It was established that these vitamins have the highest antioxidant effect, which also indicates the high antioxidant activity of parsley. Root parsley contains ascorbic acid from 20 to 76 mg/100 g of raw material, B vitamins: B_1 – 0.08–0.1 mg%, B_2 – 0.1 mg%, B_6 – 0.23 mg%, B_5, B_9; as well as nicotinic acid in the range from 1.0 mg/100 g to 2 mg/100 g, vitamins K, E and folic acid. Parsley roots have a high content of β-carotene – 0.01–0.05 mg/% and can be used in the human diet to prevent cardiovascular and cancer diseases [20].

The peculiarity of the chemical composition of parsley root is the high content of essential oils – 5–50 mg/100 g. The essential oil of parsley root consists of phenylpropanoids, monoterpenes, sesquiterpenes and aromatic components. Essential oils are biologically active substances and have antibacterial, antiviral, antifungal and anti-inflammatory effects [21]. Scientists have established in-vitro antioxidant activity of essential oils of parsley. At the same time, it was shown that apiol and myristicin have a very high antioxidant effect, which significantly exceeds the antioxidant activity of α-tocopherol. During in-vivo studies, it was established that apiol, which dominates among other components of essential oil of root parsley, helps to lower blood pressure, tones the muscles of the intestinal tract, promotes digestion and assimilation of food, and is also an active substance for increased male potency, while myristicin has anticancer effect [22, 23].

According to scientists, parsley roots contain 1.2% phthalides of aromatic plant components. The following phthalides were isolated from parsley cells: 5-hydroxy-3-butylidenephthalide, 7-hydroxy-3-butylidenephthalide, 7-hydroxy-3-butylidenephthalide 7-O-glycoside and 7-hydroxy-3-butylidenephthalide 7-O-6′-malonylglycoside [24].

Phenolic substances of parsley are represented by phenolic acids, coumarins and flavonoids, and their derivatives. According to research, they have antioxidant, anti-inflammatory, anti-hepatotoxic, antimicrobial and anti-cancer properties. Parsley contains 6.2 mg/100 g of raw weight of phenolic acids. Moreover, it is mainly hydroxycinnamic, their share is 6.03 mg. It also contains a small amount of ferulic acid, hydroxybenzoic acid and glucopyranosyloxybenzoic acid [25].

In [26], samples of parsley from different localities were analysed to determine their quality based on the concentration of arsenic, phenolic components and the antioxidant capacity of their edible parts. Arsenic concentrations were found in the range: parsley root (0.16 μg/g dm) < parsley leaf (0.35 μg/g dm). The total phenolic content of parsley roots varied depending on the place of cultivation: 5.03–9.18 mg eqGA/g DE. Among the phenolic carboxylic acids, ferulic, chlorogenic and some cinnamic acids prevailed. Among flavonoids, apigenin and its glucosides prevailed.

Flavonoids and their glycosides are biologically active substances and have a positive effect on human health. In vitro studies have shown that flavonoids can activate or inhibit certain mammalian enzymes that regulate platelet aggregation, detoxification, inflammatory and immune responses. Also, flavonoids have antioxidant, immunomodulating properties and have the activity of antibiotics, anti-allergens and anti-ulcer agents. Also, research by many world scientists has proven that the use of flavonoids in food leads to a decrease in the risk of cardiovascular diseases. In vivo studies by many scientists have established that flavonoids reduce the likelihood of polyps and malignant tumors of the gastrointestinal tract, as well as lung cancer. Apigenin is an active anticancer substance. Flavonoids and their glycosides are natural phytoestrogens. Such phytoestrogens can be used in the treatment of infertility [27].

According to the literature,parsley contains the following furocoumarins: psoralen, bergapten, methoxypsoralen, isoimperatorin, oxypoicedanin, xanthoxin, trioxalene and angelicin. Parsley contains soluble derivatives of coumarins, phytoalexins. Phytoalexin is a natural antibiotic. Scientists determined the quantitative content of psoralen in the root crops of parsley of three varieties (Sukrova, Urozhayna and Kharkivyanka). It ranges from 35 to 43 mg per 100 g of raw material [7].

