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IMPROVING THE QUALITY OF VEGETABLES AND FRUITS USING BIOFORTIFICATION STRATEGIES

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Abstract. An analysis of the state of nutrition of people in Ukraine shows that the population does not eat well, which significantly worsens the state of their health and working capacity. The solution to the problem is possible through changes in the structure of nutrition, and above all, through an increase in the diet of vegetables and fruits of high quality, the varieties of which have been created using biofortification strategies. Biofortification is an innovative and promising approach in solving global problems related to nutrition. The goal of biofortification is to create plants with increased levels of the necessary functional ingredients absorbed from the soil, as well as those synthesized in the plant. Biofortification strategies consist in the development of optimal ways of mineral nutrition of plants, the creation of new species using molecular genetic approaches, and the use of traditional breeding methods. The purpose of the research is to analyze the modern experience of creating varieties of various fruit and vegetable crops with the help of biofortification strategies, which have an increased content of functional ingredients. Based on the literature review, it was established that for many years, an unconventional direction of selection has been developing – the creation of varieties and hybrids of fruits and vegetables with the recommended chemical composition. Created varieties of vegetables and fruits with increased protein content (nuts and legumes); starch (potato); carotenoids, dry matter, disaccharides (carrot, pumpkin); vitamin C, betanin, sugars (table beet); selenium (tomatoes); bioflavonoids, vitamin C (cabbage vegetables); macro- and microelements (bulb vegetables), etc. Such raw materials can be used to create special purpose products, which will significantly improve the quality of the population's diet and health. It is shown that the development of the non-traditional direction in breeding remains promising, and the study of samples of the domestic collection of agricultural crops and the selection of the best varieties from them for various directions of use, and especially for the production of special purpose products, is an important national economic and scientific task of an innovative nature that must be developed, therefore that the problem of improving the nation should come first.

Keywords: biofortification, varieties of vegetables and fruits, biochemical composition, nutrition

Introduction. Formulation of the problem

One of the most important factors that determine the state of health and the level of working capacity of the population is the biological adequacy and safety of nutrition. Monitoring of the state of people nutrition in Ukraine shows that more than 50% of the population eats poorly [1]. This is due to the fact that:

- firstly, industrially produced products that have undergone strict technological processing have been widely used in public nutrition recently. As a result, they completely or partially lack natural biologically active substances, vitamins, mineral elements, phospholipids, phytosterols and other bioregulators of metabolism. The deficiency of these biologically active substances is accompanied by a decrease in the body's protective forces, which prevent the adverse effects of harmful environmental factors, the formation of chronic fatigue syndrome, asthenicness, and a decrease in resistance to infectious diseases;

- secondly, the nutrition structure of the population has deteriorated significantly recently. The consumption of all the main groups of products, the most biologically valuable, decreased: meat and meat products, fish and fish products, milk and dairy products by an average of 25–28%, and vegetable oil, fruits and berries to an even greater extent. The result of the mentioned changes in the nutrition of the population is the formation of a deficiency in the body of vitally necessary biologically active food substances: 25% of the examined have a deficiency of iron and vitamin A [2-4], 30–40% are at risk of iodine deficiency disorders [5], zinc deficiency is common [6,7], B vitamins, and especially B_9, vitamin C, which causes iron deficiency. At the same time, the majority of the population receives an insufficient amount of tocopherols, β-carotene, calcium, selenium, fluorine, dietary fibers and other bioregulators of life processes with food [8-10];

- thirdly, global pollution of surface water and land, local radioactive pollution lead to contamination of food products with contaminants of various origins, which weaken the body's defenses and, first of all, reduce the antitoxic function of the liver, lungs, kidneys, skin, etc. [11].

Inadequate consumption of micronutrients is a constant factor that negatively affects the health, growth, development and vitality of people. To solve these problems, various countries have implemented appropriate programs for food fortification and, in recent years, more and more often – for biofortification. For example, in Japan in 1991 the "Foschu" state concept – "Foods for specified health use" was developed, in Europe in 1986 the "Fufose" program – "Functional food science in Europe" was developed (scientific basics of functional nutrition in Europe). In addition, representatives of 159 countries of the world, including Ukraine, adopted the "World Declaration and Program of Action in the field of nutrition" back in 1992, and in November 2010, the First Global Conference on Biofortification was held in Washington. In Ukraine, in 2011, the concept of the state scientific and technical program "Biofortification and functional products based on plant raw materials for 2012–2016" was formulated and approved, where two options for solving the problem were defined: the use of biofortification and fortification.

Biofortification is the improvement of the nutritional qualities of plants through the development of optimal ways of their mineral nutrition, the use of traditional breeding methods, and through the creation of new plants using molecular genetic approaches. The ultimate goal of the biofortification strategy is to create plants with increased levels of compounds in them, both those that are absorbed from the soil (macro- and microelements) and those that are synthesized in the plant (vitamins, functional metabolites). Thanks to modern technologies, the synthesis and accumulation in certain parts of the plant of compounds that are not inherent to it (for example, enrichment of the endosperm of "golden rice" with beta-carotene) has become a reality in order to provide certain cultures with improved new properties to ensure the nutritional value of the diet.

