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## Analytical review of the market of raw materials and innovative technologies of health-improving food products of plant origin

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**Abstract.** In the modern world, interest in health products has increased due to increased attention to a healthy lifestyle and a balanced diet. However, there is a need to master technologies for the production of health products to preserve the maximum amount of useful substances and use innovative methods of processing raw materials. That is why the purpose of this study was to review and analyse existing technologies for the production of health-improving food products, in particular, with the use of plant raw materials. Scientific and technical literature and regulatory documentation served as materials and methods. A sample of individual periods was created and analysed according to selected indicators, namely the volume of food production, the dynamics of

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vegetable, fruit, and berry crops, the commodity structure of the wholesale turnover of processed fruits and vegetables, the volume of baby food and dietary food production, the volume of cocoa, chocolate, and sugar confectionery production, and the average daily consumption of basic micro- and macro-nutrients in certain food products by the population. It was determined that the volume of the health food market for the period 2015-2020 increased by 1.3 trillion USD in value terms, while the range of traditional food products expanded by an average of 2-3% per year. The production of vegetable crops by households in 2021 exceeded the production of enterprises by 6.2 times, in 2020 – 5.5 times and in 2019 – 5.2 times. The production of fruit and berry crops in Ukraine in 2021 was 6.3% more than in 2020, and in 2020 – 8.7% more than in 2019. The dynamics of the average daily intake of protein, fat, iron, niacin, ascorbic acid, thiamine, riboflavin, calcium, retinol,  $\beta$ -carotene equivalents, retinol and  $\beta$ -carotene (RET+ 1/6 B-CARQ) in food products help to determine the deficit and surplus of macro- and micro-nutrients in the diet of consumers. In general, the use of health food products, including children's and dietary nutrition, is promising and competitive, and the feasibility of using plant-based raw materials in health nutrition and the development of new health products is also confirmed

**Keywords:** functional nutrition; fruits; vegetables; food; food production

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## Introduction

The World Health Organisation estimates that 600 million people, or almost every 10<sup>th</sup> inhabitant of the planet, suffer from the consumption of low-quality food products. Every year, 420,000 people die from eating dangerous food. Diarrhoeal diseases are the most common diseases that develop as a result of eating dangerous food: 550 million people get sick and 230,000 die from dangerous food each year (State Enterprise Centre of Public Health..., 2024). Due to the development of information technology, people have become more conscious of the food they consume. Since there is a shortage of health products and a surplus of junk food in the mass market, the consumer often lacks such functional elements as vitamins, carotenoids, natural antioxidants, proteins, fatty acids, polysaccharides, etc. One of the reasons for this imbalance, as defined by M. Sychevsky (2019) studying the food industry as the basis of food security and state development, it is the production by industry of a large number of products that do not meet the requirements for indicators of biological value.

Exploring the functionality of food components and new technologies C. Galanakis (2021) presents nutritional and functional food ingredients, and provides widely used terms bioactivity, bioavailability, and biological digestibility. The influence of non-thermal technologies on the functional properties of proteins, carbohydrates, lipids, minerals, vitamins, polyphenols, glucosinolates, polyphenols, aromatic compounds, and enzymes was also discussed. Non-thermal technologies, as new methods of food production, can maintain the bioavailability of food components, improve functional and technological properties, and increase crop yields.

Individual studies by D. Granato *et al.* (2020) were devoted to the investigation of functional food products, their development, technological trends, and testing for effectiveness and safety. Food manufacturers invest resources in developing processed foods that can provide additional functional health benefits to consumers. Due to national regulations and target expiration dates in different countries, the meaning and definition of this term is still ambiguous around the world. M. Gallego *et*

al. (2018) described the most common functional ingredients, such as polyunsaturated fatty acids, probiotics/prebiotics/synbiotics, antioxidants, and the technical means of adding them to food. Researchers also provide a number of recommendations and steps that food companies should take to ensure that the products they develop are truly functional and healthy. L. Brown *et al.* (2018) indicate that there are unique challenges in clinical trials of the use of functional foods.

Herbal medicines, such as herbal products and nutraceuticals, can often be considered low-risk due to their long history of human use. Reviewing the available information and reports on side effects and clinical studies with herbal products in the literature review process, it can be concluded that they are constantly increasing, but many reports are incomplete and contradictory. For example, botanical preparations, in particular herbal products, are complex products that contain more than one active ingredient. Research in this area can be confusing due to various manufacturing processes and formulations, including cosmetics and food additives; the environment; chemotypes; misidentification or falsification.

According to Resolution No. 189 (2011) regarding the concept of the State scientific and technical program “Biofortification and functional products based on plant raw materials for 2012-2016” among the results of research introduced into production were new varieties of plants, bred considering the biofortification strategy; bread, bakery, and flour confectionery products containing vitamins of group B, A, E, calcium, iron, iodine and selenium; milk and dairy products containing multivitamin complexes, lactic acid bacteria and starter cultures; low-calorie fat and oil products containing functional ingredients; soft drinks with extracts of medicinal plants. A nutrition action plan has also been adopted to eliminate chronic deficiencies in essential vitamins, minerals, and other essential compounds in the diet.

Technologies of health products with the addition of plant raw materials can include various methods of processing, manufacturing and extraction, which are aimed at enriching products with biologically active substances, preserving the useful properties of plant components, improving their effectiveness on the human body, reducing waste from the production of analogues based on artificial or animal raw materials, increasing economic efficiency, creating jobs, and increasing the range and meeting the needs of consumers. The study by A. Antoniv *et al.* (2022) showed how bread quality indicators have changed due to the replacement of sugar with rapeseed honey for production. It was found that the use of honey in the recipe accelerates the fermentation of dough by 1.5-2.0 times, it was found that yeast is more active in the honey environment, and the sensory characteristics of the prototypes met the requirements of national standards of Ukraine.