According to the literature, it has been established that parsley is a source of new substances called salvestrols. Salvestrols also belong to phytoalexins and often have a bitter, slightly pungent taste. They, like phytoalexins, are synthesized by the plant during its protection against mold fungi, bacteria, viruses, insects, and ultraviolet radiation. Their important biological action is due to anticancer and antitumor effects [28, 29].

Chemical composition of celery. Celery has roots up to 10 cm in diameter, rounded or flat-rounded, grayish-white in color. The pulp of the root crop is white, hollow, loose.

Like parsley, celery contains the following carbohydrates: mono- and disaccharides – 2.0%, fiber – 1.0–1.8%, starch – 0.1% and pectin substances.

Paper [8] reports that celery contains (on dry matter): glucose 154.4 mg/g; fructose 132.8 mg/g and sucrose 24.8 mg/g, and also has a high mannitol content of 124.3 mg/g.

Celery is a source of polyalcohol mannitol, the amount of which, depending on the variety and growing conditions, can make up almost 50% of the total amount of carbohydrates. Mannitol has a high sweetness threshold, it is 60–70% sweeter than sucrose and does not participate in the Maillard reaction. Mannitol does not cause dental caries, can be used in low-carbohydrate or low-calorie diets, as well as for diabetics. Mannitol is slowly digested by the human body and at the same time is a good food environment for bifido and lactic acid bacteria. That is why, in order to achieve the maximum positive effect on the human body, it is very appropriate to add such sugar to functional pre- and probiotic products. The results reported in [30] indicate different roles for mannitol and sucrose, with mannitol being a more thoroughly sequestered transport carbohydrate. The cell walls of celery (Apium graveolens L.) parenchymal tissues consist mainly of cellulose (43 mol%) and pectin polysaccharides (51 mol%). Pectin polysaccharides consist of rhamnogalacturonan (28 mol%), arabinan (12 mol%) and galactan (11 mol%). The content of xyloglucan and xylan is 2 mol%. The composition and structure of the cell wall polysaccharides of the peripheral collenchyma of celery stalks were investigated in [31]. It was found that pectin was the most abundant polysaccharide [with homogalacturonan more abundant than rhamnogalacturonan I and rhamnogalacturonan II], followed by cellulose and other polysaccharides, mainly xyloglucans, with lesser amounts of heteroxylans and heteromannans. Single-pulse excitation NMR spectroscopy with magic angle rotation, which detects highly mobile polysaccharides, revealed the presence of arabinan.

The amino acid composition of celery is diverse, among them it is possible to single out essential amino acids: asparagine, tyrosine, choline, histidine, lysine. Amino acids are contained in the product in a bound state. Thus, celery root contains a choline derivative (betaine) of 0.09 mg/ 100 g of product [32]. The diversity of the amino acid composition of celery is due to the high content of such protein substances as allergens and enzymes. Celery allergens include the proteins Api g 1, which is the main homologue of the birch pollen allergen and Bet v 1. Celery root also contains Api g 4, Api g 5, profilin and a group of high molecular weight allergens [33, 34].

In the work [35] found that celery roots have the activity of enzymes, mannitol oxidase, peroxidase, chitinase, and β-1 glucanase, which have antifungal properties, as well as the enzymes mannitol 1-oxidoreductase and mannitol dehydrogenase, which are able to hydrolyze mannitol and reduce it to mannose. Mannose-6-phosphate reductase, on the other hand, is the key enzyme that synthesizes mannitol in celery.

Celery is known to change color during processing. The reason for this may be the activity of polyphenoloxidase enzymes, which when interacting with phenolic components (catechol in celery roots) lead to "fermentative browning" (darkening) of celery [36]. The activity of polyphenol oxidase can be inhibited by chemical or physical effects [37].