The natural complex of food substances from plants, in particular from fruits and vegetables, has significant advantages, first of all, because it has passed through a kind of biological filter and, as a result, has the most favorable ratio of main components for the body. A significant advantage of fruits and vegetables is also the fact that the nutrients in them are in an organically bound, i.e., the most accessible and assimilated form, as well as in a set characteristic of living nature as a whole. The diverse effect of fruits and vegetables is characterized by the fact that they are able to synthesize a huge number of chemical compounds of various nature. Most of them are characterized by physiological activity, manifested in a stimulating, tonic and adaptogenic effect, they are able to reduce fatigue, increase the body's natural resistance to infections and other adverse effects of the external environment. Currently, fruits and vegetables are considered not only as sources of food, but also as carriers of structural information necessary for human ecological adaptation. The use of biofortification makes it possible to reduce the content or even eliminate unwanted compounds from the composition of individual plants. That is why biofortification is a new, promising and promising approach in solving global problems related to nutrition. Fortification is a strategy aimed at creating functional food products by introducing targeted nutrients during the industrial production of food products, which also makes it possible to obtain products for a new generation of healthy nutrition [12]. This strategy has long been used by scientists in the creation of special purpose products.

The complex of substances obtained thanks to biofortification and fortification improves metabolism, stimulates the body as a whole, normalizes the state of its internal environment, and increases the body's resistance to harmful effects.

In connection with the above, it is relevant to monitor the use of the biofortification strategy to create varieties of fruits and vegetables with increased nutritional value.

The aim and objectives of the research. The aim of research is to analyze the modern experience of creating varieties of various fruit and vegetable crops with the help of biofortification strategies, which have an increased content of functional ingredients.

The objectives of research are:

1. Determination of approaches to the creation of biofortified varieties and hybrids of fruits and vegetables;

2. Identification of the most valuable of these varieties for use in the production of special purpose products.

Analysis of recent research and publications

It is possible to improve the nutritional properties of fruits and vegetables, first of all, using biofortification approaches, namely: through selection and thanks to genetic engineering technologies. At the same time, traditional selection has not yet fully exhausted its potential in obtaining new varieties of plants. Today, there are many directions in plant breeding, for example – selection for seed productivity, early maturity, cold resistance, winter resistance; drought resistance; selection for yield formation; suitability for mechanized cultivation; resistance to one or a complex of diseases, pests; adaptability; on resistance to a complex of stress factors (for example, acidic soils); sensitivity of plants to irrigation and mineral nutrition; on increasing the efficiency of symbiotic nitrogen fixation, etc.

An unconventional direction for the selection of fruit and vegetable crops – the creation of varieties and hybrids with an increased content of biologically active substances (BAS) and antioxidants (AO) by means of targeted selection based on biochemical indicators with the aim of changing plant metabolism towards the biosynthesis of valuable compounds for humans is promising and continues develop successfully. Raw materials enriched with BAS and AO can be used to create dietary and medical and preventive food additives, special purpose food products. As a result of the work of scientific breeders, varieties of domestic and foreign selection were studied and new varieties and hybrids with biochemical, agrotechnological and economic and biological valuable traits were created.

Breeding to improve the chemical composition of fruits and vegetables is carried out by using initial forms with high indicators to create interspecies hybrid combinations, by creating new initial materials and special parent lines, by evaluating initial materials and selecting selection samples for trait stability, as well as by using fertilizers of special composition, growth stimulants and other technological techniques developed for growing plants of a given quality.

The evaluation of highly starchy hybrids by starch quality is of great importance for the progress of potato selection for starchiness. As a result of research by scientists, a group of 12 hybrids was selected from 28 new hybrids, which are characterized by consistently high starch content (>18%) in combination with productivity and disease resistance. These are such varieties as Bilousivsky, Zarevo, Kalinka, Nikulinsky, Ramensky, Effect, etc. At the same time, the use of growth regulators, especially epin, reduced the nitrate content in the varieties. The scientists studied the yield and quality of potatoes of new varieties depending on the norms of mineral fertilizers and the growth regulator poteitin and found that in the Fantaziya and Teteriv varieties, the increase in the collection of dry matter was 16.0–23.2 kg/ha, starch 10.5–14.8 kg/ha, crude protein 337–696 kg/ha [13]. The quality of potatoes depending on the complex application of growth regulators and fertilizers was also studied by L. G. Revunova. In the Dnipriyanko and Polyana varieties, an increase in the content of dry matter, starch and a decrease in the amount of radionuclides in the tuber were found [14].

M. V. Ostrenko found that most varieties entered in the Register of Plant Varieties of Ukraine do not have a complex combination of high yield indicators, starch and crude protein content, resistance of tubers against late blight with increased and high content of vitamins C, K and provitamin A. Only some of them: Zarevo, Peresvit, Mylovitsa, Karpatska, Vodogray, Svitanok Kyivskyi, Suzirya, Agija, Halyna, Diamant and interspecies hybrids: 77.583/16, 90.673/17, 86.579c14, 89.721c43, 90.734/22, 79.534/61, 89.24c57 are characterized by a combination of these features. M.V. Ostrenko created breeding material (hybrids) of different maturity groups, as well as five new varieties of potatoes with increased and high content of vitamins C, K and provitamin A, combined with high indicators of other valuable traits. The new varieties are early Podolyanka, mid-early Levada, mid-ripening Lilea, mid-late Chervona ruta and Promin [15,16].