Especially relevant today is the creation of health-improving desserts and confectionery products that have an enriched nutritional composition, reduced or changed sugar content. One of the ways to achieve this is the use of vegetable raw materials. Therefore, the purpose of this study was to analyse the raw material market and existing innovative food technologies for health products made from plant raw materials.

## Materials and Methods

The research was conducted at the laboratories of the Department of Standardisation and Certification of Agricultural Products of the Faculty of Food Technology and Quality Control of Agricultural Products of the National University of Life and Environmental Sciences of Ukraine during January-February 2024.

The material for writing the paper was scientific, technical, and official statistical information, analysed and generalised using theoretical and statistical research methods. In the course of the study, generally accepted methods

and techniques were used: abstract and logical, inductive and deductive, analytical, synthetic, analogue and comparative methods, and methods of analysis and synthesis. Scientific and technical literature on scientometric and abstract databases Scopus, Web of Science and Google Scholar, the Ministry of Agrarian Policy and Food of Ukraine, the Ministry of Economy of Ukraine, the National Academy of Agrarian Sciences of Ukraine was processed. Regulatory and technical information was used from relevant institutions, organisations and departments, in particular the Institute of Food Resources of the National Academy of Agrarian Sciences of Ukraine, the State Statistics Service of Ukraine. The initial data were obtained upon request from the State Statistics Service of Ukraine. Statistical processing and comparison of the obtained data were performed using the built-in statistical functions of MS Excel and are shown in figures 1-10.

To determine the volume of food production, information from the State Statistics Service of Ukraine (2024) for 2014, 2019-2023 for two periods – January-September and January-December – were analysed. To track the dynamics of vegetable and berry crop production as of December 1, the periods of 2019-2021 were considered for farms of all categories and separately for enterprises and households according to the State Statistics Service of Ukraine, (2024). These intervals were chosen due to the fact that the state statistics service of Ukraine has not yet published all data for the full calendar year 2023 for food production and does not publish the latest changes in vegetable and berry production volumes. In addition, it was also necessary to compare production volumes for the first half of the year and for the whole year to determine when there is an advantage in the production of individual products or crops during the year. In addition, the selected time periods for the study provide data on the situation in various sectors of food and crop production in Ukraine,

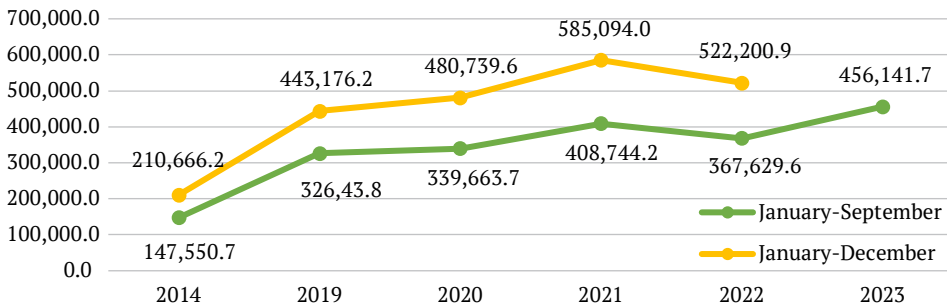
and a comprehensive analysis, comparison and general conclusions regarding the purpose of this study. Separately, the commodity structure of wholesale trade in processed fruits and vegetables for 2018-2021, the volume of production of baby food and dietary food products for 2019-2023 for two periods – January-September and January-December – were determined. The production volumes of cocoa, chocolate, and sugar confectionery products were determined for 2014, 2019-2023 also for two periods – January-September and January-December. Additionally, the average daily intake of the main micro- and macro-nutrients in all food products and separately in plant-based food products was analysed, including caloric content, calcium, retinol,  $\beta$ -carotene equivalent, retinol and  $\beta$ -carotene equivalent (RET+1/6 B-CARQ), ascorbic acid, protein, fats, iron, niacin, thiamine, and riboflavin in the context of 2000-2020 according to Balances and consumption of the main food products by population of Ukraine (2021).

## Results and Discussion

**Trends in the health food market.** The increase in demand for health products has ensured the rapid development of the industry over the past 10 years. According to T. Molodid (2021), there is a steady growth of the industry in the world, as in 2015 the value of the wellness market was USD 3.7 trillion, and as of 2020, its value exceeded USD 5 trillion. The main task of the health-improving food industry market is to create safe, affordable, and balanced food products. Analysis conducted by H. Mokhonko & K. Klymenko (2020) of global market trends shows that the expansion of the range of traditional food products was 2-3% per year, while health products by 40-50%. As indicated by A.A. Dyskina & Ya.V. Bohachenko (2016), the increase in demand is conditioned by consumers' awareness of the importance of healthy eating and the use of environmental technologies.

To consider the trends in the health food market, it was important to first determine the volume of food production (measured in mil-

lions of UAH excluding VAT and excise). Thus, the volume of food production in Ukraine is shown in Figure 1.



**Figure 1.** Food production volume, mln. UAH

**Source:** created by the authors based on the State Statistics Service of Ukraine (2024)

As can be seen from Figure 1, food production volumes during the study periods were unstable and varied. This was influenced by a number of factors, including the financial viability of the population of Ukraine, established market trends, state support for the production of social groups of products, the geopolitical situation and the full-scale aggression of the Russian Federation against Ukraine. In general, comparing production volumes for the period January-September 2023 with the same period in 2014, volumes increased by 3 times. The volume of food production in 2022 was 10.7% less compared to 2021, which is most likely due to the beginning of a full-scale war between Russia and Ukraine. But already for 9 months of 2023, there was a positive trend and the difference was 12.6% less compared to the indicators for the whole of 2022, and for the same period the volume was 24% more. Since the State Statistics Service of Ukraine has not yet presented the final data for 2023, it is likely that food production will return to the pre-war level and continue to grow.