In the work [38], the following is given, that using gas chromatography and mass spectrometry, fatty acids were identified in celery extract: linoleic, palmitic, stearic and margaric acids (linoleic acid was predominant). It was found in [39] that celery roots contain phytosterols: β-sitosterol and stigmasterol, 24-methylene cholesterol, Δ7-stigmasterol, brassicosterol, ST2, sitostanol, etc. In the work [40] studied seven varieties of celery (Yabluchnyi, Odzhansky, Makar, Gol, Luna, Mentor, Cisco) for the content of phytosterols. It was established that the varieties "Yabluchnyi" and "Gol" contain the most phytosterols (198.3 and 190.43 mg/kg, respectively) and the least in the varieties "Makar" (77.82 mg/kg) and "Cisco" (88.48 mg/kg).

Celery roots contain 2.5 mg/g of bioactive aliphatic C17-polyacetylenes per dry matter, of which: falcarinol 0.23–1.62 mg/g, falcarindiol 2.07–4.58 mg/g, 8-O-methylfalcarindiol 0.04–0.17 mg/g, panoxydiol 0.02–0.06 mg/g [12].

Paper [14] presents studied the anticancer properties of aliphatic C17-polyacetylenes. Found that falcarinol has the greatest anticancer effect, followed by panaxidiol and less falcarindiol. In vitro studies proved that the biological effect of falcarinol increases in the presence of falcarindiol, that is, the presence of these two components in the plant has a synergistic effect. The research cited in [41] proved the average level of cytotoxicity of aliphatic C17-polyacetylenes of celery. Their action is directed against certain leukemia, lymphoma, and myeloma cells.

The content of organic acids was identified in celery roots, namely: tartaric, citric, isolimonic, succinic, fumaric, pyruvic, malic and oxalic acids [12].

Many scientists have studied the mineral content of celery roots. Celery contains in 100 g of fresh substance: P 40–99 mg; K 315–590 mg; Ca 46.1–107 mg; Mg 21.2–56 mg; Na 39.6–131 mg; Fe 0.60–0.90 mg; Zn 1.0–2.8 mg; Mn 0.43–0.57 mg; Cu 0.173–1.90 mg; Cr 0.008–0.010 mg and Ni 0.036–0.051 mg [7,42].

Celery contains a small amount of vitamins (per 100 g of fresh substance): C (8.0 mg), A (4.5 mg), E (0.5 mg), PP (0.4 mg). Also B vitamins: B1 (0.03 mg), B2 (0.06–0.1 mg), B3 (0.85 mg), B5 (0.4 mg), B6 (0.08–0.15 mg), B9 (7.0 μg). Contents β-carotene is 0.01 mg, vitamin H (biotin) is 0.1 μg [7, 43].

Celery roots contain phytol [38]. Phytol belongs to monounsaturated diterpene alcohols. As an alcohol component in the form of an ether, it is part of chlorophyll and is also a component of vitamin A and K1. This substance is a growth stimulator of lactic acid bacteria.

In work [44], the following is given, that the roots contain 0.1–0.5% essential oil, which consists of terpenes, sesquiterpenes and phthalides. The main components of celery root essential oil are limonene, carvone and 3-n-butylphthalide, myristicin. Limonene and its isomers, as well as carvone, can cause allergies. Three new triterpenoids were found in the essential oil: 11,21-dioxo-2β,3β,15α-trihydrooxyurs-12-ene-2-O-β-D-glycopyranoside; 11,21-dioxo-3β,15α,24-trihydrooxyurs-12-ene-24-O-β-D-glyco-pyranoside and 11,21-dioxo-3β,15α,24-trihydrooxyoleane-12-ene-24- O-β-D-glycopyranoside [45].

As cited in work [44], celery essential oil acts against Campylobacter jejuni, and is also toxic to pathogenic worms that cause schistosomiasis in the human body – Schistosoma mansoni. Sesquiterpenes contained in celery essential oil have an antifungal effect against Bacillus subtilis and Proteus vulgaris. Celery essential oil inhibits the growth of Listeria monocytogenes, Staphylococcus aureus, Escherichia coli O:157:H7, Yersinia enterocolitica, Pseudomonas aeruginosa, Lactobacillus plantarum, Aspergillus niger, Geotrichum and Rhodotorula. Celery root extract has high activity against B. cereus and Enterococcus faecalis [46].