R. V. Ilchuk using different types of crosses based on complex interspecies and intervarietal hybrids, varieties of domestic and foreign selection, created a new genetically diverse selection material with a productivity of more than 1000 g/bush, starch content above 20.0%, resistance to late blight 8.0–9.0 points, high in crude protein, protein, amino acids, vitamin C, low in reducing sugars and nitrates. Potato varieties of different maturity groups have been created: Oksamit-99, Legend, Udai, Livadia. He also studied the already existing varieties and hybrids and established that among the potato varieties of Ukrainian selection, the following stood out as highly starchy: Suzirya, Alpinist, Volovetska, Brigantina – 20.2–20.8%. The Leleka variety had the highest crude protein and protein content – 3.16% and 1.40%, respectively. The varieties Chernihivska early, Slava, Bagryana, Krynytsia, Lugovska, Leleka were characterized by a high content of essential amino acids (4.36–4.85%). The starch content in tubers of multispecies hybrids is high and amounts to 19.9–25.2%. The most starchy hybrid was 86.563c.4 – 25.2% [17].

Breeding work on increasing the carotene content of table carrots has been carried out since 1955. The latest achievements of scientists in this direction are interesting. A comprehensive evaluation of 14 varieties and hybrids of carrots was carried out. The hybrids Zirka Fj (23.1 mg%), Altair Fj (21.8 mg%), the variety Vitaminna 6 (21.9 mg%) and Losinoostrovska 13 (21.0 mg%) were characterized by an increased content of carotenoids. It is possible to increase the content of carotenoids (lycopene and xanthophyll) in carrots due to the long-term use of mineral fertilizers in calculated doses by 2.2–4.9 times. In addition, in order to obtain ecologically safe vegetable products (cabbage, table beets, carrots) with an increased amount of vitamin C, sugars and dry matter and to reduce the content of heavy metals in the soil, it is necessary to regularly, once per rotation, apply fresh organic matter in the form of siderates in crop rotation (15–20 t/ha), wood sawdust (3–4 t/ha) or straw cuttings (5–6 t/ha) with simultaneous application of recommended doses of mineral fertilizers: for carrots – P60Ki50; for table beets – N90P60Ki50; for cabbage – Ni50P60K240.

Scientists have studied 59 collection samples of table breeding carrots from various countries of the world. A model of its varieties and lines was developed, according to which the source material is divided into 4 groups according to the content of carotenoids, within which 12 promising samples of carrots with:

1) with a low content of β-carotene – from 0 to 10 mg% (Long white (USA), Large white Belgium (USA), Local (Uzbekistan), Royal Shantaney (USA));

2) the average β-carotene content – from 10 mg% to 15 mg% (New Kuroda (Japan), SK 4-31-6 (Japan));

3) with a high content of β-carotene – from 15 mg% to 20 mg% (Amsterdam (Netherlands));

4) with a very high content of β-carotene – from 20 mg% and above (NIIOH 336, Losynoostrovska 13, Vitamin 6).

Among domestic scientists, a great contribution to solving the problem of improving the nutritional value of table carrots was made by V. E. Barsukova. In the collection nursery, five varieties of carrots were evaluated – Nantska, Shantane, Amager, Geranda and Valeria, which included 96 samples. After evaluating carrot samples for content of β-carotene in the phase of technical ripeness, the following varieties deserve attention: Nadezhda, Svitozara, Flakkes 2 with the β-carotene content 14.1–21.9 mg%, plastic lines UU – 14750 (23.7 mg%) and 15065 (22.3 mg%), Shantane (22.9 mg%), Fontana F (24.0 mg"). Samples with a potentially high content of vitamin C were also selected, the indicator of which varied from 6.1 mg% to 9.7 mg%, namely: Losinoostrovska 13, Spartan Bonus, Bejo 1324 F1, Clairon F1, Nanarin F1, Alamo F1, Bangor F1 , Nantes Tip Top, Neras F1, D-116, line 8/95, Miss, Deforaggio, Rubina. Carrot varieties were selected as the best sources of sugariness and nutritional qualities: Nadezhda (7.0–7.6%), Flakkes 2, Meshteva. V. E. Barsukova, the following beet varieties were selected for research: Egyptian, Bordeaux and Eclipse, which combined 84 samples. The following table beet collection samples have proven themselves to be high in vitamin C: Detroit 2 - Nero (10.7 mg%), Wodan F1 and line 48/2 (10.2–11.4 mg%). Valuable sources of high betanin content of such varieties as: – Crimson, lines 38D, 48/2, 9/2, Bordeaux 237, Local, Pablo, Detroit 2 – Nero, Amer, KhRN-3646 were also identified. V. E. Barsukova created high-quality competitive varieties of root crops, namely: carrots – Yarkka (β-carotene content up to 24.5 mg%) and K-2469 (Bars) (β-carotene content up to 21–23 mg%) and table beet – Bordeaux Kharkiv (betanin content – 198 mg%) [18].