Most of the health products are made up of products made from vegetable raw materials or its addition. Research by L.H. Byshovets & O.H. Oliferchuk (2020) confirms that such a

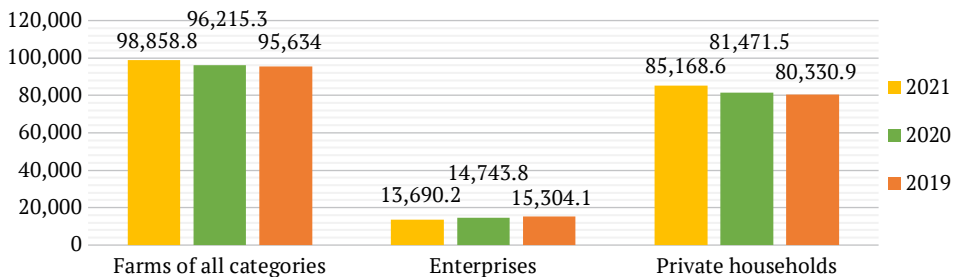
product can be suitable for all age and cultural groups, because the vast majority of such products quickly satisfy hunger are affordable and ergonomic. Analysis of the market of health products of plant food, which was conducted by H.O. Simakhina (2018) includes an investigation of key trends, factors of influence, competitive environment, and prospects for the development of this sector.

In line with the growing demand, companies from different countries are beginning to actively expand the production of health products of plant origin considering the expansion of technological support, which is also highlighted by O.V. Kovalenko & N.S. Kotkova (2020). This applies not only to basic foods such as vegetables, fruits, and cereals, but also to various alternatives to meat, dairy, and sweets. New and improved products are emerging on the market that meet the demand for healthy and functional food products. As indicated by O. Dikhtiar *et al.* (2023), these can include superfoods, speciality drinks, alternative meat and dairy products, vegan snacks, healthy desserts, etc. Clearly, with the growing popularity of health-improving nutrition, competition between companies in the market is also growing. This leads to the emergence of

more brands and products, the development of marketing strategies, and continuous improvement in quality and innovation. The review by M.P. Sychevsky (2019) on the growth of demand and competition points to the improvement and regulation of the market for health products, in particular regarding labelling, safety and quality of products. Overall, the health food

market is a dynamic and rapidly growing sector of the food industry, attracting the attention of consumers, manufacturers and regulators.

To find out the prospects for using Ukrainian vegetable raw materials for organising the production of health-improving food products, the dynamics of vegetable crop production was determined (Fig. 2).



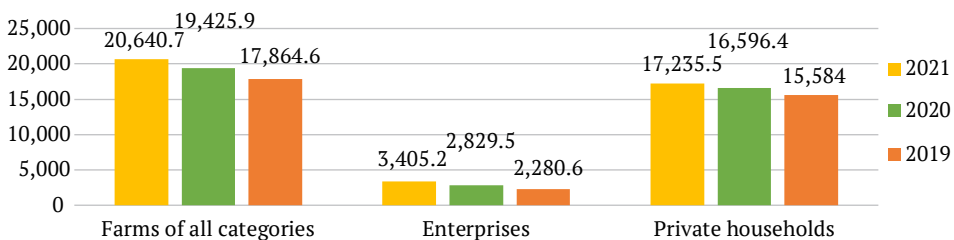
**Figure 2.** Dynamics of vegetable crop production as of December 1, thous. hwt

**Source:** created by the authors based on the State Statistics Service of Ukraine (2024)

Based on the data from Figure 2, the main producers of vegetable crops in Ukraine are specialised enterprises and households, the predominant number of vegetable crops in Ukraine is produced by households. Thus, in 2021, they produced 6.2 times more products than enterprises, in 2020 – 5.5 times, in 2019 – by 5.2 times. In addition, production volumes for the study period increase annually. Thus,

3% more vegetable crops were produced in 2021 compared to 2020, and 0.6% more in 2020 compared to 2019. Considering the data obtained, there is a constant increase in the production of vegetable crops, mainly at the expense of households, which can positively affect its use in health-improving nutrition.

The dynamics of the production volume of fruit and berry crops is shown in Figure 3.



**Figure 3.** Dynamics of fruit and berry crop production as of December 1, thous. hwt

**Source:** created by the authors based on the State Statistics Service of Ukraine (2024)

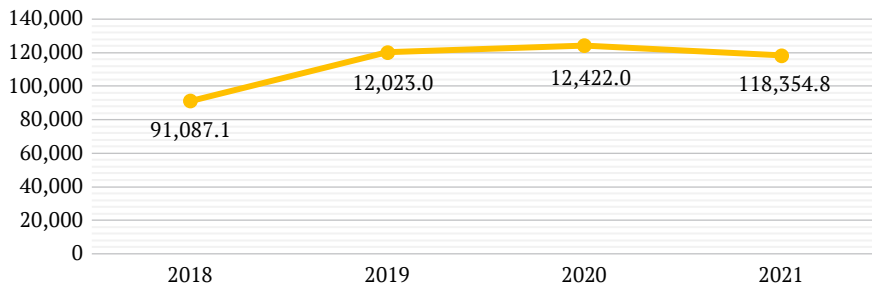
Considering the data in Figure 3, the production of fruit and berry crops in Ukraine occupies smaller volumes compared to vegetable

crops, but their dynamics are much higher. Thus, there is an increase in the production of fruit and berry crops by both specialised

enterprises and households, although households also occupy leading positions. Comparing the dynamics by year, it can be noted that in 2021 the production of fruit and berry crops increased by 6.3% compared to 2020, and in 2020 it increased by 8.7% compared to 2019. Therefore, based on the data obtained, there are opportunities to provide the plant with raw

materials, in particular vegetable, fruit and berry crops for the production of food products for healthy nutrition.