The results of the research presented in work [38] show that the main aromatic components of celery root include: sedanolide (3–20 mg/kg), 3-butylphthalide (0.6–1.6 mg/kg), 3-3a,4,5,6-butyltetrahydrophthalide (1.0–4,4 mg/kg), 3-butylhexohydrophthalide and Z-ligustilide (0.6–2,0 mg/kg). In the process of product processing, the composition of aromatic components changes. Investigated investigated the change in aromatic components during the processing of root crops of the Monarch and Bergers varieties. It was established that the change in aroma in the obtained celery juice is caused by the appearance of stereoisomers 3-butylphthalide. In addition, in work [38], phthalides were identified in the extract of celery roots zoned in Lithuania using gas chromatography and mass spectrometry: β-phellandrene, α-terpenyl acetate, 3n-butylidene phthalide (E), 3n-butylidene phthalide (Z), cis-ligustilide, trans-ligustilide. The predominant substance is the bioactive substance cis-ligustilide. Clinical studies have shown that cis-ligustilide has a relaxing effect on the smooth muscles of the lungs, intestinal tract and vascular system [40].

The essential oil of celery roots is rich in sedanolides and sedanonine anhydrides, which determine the characteristic aroma of celery. Their physiological effect is due to antitumor effect. Studies have shown that tumor size can be reduced from 68% to 30% and sometimes to 11%. Derivatives of phthalides can be classified as natural pesticides, as they have antimicrobial, herbicidal, insecticidal and nematicidal effects. Celery roots are a source of substances with high antioxidant activity due to the content of phenolic components [47, 48]. The total phenolic acid content of celery roots is 1.3 mg per 100 g of raw mass, of which 1.01 are hydroxycinnamic acids, 0.81 are ferulic acid. Celery roots also contain chlorogenic, isochlorogenic and caffeic acids. According, which are given in work [49], celery roots contain 100 g of dry matter contains caffeic 7.5–16.7 mg, ferulic 94.33–109.4 mg, and p-coumaric acid 11.04–0.18 mg. Celery root flavonoids include apigenin, luteolin, quercetin, myricetin and kaempferol. Celery contains the most kaempferol – 30 mg/kg and quercetin 10 mg/kg. After analyzing 11 varieties of celery roots their determined quantitative content. Apigenin is contained in 100 g of dry matter 55.6–144.85 mg, luteolin 24.83–65.91 mg, kaempferol 85.31–174.72 mg. Paper [45] provides data on identified two more new celery flavonoids: apigenin-7-O-[2″-O-(5‴-O-feruloyl)-β-D-apiofuranosyl]-β-D-glycopy- ranoside and chrysoeriol-7-O-[2″-O-(5‴-O-feruloyl)-β-D-apiofuranosyl]-β-D-glycopyranoside. As evidenced by the results of studies reported in [50] the content of celery flavonoid glycosides was identified for the first time (Apium graveolens L. and varieties): luteolin 7-O-a apiosylglycoside, luteolin 7-O-glycoside, apigenin 7-O-apisylglycoside, chrysoeriol 7-O-apiosylglycoside, chrysoeriol 7-O-glycoside and more than 10 malonyl woodates of these glycosides.

Like root parsley, celery contains furocoumarins. Celery can contain from 5 to 20 mg/kg of furocoumarins. 4 linear furocoumarins have been identified in celery: psoralen, bergapten, xanthotoxin and isopimpinellin [51].

Chemical composition of parsnip. Parsnip is also a very valuable root vegetable. It has a conical pointed or rounded compressed shape, depending on the variety. The surface of root crops is uneven and has a white or grayish-white color; pulp is white with a yellowish tint. Parsnip root crops are rich in easily digestible carbohydrates, in terms of their content, they occupy one of the first places among white root crops. The work [52] shows that the plant contains an average of 16.2% carbohydrates in dry matter, due to which they have a sweet taste and a high glycemic index. Among the carbohydrates present in parsnip, sucrose (4.8%), fructose (1.11%) and glucose (1.32%) prevail. The root crop also contains arabinose, galactose, mannose, xylose and maltose in small amounts. Parsnip is a vegetable with a low starch content and contains up to 4% starch. Also, the fleshy roots of parsnip are enriched with fiber up to 1.2–3.6%, pectin substances 10.68% and uranic acids.