Many scientists have studied the effect of fertilizers on the biochemical parameters of table beets. It was established that the accumulation of dry substances, sugars, ascorbic acid depends to a greater extent on the applied doses of phosphoric and especially potassium fertilizers. Application of compost contributed to the accumulation of antioxidants, especially ascorbic acid (8.53 mg% vs. 6.8 mg% control) and betanin (249 mg% vs. 193 mg% control). It was also established that excessive doses of nitrogen fertilizers negatively affect the content of fiber, protein, ascorbic acid, betanin and contribute to the accumulation of nitrates in root crops [19].

Interesting results were obtained by O. V. Kuts during the study of the influence of trace elements on the quality of late-ripening white cabbage and table beets. He claims that during the cultivation of these vegetables against the background of the received doses of mineral fertilizers, it is advisable to apply fertilization with salts of trace elements. It was established that this reduced the nitrate content in cabbage by 13–54%; manganese increased the content of ascorbic acid by 1.4–2.2 mg/100 g, zinc increased the content of ascorbic acid by 1.3–4.5 mg/100 g, and sugar by 0.26%. Manganese, molybdenum, a mixture of Mn+B+Mo and "Reacom" significantly reduced the content of nitrates in root crops of table beet to the level of 98–178 mg/kg of raw weight. At the same time, the content of dry matter in root crops increased by 0.8–2.1%, and the content of ascorbic acid by 1.1–1.8 mg/100 g, total sugar by 1.04–1.21%, and betanin by 42–81 mg/100 g [20].

Work is being successfully carried out to create varieties and hybrids of tomatoes for canning and processing. The main indicators that determine the external marketable quality of fruits are the intensity and uniformity of color, as well as the alignment of fruits. Recently, more attention has also been paid to improving their biological indicators, as well as safety indicators [21].

Breeding scientists suggest the use of growth regulators to improve the chemical composition of tomatoes. Thus, the work of I.L. Havrys presents an assessment of the effectiveness of plant growth regulators (Ivin, Biolan, Reastim, and

Immunocytophyt) on the growth, development, yield, and quality of tomato fruits of Rais F_1 and Mayev F_1 hybrids. It was found that the use of plant growth regulators increased the content of dry matter, sugars and vitamin C, decreased the content of nitrates and heavy metals in tomato fruits, which improved their quality. The technology for growing selenium-enriched tomato products using sodium selenate and selenite salts in the drip irrigation system and the biological preparation epin was developed. The content of selenium in tomato fruits reaches up to 60–65 μg/kg of raw fruit weight, while the content in the control is 8–11 μg/kg (the daily rate of selenium consumption is 50–200 μg). Varietal study of tomatoes was carried out – Chervona Strila, Faraon, Frontero, Strauss, Admiral, Titanic. Varietal features of selenium accumulation by tomato culture have been studied and a method of obtaining selenium-enriched products by introducing selenium salts into the drip irrigation system has been developed. The positive effect of selenium on the yield and biosynthesis of vitamin C in tomato fruits was also noted [22].

Scientists have discovered varietal variability in the content of bioflavonoids, namely: the content of quercetin, oxycinnamic acids and their esters, as well as the amount of flavonoids during the selection of cabbage vegetables. Varietal variability in the content of dry matter, vitamin C, mono- and total sugars, as well as the degree of accumulation of nitrates and potassium ions in the leaves was found in the seeds and productive part of varieties and hybrids of white cabbage. In the work of O. Y. Dydiv, which is devoted to the justification of the elements of the technology of growing late-ripening white cabbage varieties and hybrids in the conditions of the Western Forest Steppe of Ukraine, their economic and biological evaluation was carried out. It was established that the domestic varieties Violanta and (9.40%), Knyaginya Olga (9.36%), Yaroslavna (9.08) and hybrids of the French selection Marabou F_1 (9.36%), Count F_1 (8.97%) and Brigadier F_1 (99.08%). The amount of sugars in white cabbage heads of the Amager variety ranged from 3.84 (control) to 4.95% (Yaroslavna), and for the Langendeiska zymova variety – from 4.65 (Violanta) to 5.21% (Princess). Indicators of the content of vitamin C in the heads of late-ripening varieties and hybrids of the Langendeiska variety type, the winter deviation relative to the control ranged from 19.3 mg/100 g to 31.9 mg/100 g. The Ukrainian autumn variety is the best for fermentation [23].

O. I. Voloshyna studied the influence of elements of the technology of growing red cabbage in the Forest Steppe of Ukraine. An economic and biological assessment of varieties and hybrids of different geographical origin was carried out: medium-ripening – Olena, Rubin, Rodeo F_1, Redma F_1, Topaz, Toparani; medium-late – Gako 741, Kalibos, Dauerrot, Cabeza negra and late-ripening – Roxy F_1, Milana, Autoro F_1, Fuego F_1, Langendaker, Langendaker red, Garnet, Late Beauty, Maxilla. Red cabbage samples had high quality indicators. Toparani, Maxilla varieties prevailed in terms of dry matter; Gako 741 and Late Beauty – 9.40%; 9.64%; 9.75% and 9.95% respectively. Olena (4.26%), Cabeza negra (4.57%), Maxilla (5.20%) and Autoro F_1 hybrid (4.95%) accumulated the most sugars. By the content of vitamin C, the Rubin, Cabeza negra, Autoro F_1 hybrid, and the Pomegranate and Late Beauty varieties stood out – 44.33 mg/100 g; 47.63 mg/100 g; 48.10 mg/100 g; 49.45 mg/100 g and 50.76 mg/100 g, respectively. A regularity was established regarding the accumulation of biochemical substances – a lower content of dry matter, sugars and vitamin C was observed in mid-ripened and mid-late samples, higher in late-ripened ones [24].