Additionally, during the study of trends in the market of health-improving food products, the commodity structure of wholesale trade in fruits and vegetables processed by Ukrainian enterprises was determined (Fig. 4).

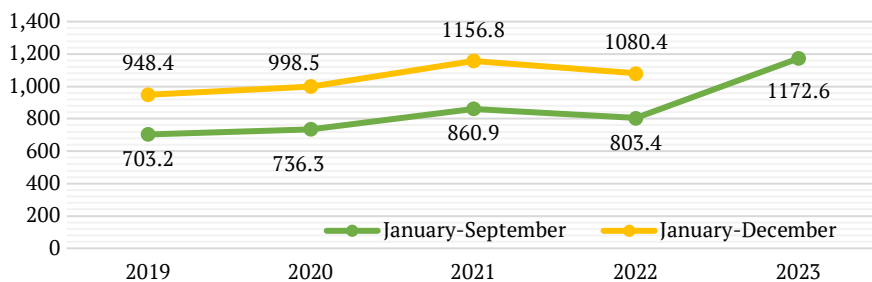


**Figure 4.** Commodity structure of wholesale turnover of processed fruits and vegetables, t  
**Source:** created by the authors based on the State Statistics Service of Ukraine (2024)

As can be seen from Figure 4, the commodity structure of wholesale turnover of processed fruits and vegetables tends to increase. Thus, from 2018 to 2021, it increased by 29.9%, despite a slight decrease in the period 2020-2021 – by 4.7%. This indicator is also important when reviewing the market and technologies of

health products with the addition of vegetable raw materials, because it allows regulating the production of goods as well.

One of the areas in which health food products are used is in children's and dietary nutrition. Figure 5 shows the production volumes of baby food and dietary food products.



**Figure 5.** Volume of production of baby food and dietary food products, mln. UAH  
**Source:** created by the authors based on the State Statistics Service of Ukraine (2024)

As can be seen from the data in Figure 5, despite critical developments in the country, there is a rapid increase in the production of baby food and dietary food products and income generation. Thus, without final data for

2023, the volumes for the period January-September already exceed by 8.5% the volumes of the entire 2022. In general, in monetary terms, since 2019, the production of baby food and dietary food products has increased by 66.7%.

According to the results obtained, there are prospects for the use of health products, including in children's and dietary nutrition.

**Innovations in food technologies for health improvement.** New trends in food technology include fortified and functional products, additive manufacturing, cultured meat, precise fermentation, and personalised nutrition. According to A. Hassoun *et al.* (2024a), other food trends are expected to emerge in the future and increase consumer interest in the transition to sustainable food development and innovative environmental strategies. S. Khan *et al.* (2024) report the start of implementation of smart food monitoring, which consists of intelligent packaging and instant testing technology to detect spoilage and contamination at the product's location.

Innovative food technologies, as described by B. Liu *et al.* (2024), include the use of hydrogels as functional food products in various types of products, with a particular focus on their use in edible shells, saturating gels, nutrient delivery systems, food colouring adsorption, and food safety monitoring. In addition, D.B. Berdahl & J. McKeague (2015) investigated the effects of rosemary and sage extracts as antioxidants for food preservation. A. Hassoun *et al.* (2024B) point to the spread of Food Traceability 4.0 (FT 4.0) in food technology, which is food tracking in the era of the Fourth Industrial Revolution. The main assets of FT 4.0 are blockchain, the Internet of Things, artificial intelligence, and big data.

**Overview of the most common innovative food technologies using vegetable raw materials.** Modern food technologies have significantly expanded the possibilities of creating health-improving products with the addition of plant raw materials, which contributes to improving the quality of life and ensuring the health of consumers.

**Extraction using green technologies.** This technology is an environmentally friendly approach to extracting useful compounds from

plant raw materials. This method helps to save more useful substances and minimise the negative impact on the environment compared to conventional chemical extraction methods. F. Suvanova *et al.* (2023) report on the use of various extraction methods. The use of water extraction methods instead of organic solvents can be harmful to the environment and health. Thus, green technologies are based on the use of water or aqueous solutions as a solvent. This reduces the risk of contamination and promotes safe processing of raw materials by extraction using ultrasound or microwave radiation, as indicated by M.S. Arshad *et al.* (2023), used to improve efficiency, reduce the time and temperature required for the extraction process, which contributes to the preservation of more biologically active substances in the product.

Extraction using supercritical solvents, which was described by H.W. Huang *et al.* (2013) is a method of using high pressure and temperature to increase the dissolution of beneficial compounds in a plant. It allows to get high-quality extracts with less solvent and a higher concentration of useful substances. The use of supercritical solvents is a method based on the use of solvents that are in a state above their critical pressure and temperature point. As indicated by M.E. Braga *et al.* (2023), they allow the extraction of substances that cannot be extracted by other methods. Such green extraction technologies allow obtaining high-quality health products from plant raw materials, while maintaining the maximum amount of useful substances and reducing the negative impact on the environment.