The research presented in work [12] shows that parsnip roots contain up to 8.09% of nitrogenous substances. They include the following enzymes: phenylalanine ammonia lyase, oxidoreductases, lactate and pyruvate dehydrogenase. The content of phospholipids in parsnip is (μmol of fat per 1 g of dry matter): phosphotidyl-choline – 0.33; phosphotidyl-ethanolamine – 0.18; phosphotidyl-inositol – 0.11; phosphotidyl-glycerol – 0.07 and diphosphotidyl-glycerol – 0.19. The content of monogalactosyl glyceride is 0.17 μmol of fat per 1 g of dry matter and digalactosyl glyceride is 0.34.

Parsnip roots contain more bioactive aliphatic C17-polyacetylenes than other white root crops 7.5 mg/g of dry matter. Of course, parsnip root contains falcarinol (1.60±0.03 mg) and falcarindiol (5.77±0.07 mg) per 100 g of dry matter. The content of polyacetylenes in 8-O-methylfalcarindiol and panoxydiol were not detected [53].

According to literature data, parsnip root contains the following organic acids: oxalic acid, depending on the variety, from 176 to 220 mg% and gallic acid from 15 to 40 mg per 100 g of fresh matter [54].

Of the minerals in parsnip root crops, there are: (per 100 g of product) sodium 4–39.6 mg; potassium – 217–529 mg; calcium – 27–54.8 mg; magnesium – 5.7–23 mg; iron 0.6 mg; phosphorus – 53–85 mg; zinc – 1.0 mg; manganese – 0.43 mg; copper – 0.173 mg; chromium – 0.008 mg; nickel – 0.036 mg. The content of selenium in parsnip is 0.023–0.074 μg/g of fresh matter [55].

According to the data presented in work [56], due to the high content of B group vitamins in root vegetables (B_1 – 0.08, sometimes up to 1.9 mg/100 g, B_2 – 0.09 mg/100 g, B_3 – 0.94 mg%, B_5 – 0.50 mg%, B_6 – traces, B_9 – 0.002 mg%) parsnips are classified as functional vegetable crops, because these vitamins normalize protein metabolism, stimulate hematopoietic processes, improve eyesight, and also regulate the work of the liver and the central nervous system. Also, this root vegetable contains other vitamins: β-carotene – 0.02 mg/100 g, C – up to 40 mg/100 g, PP – 0.94 mg/100 g [57].

Parsnip is enriched with essential oils (0.7–3.5%), which determine the characteristic smell and aroma of the plant. The work [58] states that parsnip root essential oil is represented by monoterpenes, sesquiterpenes, phthalides and phenolpropane derivatives. The composition of essential oil of parsnip roots includes ethers of heptyl and hexyl acids and octylbutyl ether of butyric acid, which has a pleasant smell. It was established that its composition includes terpinolens 25.5%, hydrocarbon monoterpenes 2.8%, trans-β-farnesenes 1.5%, β-bisabolenes 0.8%, β-sesquiphelandrenes 0.5%, myristicin 62.6%, γ-palmitolactones 2.8%. As a result, it is possible to say that the essential oil of parsnip roots contains myristicin most of all. It has hallucinogenic, antibacterial and anticarcinogenic properties.

The total content of phenolic acids in parsnips per 100 g of raw material, as evidenced by the data in work [59], is 5.7 mg, of which 4.54 mg are hydroxycinnamic acids, 1.8 mg are caffeic acid, and 2.2 mg are ferulic acid. Among parsnip flavonoids, kaempferol is the most abundant (30–66.4 mg/kg). The identified compounds also included quercetin, apigenin and genquanine. The highest antioxidant capacity was found for the group with the lowest root weight.