The accumulation level of such substances as: selenium, iron, zinc, copper, manganese, chromium, cobalt in bulbous vegetables can be affected by various factors – soil and climatic conditions, species and variety characteristics, treatment with various growth stimulants. Thanks to the research of scientists, for practical breeding, the Lieder variety slime onion, Selenium – Schnitt 2/2002 onion, Pikantny variety sweet onion for copper and manganese, and Nadiynyst variety slime onion for zinc and iron were recommended for practical selection. O. M. Bilenko established that the sources of selection for dry matter content in bulbs are variety samples: Local (k-39) – 21.91%, Local (k-34) – 21.65%, Local (k-31) – 21.30%, Kharkiv local (k-19) – 21.20% and Donetsk (k-26) – 21.03%; of total sugar – Zaporizhzhia (k-24) – 14.45%, Kharkiv local (k-19) – 14.28%, Donetsk (k-26) – 14.06% and Meshetovo (k-39) – 14.00 %. According to the content of total sugar in the green leaves of shallots, the following forms are distinguished: Local (k-35) – 6.41% and Local (k-40) – 6.10%. Local (k-43) – 53.23 mg/100 g and Local (k-39) – 52.12 mg/100 g were selected as sources of ascorbic acid content.

As a result of the breeding work of O.M. Bilenko, 2 varieties of onions were created – Mavka (salad purpose) and Lyubchyk (universal use) and 3 varieties of shallots – Zabava, Surprise and Lira [25,26].

To obtain garlic with a high content of selenium, the most common approach in the world is the use of NPK fertilizers containing sodium selenate [27]. However, this method is not very effective, since the assimilation coefficient of selenium introduced into the soil is only 2–10%. The other part of the trace element undergoes recovery with subsequent formation of biologically inactive insoluble components with iron and ammonium. The result of this process is the need for annual introduction of selenium into the soil, as well as the formation of a potential opportunity for the manifestation of selenium toxicosis in conditions of liming. 2 ways of obtaining garlic with an increased content of selenium are proposed: 1) implementation of plant selection taking into account the factor reflecting the level of selenium accumulation and 2) development of a highly effective and environmentally friendly method of increasing the concentration of the trace element. It has been proven that the accumulation of anionic forms of selenium under the influence of humate is enhanced (by 35–75%), and the use of apions containing sodium selenate is recommended as an environmentally safe way to enrich garlic with selenium [28].

Pumpkin belongs to the number of valuable vegetable crops. Scientists-breeders pay great attention to the improvement of economic and valuable features of this culture and especially the nutritional value. An interesting study was conducted by a group of scientists who studied the varietal specificity of the content of chemical elements in pumpkin fruits of 9 varieties of Ukrainian selection. It has been established that Slavuta, Zhdana, and Khutoryanka varieties differ in their high content of pectin substances (1.85%). It is shown that these varieties contain a lot of potassium – from 139 mg% (Khutoryanka) to 289 mg% (Marmurovy). According to the content of vitamin C, the most valuable varieties were selected: Ukrainian multifruit (28.1 mg%), Slavuta (19.4 mg%) and Zhdana (17.9 mg%). Such pumpkin varieties as: Zhdana (15.8 mg%), Arabatsky (9.8 mg), Khutoryanka (9.6 mg), Slavuta (9.0 mg%), Khersonsky and Marmurovy (6.6 mg each"). Chlorophyll content, depending on the variety, ranges from 1.3 mg% (Khutoryanka) to 6.4 mg% (Zhdana) [29].

It is known that vegetable peppers contain large amounts of vitamins C and PP. The content of β-carotene in its fruits is not high and varies between 20 and 30 mg/%. Considering the high biological value of vitamin A, breeding scientists pay great attention to the selection of pepper for increased β-carotene content. Thus, the comparative evaluation of 126 samples of vegetable pepper for the content of β-carotene and vitamin C allowed to identify as sources of high content of both vitamins the varieties Fasciculatum and Grossum, from which the most promising lines L-29 and L-49 were obtained. In addition, the following varieties and lines of vegetable pepper are recommended for them based on a complex of economic and valuable characteristics (high vitamin content and resistance to verticillium wilt): Prometheus, L-29, L-49, L-46, L-31, L 61/1, L 22. Breeders are also doing a lot of work on expanding the gene pool of vegetables, especially sweet pepper, paying great attention to the nutritional value of the crop. 7 varieties of bitter pepper and 86 varieties of sweet pepper are listed in the State register of plant varieties suitable for distribution in Ukraine [30]. A great deal of work in this direction is carried out by the Institute of Vegetable and Melon Growing of the National Academy of Agrarian Sciences. In the works of Letuta T. M., Kuzyakhmetova A. A. and others, 10 varieties and 10 hybrids of sweet pepper selected by this institute were studied. During the study by the authors of the chemical composition of sweet pepper, it was established that the experimental samples contain pectin substances, namely: from 0.27% in hybrid #388 to 0.33% in hybrid #378. The content of vitamin C in the experimental samples ranges from 14.4 mg% – the Podaranok Moldova variety to 51.0 mg% – the Giant variety. Chlorophyll content is an equally important indicator of chemical composition, which ranges from 2.22 mg% (hybrid #384) to 2.45 mg% (Valiusha variety). Having studied the content of carotenoids in different botanical varieties of sweet pepper, it can be stated that hybrid #378 contains 30.05 mg%, and hybrid #482 contains 31.42 mg%. After analyzing the obtained data, the authors found that the best variety of sweet pepper in terms of chemical composition is the Veleten variety, which contains a significant amount of vitamin C, carotenoids and chlorophyll. It is recommended to use this grade for special purpose products [31-36].