**Fermentation technology and the use of prebiotics** to make health products from plant-based raw materials is an effective method for creating products that promote gut health and overall well-being. A.M. Solomon *et al.* (2020) note that during fermentation, micro-organisms such as bacteria or fungi break down complex substances in the plant into simple components through chemical reactions.

This process can increase the bioavailability of plant nutrients, such as vitamins and antioxidants, and create new beneficial compounds. Prebiotic substances include those that are not absorbed by the body, but serve as food for beneficial bacteria in the gut. These can be certain carbohydrates, such as inulin, fructan, and oligosaccharides. H.O. Simakhina (2019) notes that adding prebiotics to health products can support gut health and stimulate the growth of beneficial bacteria. During fermentation, some microorganisms that are produced or added to the product can become probiotics. Probiotics are live microorganisms that are useful for restoring gut health. During fermentation, new aromatic and flavouring compounds can also be synthesised, making health products more attractive to consumers. Fermentation can change the texture of a product, giving it a certain consistency or softness.

**Nanotechnology.** The use of nanotechnology for the production of health products from plant raw materials opens up wide opportunities for improving the quality, effectiveness and safety of such products. Adding nanoparticles to health products, as described by V.K. Bajpai *et al.* (2018), may increase their bioavailability, i.e., the body's ability to absorb nutrients from a product. For example, nanoparticles can help increase the solubility of fat-soluble vitamins or polyphenols from plant materials.

It is known that the use of nanoemulsions allows creating stable emulsions that improve the safety of the product and increase its shelf life (Bajpai, 2018). This is especially important for plant-based products, which tend to oxidise and spoil. Nanoencapsulation for controlled release of substances, according to L. Taouzinet *et al.* (2023), allows useful substances to be enclosed in nanomaterials, such as liposomes or nanoparticles, which ensures their controlled release in the body. This can be useful for gradually releasing active substances into the digestive tract or for increasing their stability in the product. E. Poeta *et al.* (2023) also provide

information that the development of nanosensors allows real-time measurement of the levels of nutrients, antioxidants, and other components in health products. This helps to ensure high quality and safety of the product for the consumer.

The use of nanotechnology in the production of health products with the addition of plant raw materials can significantly improve their properties and effectiveness, which contributes to a healthy lifestyle and the overall well-being of consumers. However, it is important to consider the ethical and regulatory aspects of using nanomaterials in the food industry to ensure the safety and health of consumers.

**Replacing animal proteins with vegetable ones.** According to C. Floret *et al.* (2023), the use of plant-based proteins and alternative products for the production of health products from plant-based raw materials is becoming increasingly popular and opens up wide opportunities for the development of high-quality and healthy food products. Plant-based protein sources such as soy, peas, nuts, hemp, buckwheat, and others are excellent alternatives to traditional animal proteins. Not only do they have a high nutritional value, but they can also be more environmentally sustainable and ethical to produce. A. Carballo-Casla *et al.* (2024) point out that plant-based milk substitutes such as almond milk, soy milk, oat milk, and others are becoming increasingly popular among consumers looking for alternatives to traditional dairy products due to allergic reactions or ethical reasons. M. Thierry (2020) notes that for those who have avoided or restricted the use of eggs and dairy products, there are many plant substitutes on the market, such as flaxseed, chia seeds, bananas, etc.

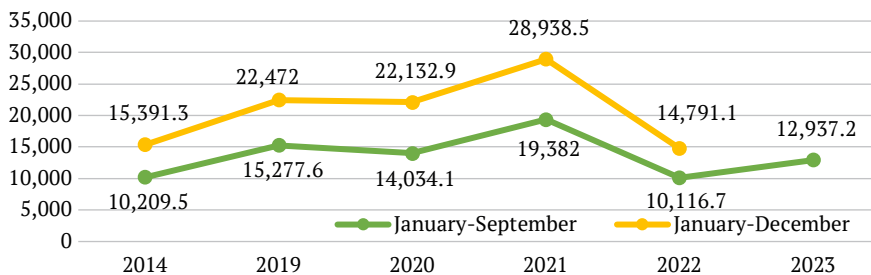
These technologies not only help expand the range of health products on the market, but also make them more efficient and affordable for consumers.

**Healthy sweets.** Instead of traditional sweets, which often contain high amounts

of sugar and saturated fat, researchers S.P. Kraievskia & N.O. Stetsenko (2013) and D. Angelino *et al.* (2019) investigated vegetable sweets and desserts with the addition of vegetable raw materials and reported that they can be made using natural ingredients such as fruits, nuts, honey, etc. An atypical combination of local fruits and vegetables allows creating new health products. Thus, the snack “Kalabu” is a food product made by Ismiati *et al.* (2024) from a blend of local (Indonesian) food ingredients

kalamansi orange and purple sweet potato. S.S. Sekhavatizadeh (2024) developed a jelly dessert with aloe vera, supplemented with *Lactobacillus curvatus*, encapsulated in mucilage of *Plantago major* and sodium alginate.

Investigating the issues of health products using vegetable raw materials, in particular desserts made from vegetable raw materials, the volume of production of cocoa, chocolate, and sugar confectionery products that meet these criteria was analysed (Fig. 6).