As cited in work [60], parsnips can contain from 5 to 20 mg/kg of furocoumarins. Compared to fruits and leaves, parsnip root contains the least amount of furocoumarins. According to other data, which are presented in work [61], their total content is 0.06–6.40 mg/100 g of dry matter. Parsnip root contains the following furocoumarins: bergapten, psoralen, xanthotoxin, xanthotoxol, sphondin, imperorin, alloimperatorin, isopimpinelin. Parsnip roots contain phytoalexin – xanthotoxin. Like all white root crops, parsnip has antioxidant properties.

Contaminant content in white root vegetables. Along with a large number of biologically active components contained in white root crops, their composition also includes various contaminants, which have a toxic effect on the human body.

According to the results of research, given in work [55], it was established that the content of psoralen in celery, depending on the variety, ranges from 26 mg/100 g to 46 mg/100 g, in parsley it is within 35–44 mg/100 g of the product, and in parsnip – from 38 to 81 mg/100 g. In celery, in accordance with the anatomical and morphological structure, psoralen accumulates in the following sequence: periderm > bark. In parsnip and parsley, it is distributed as follows: periderm > bark > central cylinder. In-vivo studies have established that psoralen has relatively low toxicity, when consuming 300 g of celery roots and at UV radiation of 1.5–9 J/cm^2, no skin reactions were detected.

The next natural toxicant is oxalic acid, which is part of vegetables and fruits. Oxalic acid ($H_2C_2O_2$) is a dibasic saturated carboxylic acid. In vegetable raw materials, it is contained both in a free state and in the form of salts and ethers. This strong organic acid is responsible for the formation of the taste of vegetable raw materials and can have a toxic and antinutritive effect on the human body. The toxic effect of oxalic acid is due not to its acidity, but to the presence of the oxalate ion. Due to the ability of oxalic acid to bind bivalent metal cations (Ca^{2+}, Fe^{2+}, Mg^{2+}, Na^{2+}), oxalic acid salts can easily form. Oxalic acid salts are called oxalates. Both free oxalic acid and its salts are toxic and cause oxalosis. Oxalosis refers to diseases of various organs and tissues: diseases of the urinary tract and kidney failure, macular degeneration of the retina, rheumatic disease, instability of cell membranes. Crystals of magnesium and iron oxalate irritate the walls of the small intestine, which leads to diarrhea. Also, oxalic acid and its salts can cause food poisoning. This is evidenced by veterinary studies that studied the clinical picture of oxalic acid poisoning in sheep, cows, and chickens. The acute toxicity of oxalates manifests itself with their daily consumption in the amount of 4–5 g. A person can consume daily without harm 600–700 mg of oxalic acid, but with sufficient supply of calcium and vitamin D. The lethal dose of oxalic acid and oxalates for humans is 600 mg/kg of human body weight. Antinutritional effects of oxalic acid or oxalates can be predicted based on the oxalate/calcium ratio in the product (oxalate index). If it is more than one, oxalates are able to show an anti-nutritional effect [62]. The work [55] presents research on the content of oxalic acid in white root crops. It was established that they have a high content of oxalic acid and its salts, namely: in celery – 309–418 mg/100 g, parsley – 176–210 mg/100 g, parsnip – 176–220 mg/100 g. They have an oxalant index of more than one.

In particular, natural toxicants, white root crops are also able to accumulate toxic substances that enter products from the environment, as a result of violations of the technology of cultivation, production, and preservation of products. The most common toxicants are nitrates, heavy metals, and radionuclides [63].

According, presented in work [64], parsley was classified as a product with a high nitrate content (1000–2500 NO_3 mg/kg of fresh matter), and celery was classified as a product with a very high nitrate content (>2500 NO_3 mg/kg of fresh matter). Moreover, after analyzing the content of nitrates in celery roots that were grown in Austria, Belgium, Germany, the Netherlands and Switzerland, the maximum content of nitrates in celery from Belgium was found (4000 NO3 mg/kg of fresh substances).