Breeding work with white root crops is carried out on a small scale. Although they are a source of easily digestible carbohydrates, dietary fibers, minerals (especially potassium), as well as such functional ingredients as phytosterols, phenolic compounds, phytoalexins (salvestrols), phthalides, bioactive aliphatic polyacetylenes [37-54]. 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 [55-62]. They have antibacterial, antimicrobial, anti-inflammatory, anti-cancer and antioxidant effects. Therefore, their use in food will allow to obtain many new special purpose products. Preparations obtained from them raise the general tone, strengthen physical and mental performance, improve blood supply, etc. In addition, in addition to the high nutritional and biological value of food, its taste and aromatic properties are an indispensable condition for a person's full nutrition. And white root vegetables precisely due to the presence of aromatic substances in them allow improving the sensory characteristics of food [63,64].

4 varieties of parsnip, 23 varieties of parsley and 11 varieties of celery are entered in the State Register of Ukraine. S. O. Dubinina (Lenert) studied the root varieties of these vegetables, namely: 3 varieties of parsley (Sukrova, Urozhayna, Kharkivyanka), 3 varieties of celery (Yablyuchna, Monarch, President) and 4 varieties of parsnip (Student, Round, Petryk and Best of all). The chemical composition of white root crops of various economic and botanical local varieties was studied. Its main part is water – 75.4–87.0%. The main part of dry substances consists of carbohydrates, which are mainly represented by sugars (5.4–16.6%), fiber (1.7–3.9%), starch (0.2–3.8%), pectin substances (0.6–1.3%). A feature of the mineral composition is the high potassium content – from 312 mg/100 g in parsnips to 668 mg/100 g in celery. It was also established that experimental varieties of white root crops contain oxybenzoic and oxycinnamic acids,

coumarins, flavonols, flavones, isoflavones, flavonones [65].

It has been proven that experimental white root crops are a source of phytosterols. A total of 13 types of steroids were identified in experimental white root crops. According to their total content, parsnip contains the most 3.71–5.25 g/100 g, in celery – 0.93–4.03 g/100 g, in parsley – 0.63–4.27 g/100 g. But in terms of β-sitosterol content, the leader is celery – 0.74–2.24 g/100 g (especially in the Yabluchna variety) [66]. The antioxidant activity of white root crops was determined. Varieties of parsley are almost the same in their content – 223–256 Kl/100 g. Parsnip of the Kruglyi variety has the highest antioxidant activity – 317.5 Kl/100 g. Among the experimental samples of celery, the Monarch variety should be singled out – 316 Kl/100 g [67]. Due to the researches of Lenert S.O. and Mardar M.R., the prospects of using white root crops in the creation of products of increased biological value have been proven [68,69].

The level of well-being of any country has recently been determined by the amount of protein consumed per capita. In this regard, legumes occupy an exclusive place among agricultural plants due to their unique biochemical composition, due mainly to a high protein content, a balanced content of vitamins C, group B, E, minerals and fiber. Among food leguminous crops, common beans stand out in terms of nutrition. Doctors in many countries recommend eating beans for metabolic disorders, including diabetes, due to the content of arginine, the mechanism of action of which is similar to insulin. Beans are the champion among vegetable crops in terms of protein content and are therefore widely used in children's and diet food.

Despite the importance and traditionality of common beans for Ukraine, the volume of industrial cultivation of this crop in the country continues to remain insufficient. In solving the problem of creating new, competitive varieties, the source material studied in detail and adapted to specific conditions plays an important role. Such work was carried out by S. I. Silenko in the conditions of the left-bank part of the Forest Steppe of Ukraine. Significant polymorphism in the manifestation of valuable economic traits in the collection material of the modern common bean gene pool was established. The most promising material from:

– a set of valuable traits: Alfa, Stepova 5, Tenderlang Resistant, UD 0301025, Moleiro, Kompolti gyongybab, UD 0300835;

– high protein content – protein content more than 26%: UD 0302866, Strogele, Flageolet wax, Sidukha-29, Strindless Qreen pod, Crayon, UD 0301803, Sparzheva;

– improved amino acid composition: 22 variety samples with a stably increased content of three or more amino acids and 32 samples with a high content of individual essential amino acids in the protein: lysine (>6.1%) – 7 samples; methionine (>1.1%) – 6 samples; tryptophan (>1.1%) – 19 samples [70]. S. I. Silenko, for the first time in Ukraine, a collection of common beans based on the chemical composition of seeds was formed and registered in the Center of Plant Genetic Resources of Ukraine – 58 samples originating from 22 countries of the world [71].