**Figure 6.** Production volume of cocoa, chocolate, and sugar confectionery products, mln. UAH, excluding VAT and excise tax

**Source:** created by the authors based on the State Statistics Service of Ukraine (2024)

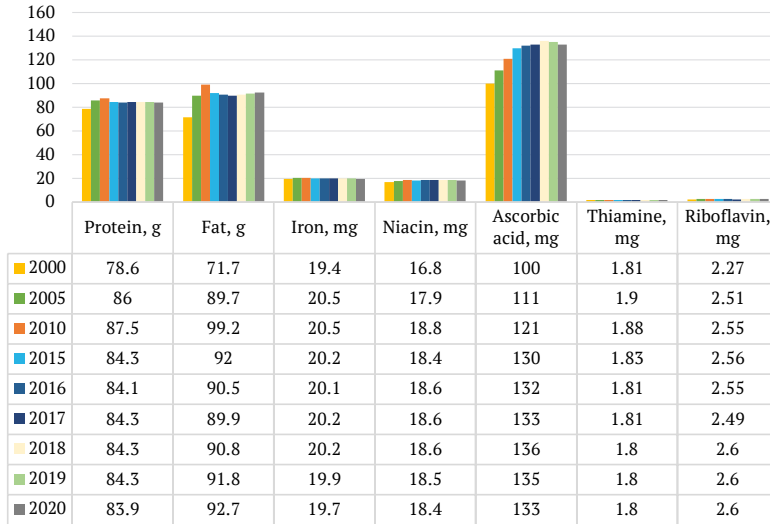
Analysing the data from Figure 6, it can be seen that production volumes are variable in nature. Thus, from 2014 to 2021, there is an increase in production by 88%, despite a slight decrease in 2020 (23.5% less compared to 2021 and 1.5% less compared to 2019). Since 2022, there has been a reduction in production volumes by almost half, which may be due to martial law and Russia’s war against Ukraine. But already for 9 months of 2023, the volume of production was 27.8% more than in the same period of 2022, and the difference with the overall indicators of 2022 remained only 12.5% less. But with the publication of the final information for 2023 by the State Statistics Service of Ukraine, the situation may change. Considering the analysis of information, the production of cocoa, chocolate, and sugar confectionery products returns to the indicators of pre-war periods, which will be expressed positively in monetary terms.

Therefore, the production and research of desserts, including those with vegetable raw materials, is promising.

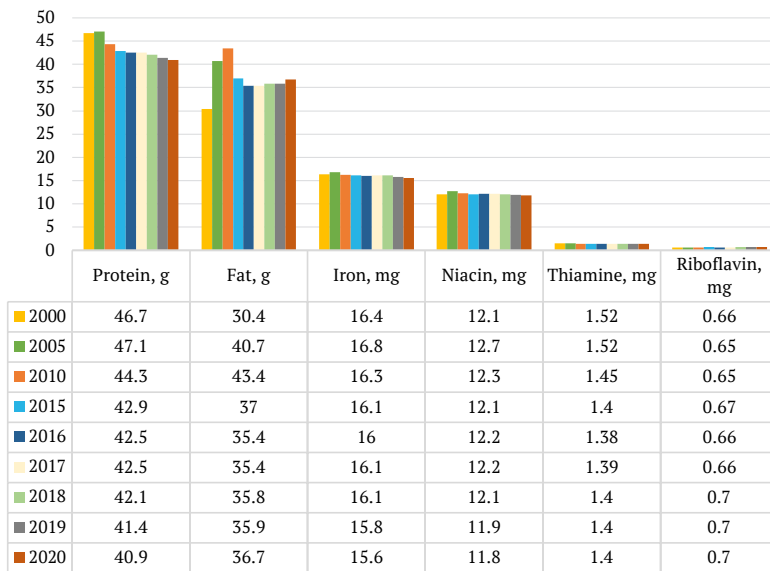
For the completeness of the analytical review of the market and technologies of health products with the addition of plant raw materials, it was advisable to determine the average daily consumption of basic micro- and macro-nutrients in food products, in particular food products of plant origin. Such information helps to determine the food balance of the population and understand which substances are in short supply and which are coming in excessive quantities, to carry out a preliminary assessment of the health of the population, to develop strategies and recommendations for healthy nutrition, the authorities and specialised organisations of the GA can set minimum consumption standards and control the quality of food products based on such data. Moreover, for the food and plant industry, this is important

information that helps to create products with a balanced composition, in accordance with the needs of the population. The consumption of such micro- and macro-nutrients as protein,

fat, iron, niacin, ascorbic acid (for all food products), thiamine, riboflavin by the population of Ukraine in the context of 2000-2020 is shown in Figures 7-8.



**Figure 7.** Average daily consumption of basic micro- and macro-nutrients in all food products  
**Source:** created by the authors based on Balances and consumption of the main food products by population of Ukraine (2021)

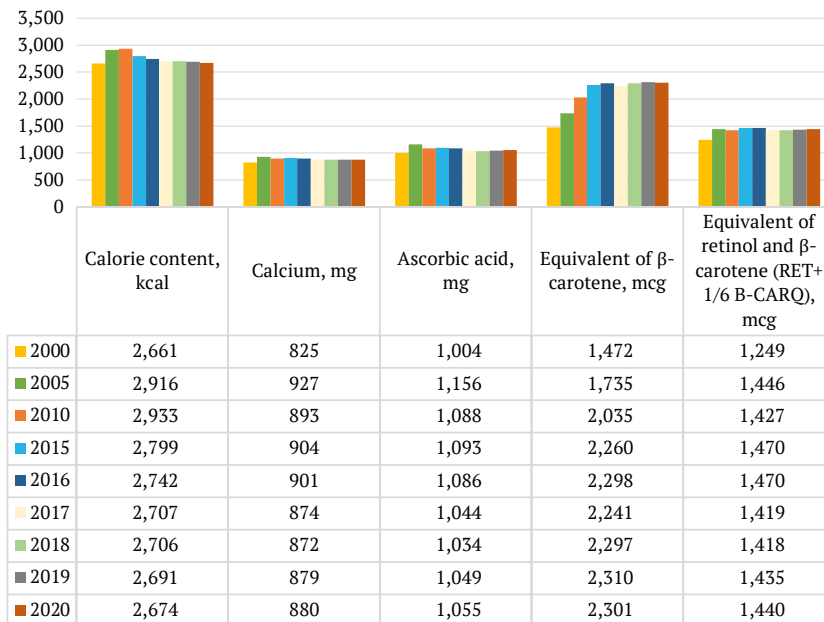


**Figure 8.** Average daily consumption of basic micro- and macro-nutrients in food products of plant origin  
**Source:** created by the authors based on Balances and consumption of the main food products by population of Ukraine (2021)