Individual botanical varieties of fresh vegetables and their anatomical and morphological parts are characterized by different ability to accumulate nitrates. Research, which are given in work [65] has established that the nitrate content in parsley, parsnip and celery can range from 90 mg/kg to 1500 mg/kg. Therefore, residual nitrates in plants are unevenly distributed. So, in the vegetative parts of plants, the amount of nitrates is 60–80% less than in the generative parts. Regarding the difference in nitrate accumulation in different anatomical and morphological parts of the root, Scientists found that the core and exoderm of the parsley root has the highest nitrate content [66].

The problem of accumulation of heavy metals by vegetables is very relevant today and many scientists of the world are interested in it. Domestic scientists also studied the accumulation of heavy metals (lead, copper, zinc, cadmium) by white root crops. As evidenced by the results presented in work [67], their content in all studied varieties did not exceed the maximum permissible concentrations. Anatomical parts are divided according to the degree of contamination as follows: periderm > bark > central cylinder. The problem of accumulation of heavy metals by vegetables in India is acute. As cited in work [68], the content of heavy metals in celery roots is: Pb 20.8–28.6; Zn 87.8–98.6; Cd 6,0–22.5; Cr 33,0–36.8; Cu 17.9–22.5 and Ni 20.4–62,0 and parsley: Pb 28–36.9; Zn 97–130; Cd 5.4–25.6; Cr 69.5–85.3; Cu 19.7–35.1; Ni 45.8–76,0 mg/kg of dry matter. The work [69] shows, that parsley and celery roots in Greek markets contain cadmium 5.8 and 5.1, and lead 69.6 and 8.8 nano g/g of fresh matter, respectively. Parsley that was grown in industrial areas of Turkey, as shown in work [70], contains lead 0.99–2.54 and cadmium 0.03–0.05 μg/g. Roots of parsnips (Półdługi Biały) grown near Krakow in Poland contain less cadmium and lead than their stems, with 0.76 and 1.61 mg/kg dry matter, respectively [71].

The problem of soil and water contamination by radionuclides became especially acute after the accident at the Chernobyl nuclear power plant. There are more than 200 radionuclides, the most dangerous are cesium-137 and strontium-90, whose half-life is 30 and 28.6 years, respectively.

According to research, which are given in work [72], the content of radioactive isotopes of potassium (40K) in celery and parsley roots is 210 and 310 Bq/kg. The content of radioactive strontium was not detected. Parsley roots grown near Tehran contain 226 Ra – 76–102 Bq/kg fresh matter and 228Ra –144–202 Bq/kg of fresh substance [73]. In the work [74] also studied the accumulation of cesium-137 and strontium-90 by white root crops. It was established that the content of these isotopes in celery, parsley, and parsnips is significantly lower than the maximum permissible concentrations, and the sum of the ratios of radionuclide activity measurements to their normative content is in the range from 0.14 to 0.23 (with requirements ≤1). Common to all crops is that all studied varieties accumulate more cesium than strontium. According to the level of radionuclide accumulation, celery tissues are arranged in the following order: bark > periderm > rusty spots; and parsnip and parsley tissues in the following: periderm > bark > central cylinder.

Today, there are many technologies for reducing the content of contaminants in water, such as filtration, reverse osmosis, adsorption, solvent extraction, chemical precipitation, and ion exchange [75]. But all of them are not very effective.

As in the whole world, so in Ukraine, the problem of accumulation of contaminants by white root crops is very relevant and still not fully investigated. Therefore, the most important task is to identify agricultural crops that accumulate less heavy metals in order to select them for the production of environmentally friendly products.

Conclusions

1. Based on a systematic analysis of domestic and foreign literary sources, it has been established that white root crops have a very diverse chemical composition. They are a source of easily digestible carbohydrates, ballast substances, minerals (especially potassium), as well as such functional ingredients as phytosterols, phenolic compounds, phytoalexins (salvestrols), phthalides, bioactive aliphatic polyacetylenes. Thanks to this, white root crops have very good medicinal properties – from a positive effect in obesity, neuroses to the treatment of atherosclerosis, prostate adenoma. They have antibacterial, antimicrobial, anti-inflammatory, anti-cancer and antioxidant effects, so their use in food will allow obtaining many new special purpose products. But in the literature, there is not enough modern data on the chemical composition of varietal varieties, especially white root crops of local varieties. In order to create special purpose products, the study of this issue is absolutely necessary, and the popularization of these studies among the population and food industry specialists is very important.