Another source of vegetable protein is corn. According to FAO (Food and Agriculture Organization), its grain and the plant itself are raw materials for almost 3,500 types of products that are used not only in agriculture, but also in industry. The average annual consumption of corn per capita in many countries reaches more than 30 kg, while in Ukraine it is only 3–7 kg. Therefore, domestic breeders are constantly working on the creation of new varieties with increased nutritional value, which could be used for food purposes. Thus, in the work of V. A. Marochko, for the first time in Ukraine, the peculiarities of the technological qualities of corn grain intended for the production of groats were established, and their dependence on the consistency of the endosperm was established. Evaluation and selection of siliceous starting material of corn for the selection of hybrids for food purposes was carried out [72]. A source material with an increased content of carotenoids in grain was proposed: DK 303/427 (0.27 mg%), DK 276-1 (0.202 mg%), which can be effectively used in the selection of hybrids with improved grain quality [73].

Nuts are a source of protein and useful vegetable oil. But their capabilities have not yet been fully utilized for the production of special purpose products. Great help in solving this problem can be provided by the work of O. V. Morgun, which is devoted to the economic and biological evaluation of new hazelnut varieties in the conditions of the Northern Forest Steppe of Ukraine. As a result of many years of work, 37 varieties of hazelnuts were studied, varieties were selected for their protein and fat content. The highest protein content is found in the fruits of the varieties Badius (21.8%), Bolgradska novinka and Svichkovy (20.3% each), as well as Shedevr (20.1%), while the lowest is found in Futkurami (13.4%) and Stepovoy (13.8%). All other varieties were characterized by an average content of these substances – ranging from 14.9% (Hazelnut-45) to 19.9% (Gift to Yunnat). Morozivskyi, Funduk-85, and Peremoha varieties are classified as high-oil varieties (oil content in the range from 70.0% to 70.6%). Oil varieties (from 65.1% to 68.9%) – Lozivsky yielding, Urozhayny-80, Lozivsky globular, Cherkesky-2, Lozivsky club-shaped, etc. Medium oil (from 60.2% to 64.5%) there are Veresnevy, Karamanivskyi, Bolgradska novelty, Davydivskyi and a number of other varieties. The total content of the main nutrients – fat and proteins in the kernels of the best varieties is 85.1% (Dar Pavlenka); 85.2% (Hazelnut-85); 85.7% (Cherkesky-2 and Borovsky); 86.0% (Lozivsky club-shaped) and 87.2% (Obilny) [74].

Taking into account the high medical and dietary benefits of fruits, breeder scientists conduct research on their introduction and varietal study with the aim of further recommendations for special purpose products. The main indicators of fruit quality include the chemical composition, that is, the ability of plants to accumulate a high amount of nutrients and biologically active substances in fruits and to store them as long as possible. The ratio of some chemical substances - sugars, organic acids, polyphenols affects the taste, nutritional value and technological properties of fruits; of other trace elements, vitamins and other biologically active substances – determines the dietary and medicinal qualities of fruits. Knowledge of all these properties is taken into account by breeders in their work.

It is interesting to study the scientific chemical and technological properties of gooseberry. It was established that the fruits of the Chornomor, Kozachok, Sirius, and Plum varieties contained the largest amount of sugars and dry substances (11.4–14.4%); in terms of accumulation of ascorbic acid, the black-fruited varieties Black Plum, Black Plum, and Kozachok are in the lead (32–43%); Kozachok, Slabkoshipuvatiy-3, Chornomor are characterized by a high sugar-acid ratio; Black plum and Jubilee varieties are the richest in catechins. The total content of P-active compounds increases as the color intensity increases, which is the highest in black-fruited varieties (933–1060 mg%). The maximum level of pectin substances is indicated in the Jubilee, Russian, and Black plum varieties. The optimal combination of chemical and technological properties of berries is characterized by the Blackberry, Blackberry, Russian, Kozachok, and Plum varieties. Ecological and biological study of other collection samples of gooseberry made it possible to identify varieties with a high content of sugar and dry soluble substances (Chervonoslovyanskyi, Seyanets Lefora, Black Negus); high content of vitamin C (Shalun – 47.5 mg%, Jubilee – 37.3 mg%, Seedling Lefora – 35.5 mg%). Significant variability was established in the quantitative and qualitative composition of carotenoids depending on the color of the berries. Yellow-colored fruits have the highest content of carotenoids in terms of β-carotene – 3.9 mg% (Progress variety). The most diverse qualitative composition is indicated in the black-fruited variety Chornomor (4 carotenoids). Elemental analysis of 5 gooseberry samples (Chervonoslovyansky, Malachite, Progress, Chornomor, Shalun) revealed the content of such chemical elements as potassium, calcium, chromium, iron and nickel. Long-term research by domestic researchers has established that the BAR of gooseberry varieties of Ukrainian origin (Green bottle, Green fertile, Pavlov green, Malachite) are represented by chlorophylls (3.5–4.3 mg%), carotenoids (0.34–0.42 mg%), catechins (80.8–105.7 mg%), leucoanthosans (111.7–155.4 mg%) and flavonols (11.3–12.0 mg%) [75].