Considering the data from Figures 7-8, it can be seen that over 20 years there is a certain dynamics in the average daily consumption of protein, fat, iron, niacin, ascorbic acid (for all food products), thiamine, riboflavin in the composition of all food products and food products of plant origin was not. Separately, it should be noted that the consumption of plant-based protein in 2020 decreased by 12.4% compared to 2000 and generally decreased over 20 years. As for the protein that entered the human body as part of all food products, its amount increased by 6.7% over the same period. Consumption of vegetable fats as of 2020 increased by 20.7% compared to 2000. In addition, an increase in fat intake was observed in the composition of all food products – by 29.2% in 2020 compared to 2000. The consumption of ascorbic acid in all food products has gradually increased over 20 years

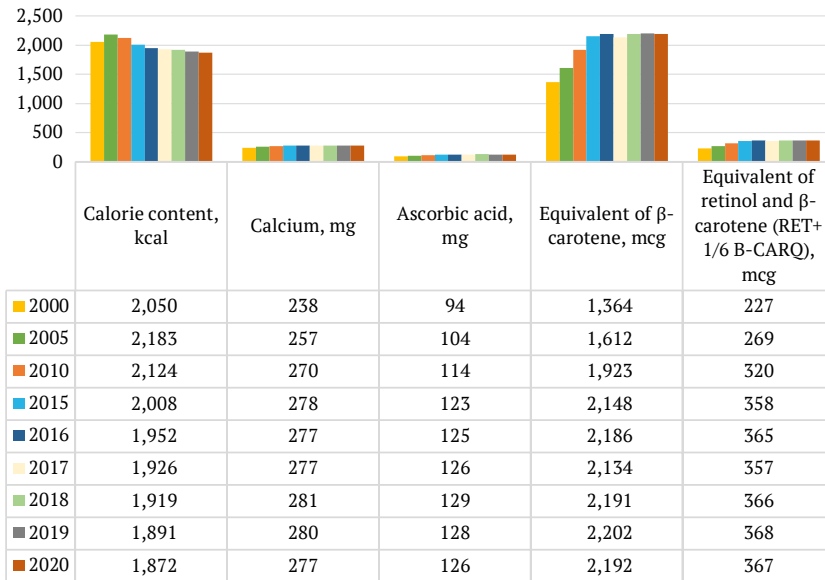
and as of 2020 increased by 33% compared to 2000. Regarding the consumption of iron, niacin, and riboflavin in all food products, their amount in 2020 compared to 2000 increased by 1.5%, 9.5%, and 14.5%, respectively. Considering consumption of iron, niacin, and thiamine in plant-based food products, their amount as of 2020 compared to 2000, on the contrary, decreased by 4.8%, 2.5%, and 7.9%, respectively. But the consumption of riboflavin in plant-based food products increased by 6% over the same period.

The total caloric content from the consumption of all food products and food products of plant origin, intake of calcium, retinol,  $\beta$ -carotene equivalent, retinol and  $\beta$ -carotene equivalent (RET+ 1/6 B-CARQ) and ascorbic acid (for food products of plant origin) of the population of Ukraine in the context of 2000-2020 is shown in Figures 9-10.



**Figure 9.** Average daily consumption of basic micro- and macro-nutrients in all food products

**Source:** created by the authors based on Balances and consumption of the main food products by population of Ukraine (2021)



**Figure 9.** Average daily consumption of basic micro- and macro-nutrients in food products of plant origin

**Source:** created by the authors based on Balances and consumption of the main food products by population of Ukraine (2021)

As can be seen from the data of Figures 9-10, in the period 2000-2005, there was an increase in caloric intake by the population of Ukraine, but since 2005 there has been a gradual reduction in the caloric content of the population's diets. Thus, the caloric content of food products increased by 9.6% as of 2005 compared to 2000, but as of 2020 it decreased by 8.3% compared to 2005. The situation is similar with the caloric content of plant-based foods, with a 6.5% increase in caloric content as of 2005 compared to 2000, and a 14.2% decrease as of 2020 compared to 2005. Regarding the intake of calcium from the consumption of all food products, for the period 2000-2020, it increased by 6.6%, from the consumption of plant-based food products – by 16.4%, although the largest intake of calcium in the composition for all food products was observed in 2015 – 2.7% more than in 2020, and 3.6% more for plant-based food products in 2018 than in 2020. The average daily consumption of ascorbic acid

as part of plant-based food products by the population increased by 34% during 2000-2020. The average daily intake of  $\beta$ -carotene equivalent, retinol equivalent, and  $\beta$ -carotene (RET+ 1/6 B-CARQ) increased by 60.7% and 61.7%, respectively, as part of plant-based food products. All foods also showed an increase in intake of  $\beta$ -carotene equivalent, retinol equivalent, and  $\beta$ -carotene (RET+ 1/6 B-CARQ) by 56.3% and 15.3%, respectively. The amount of retinol in all food products increased by 15.1% as of 2005 and by 5% as of 2020 compared to 2000. In general, the analysis of the average daily consumption of basic micro- and macro-nutrients in food products, including plant origin, is important for maintaining and increasing public health, assessing food safety, identifying deficiencies in nutrition, strengthening agriculture, and for maintaining economic stability and competitiveness in the food market.