2. It has been established that along with a large number of biologically active components contained in white root crops, their composition also includes various contaminants that have a toxic effect on the human body. Such substances include the well-known "natural toxicants" linear furocoumarins (psoralen), oxalic acid and its salts, as well as other toxic substances that enter products from the environment - nitrates, salts of heavy metals, radionuclides. It has been proven that the content of contaminants in white root vegetables depends on the area of their cultivation, the type of crop and its variety, as well as the tissue specificity of the accumulation of all chemical elements. Data on the high content of oxalic acid and its salts, nitrates and salts of heavy metals in white root crops are presented. However, the monitoring of the content of contaminants in white root crops is incomplete.

3. The conducted theoretical research indicates the expediency of comparative characteristics of various economic and botanical varieties of agricultural crops in order to identify among them and their varieties that accumulate contaminants to a lesser extent and are most suitable for the production of environmentally friendly products. In addition, the study of patterns of entry and accumulation of contaminants in plants is necessary for the correct justification of the development of methods that reduce their content in finished products. In the literature, there are many ways to detoxify vegetables, but all of them are not very effective. At the same time, a more precise approach is needed, which will take into account the morphological features of plants. The above indicates the need to conduct scientific research on the search for new, more effective methods of processing raw materials. It is also important for the creation of special purpose products.

The simultaneous development and implementation of the listed recommendations will contribute to solving the current problem – increasing the resource food base with a corresponding increase in the production of high-quality products for special purposes.

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МОНІТОРИНГ ДОСЛІДЖЕНЬ ЩОДО ХІМІЧНОГО СКЛАДУ БІЛИХ КОРЕНЕПЛОДІВ

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Анотація. Останнім часом спостерігається зростання попиту на білі коренеплоди завдяки їх дієтичним властивостям. Проблема, яка вирішується в цій роботі – це визначити можливість подолання дефіциту в харчуванні есенціальних речовин за допомогою використання білих коренеплодів, а саме: петрушки, селери та пастернаку. Методологія, яка прийнята для цього дослідження спирається на аналізі і синтезі даних літературних джерел (статей в наукових виданнях, монографій та ін.). Наведено результати досліджень хімічного складу білих коренеплодів багатьох вчених. Показано, що вони є джерелом не тільки легкозасвоюваних вуглеводів, баластних і мінеральних речовин, а також і функціональних інгредієнтів – фітостеролів, фенольних сполук, фітоалексинів, фталідів, біоактивних аліфатичних поліацитиленів. Завдяки цьому білі коренеплоди мають дуже гарні лікувальні властивості – від позитивної дії при ожирінні, неврозах до лікування атеросклерозу, аденоми простати. Вони мають антибактерицидну, протимікробну, протизапальну, протиракову та антиоксидантну дії. Розглянуто проблему накопичення білими коренеплодами контамінантів, які проявляють токсичну дію на організм людини. Показано видову, сортову та морфологічну специфіку до накопичення контамінантів білими коренеплодами, а також вплив на цей процес місцевості їх вирощування, виду культури та її сорту, а також тканинної специфічності накопичення усіх хімічних елементів. Наведено дані про високий вміст у білих коренеплодах щавлевої кислоти та її солей, нітратів та солей важких металів. Доведено необхідність проведення наукових досліджень щодо пошуку нових, більш ефективних методів обробки сировини. При цьому потрібен більш прецизійний підхід, який буде враховувати морфологічні особливості рослин. Доведено перспективність використання білих коренеплодів для виробництва продуктів спеціального призначення після проведення їх детоксикації.

Ключові слова: білі коренеплоди, петрушка, пастернак, селера, контамінанти, хімічний склад.