Conclusion

The analysis of literary sources made it possible to establish that modern medicine believes that the state of health of Ukrainian citizens is unsatisfactory. More than 50% of the population eats poorly. 25% of those examined have a deficiency of iron and vitamin A, 30–40% are at risk of iodine deficiency disorders, there is a widespread deficiency of zinc, B vitamins, and especially $B_{9(10,11,12,13,14)}$, vitamin C, which causes a deficiency of iron The majority of the population receives insufficient amounts of tocopherols, β-carotene, calcium, selenium, fluorine, dietary fibers and other bioregulators of vital processes. Global pollution of surface water and land, local radioactive pollution lead to contamination of food products with contaminants of various origins. The solution to the problem is possible through changes in the structure of nutrition, and above all, through an increase in the diet of vegetables and fruits of high quality, the varieties of which have been created using biofortification strategies. Biofortification is an innovative and promising approach in solving global problems related to nutrition. The goal of biofortification is to create plants with increased levels of the necessary functional ingredients absorbed from the soil, as well as those synthesized in the plant. Biofortification strategies consist in the development of optimal ways of mineral nutrition of plants, the creation of new species using molecular genetic approaches, and the use of traditional breeding methods.

Based on the literature review, it was established that for many years, an unconventional direction of selection has been developing – the creation of varieties and hybrids of fruits and vegetables with the recommended chemical composition.

Created varieties of vegetables and fruits with increased protein content (nuts and legumes); starch (potato); carotenoids, dry matter, disaccharides (carrot, pumpkin); vitamin C, betanin, sugars (table beet); selenium (tomatoes); bioflavonoids, vitamin C (cabbage vegetables); macro- and microelements (bulb vegetables), etc.

But due to the fact that the selection of vegetable and fruit crops is mainly carried out to increase yield, resistance to disease, to weather conditions, etc., due attention is still not paid to the selection for the increased content of BAR and AO. Therefore, the development of non-traditional selection in breeding remains promising, and the popularization of these developments, their implementation in life is urgent. Moreover, such raw materials are necessary for the population and the food industry, especially for the creation of special purpose products. This will provide an opportunity to significantly improve the quality of the population's diet and health.

To increase the effectiveness of the solution to this problem, it is necessary to increase and accelerate the production of already created biofortified varieties of agricultural crops. And the study of samples of the domestic collection of agricultural crops and the selection of the best varieties from them for various areas of use, and especially for the production of special purpose products, is an important scientific task of an innovative nature, which must be developed, because the problem of improving the health of the nation must be in the first place.

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ПОКРАЩЕННЯ ЯКОСТІ ОВОЧІВ ТА ФРУКТІВ ЗА ДОПОМОГОЮ СТРАТЕГІЙ БІОФОРТИФІКАЦІЇ

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Анотація. Аналіз стану харчування людей в Україні свідчить, що населення харчується не якісно, що значно погіршує стан його здоров’я та працездатності. Розв’язання проблеми можливе шляхом змін у структурі харчування, і перш за все, шляхом збільшення в раціоні овочів і фруктів високої якості, сорти яких створені за допомогою стратегій біофортифікації. Біофортифікація є інноваційним та багатообіцяючим підходом у вирішенні глобальних проблем, пов’язаних із харчуванням. Метою біофортифікації є створення рослин з підвищеними рівнями вмісту у них необхідних функціональних інгредієнтів, що поглинаються з ґрунту, а також і тих, що синтезуються в рослині. Стратегії біофортифікації полягають у розробці оптимальних шляхів мінерального живлення рослин, створенні нових їх видів за допомогою молекулярногенетичних підходів та у використанні прийомів традиційної селекції. Метою роботи є аналіз сучасного досвіду створення за допомогою стратегій біофортифікації сортів різноманітних фруктових та овочевих культур, які мають підвищений вміст функціональних інгредієнтів. На основі літературного огляду встановлено, що багато років розвивається нетрадиційний напрямок селекції – створення сортів і гібридів фруктів та овочів із рекомендованим хімічним складом. Створені сорти овочів і фруктів з підвищеним умістом білка (горіхоплідні та бобові); крохмалю (картопля); каротиноїдів, сухих речовин, дисахаридів (морква, гарбузові); вітаміну С, бетаніну, цукрів (буряк столовий); селену (томати); біофлавоноїдів, вітаміну С (капустяні овочі); макро- та мікроелементів (цибулинні овочі) і ін. Таку сировину можливо використовувати для створення продуктів спеціального призначення, що значно покращить якість раціону харчування населення та його здоров’я. Показано, що розвиток нетрадиційного направлення в селекції залишається перспективним, а вивчення зразків вітчизняної колекції сільськогосподарських культур і виділення із них найкращих сортів для різноманітних напрямків використання, а особливо для виробництва продуктів спеціального призначення є важливим народногосподарським і науковим завданням інноваційного характеру, який треба розвивати, тому що проблема оздоровлення нації повинна стояти на першому місці.

Ключові слова: біофортифікація, сорти овочів і фруктів, біохімічний склад, харчування.