According to S. Parashar *et al.* (2023), due to a rational and balanced selection of food,

it is possible to reduce the likelihood of occurrence and development of many diseases, improve the growth and development of the body, increase the body's resistance to adverse factors, and the emotional state of a person. That is why, as consumers seek to maintain and improve their health, they have become actively interested in wellness products. However, at the beginning of the cult of healthy eating, there was a lot of speculation and fraud about this type of product, which is associated with the use of questionable components. But with the development of healthy nutrition, the creation of a regulatory framework and consumer awareness, the production of health-improving products has moved to the next stage, namely the expansion and improvement of technologies. Attraction of plant raw materials, as indicated by P. Tangjaidee *et al.* (2023), although it is a basic technology for the production of healthy food, new ways of using it and combining it with animal raw materials are emerging with the emergence of new trends.

The use of plant-based raw materials to create health-improving food products is a promising area, as plant components have great potential to improve health and support physical and mental well-being. Modern technologies, such as extraction using green technologies, fermentation, the use of nanotechnologies, and the use of plant proteins and alternative products, allow maximising the useful properties of plant raw materials and create products that meet the needs of modern consumers. These technologies contribute to the development of the market for health products made from plant raw materials, contributing to the preservation of health and improving the quality of life of consumers and obtaining a safe and high-quality product.

## Conclusions

Based on the results of an analytical review of the market and technologies of health products with the addition of vegetable raw

materials, the main trends of the health food market were identified. Thus, for 5 years (from 2015 to 2020), the value of the health products market increased by 35%, which in monetary terms amounted to USD 1.3 trillion, in addition to expanding the range of traditional food products, it averages 2-3% per year, and health products by 40-50%. It was determined that the volume of food production for the period January-September 2023 compared to the same period in 2014 increased by 3 times, in 2022 it was 10.7% less compared to 2021, and in 9 months of 2023 the difference was 12.6% less compared to the figures for the whole of 2022, and the volume was 24% higher for the same period.

The main producers of vegetable crops in Ukraine are households that produce the predominant number of products, while specialised enterprises are in second place. It is determined that in 2021 they produced 6.2 times more products than enterprises, in 2020 – 5.5 times, in 2019 – 5.2 times. As for the production of fruit and berry crops in Ukraine, it occupies smaller volumes compared to vegetable crops. In 2021, fruit and berry crops were produced by 6.3% more than in 2020 and by 8.7% more in 2020 compared to 2019. Wholesale trade in processed fruits and vegetables increased by 29.9% from 2018 to 2021, despite a slight decrease of 4.7% in 2020-2021. Rapid growth in the production of baby food and dietary food products and income generation is determined. Volumes for the period January-September 2023 exceeded by 8.5% the volume of the whole of 2022, and in monetary terms, since 2019, the volume of production of baby food and dietary food products has increased by 66.7%. From 2014 to 2021, the production of cocoa, chocolate and sugar confectionery products increased by 88%, despite a slight decrease in 2020. Since 2022, there has been a reduction in production volumes by almost half, but for 9 months of 2023, the volume of production was 27.8% more than in the same period of 2022. Studying the average daily intake of protein, fat, iron, niacin, ascorbic acid,

thiamine, riboflavin, calcium, retinol,  $\beta$ -carotene equivalent, retinol equivalent and  $\beta$ -carotene (RET+ 1/6 B-CARQ) in the composition of all food and plant products revealed certain dynamics and instability of individual indicators. In general, plant-based products had a predominant share in the average daily intake of basic micro- and macro-nutrients by the population.

Considering the analytical review and analysis of the market of raw materials, innovative technologies of health-improving food products, further promising areas of research are the creation of new and improvement of existing health-improving food systems. In the fu-

ture, it is relevant to develop health-improving desserts, considering the use of vegetable raw materials and other biologically active components for functional nutrition.

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### Conflict of Interest

None.

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## **Аналітичний огляд ринку сировини та інноваційних технологій оздоровчих харчових продуктів рослинного походження**

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**Анотація.** У сучасному світі інтерес до оздоровчих продуктів зріс через збільшення уваги до здорового способу життя та збалансованого харчування. Разом з тим виникає необхідність в освоєнні технологій виробництва оздоровчих продуктів задля збереження максимальної кількості корисних речовин та використанні інноваційних методів оброблення сировини. Саме тому метою цієї роботи було провести огляд та аналіз існуючих технологій виробництва харчових продуктів оздоровчого напрямку, зокрема з використанням рослинної сировини. Матеріалами та методами слугували науково-технічна література та нормативна документація. Створювали вибірку окремих періодів, які аналізували за вибраними показниками, а саме обсяг виробництва харчових продуктів, динаміка обсягу виробництва овочевих, плодкових та ягідних культур, товарна структура оптового товарообороту фруктів та овочів перероблених, обсяг виробництва дитячого харчування та дієтичних харчових продуктів, обсяг виробництва какао, шоколаду та цукрових кондитерських виробів, а також середньодобове споживання населенням основних мікро- та макронутрієнтів у складі певних харчових продуктів. Визначено, що обсяг ринку оздоровчого харчування за період 2015-2020 років збільшився на 1,3 трлн доларів США у вартісному вираженні, водночас асортимент

традиційних продуктів харчування розширювався в середньому на 2-3% на рік. Виробництво овочевих культур господарствами населення у 2021 році перевищило виробництво підприємств у 6,2 рази, у 2020 році – 5,5 рази та у 2019 році – 5,2 рази. Виробництво плодово-ягідних культур в Україні у 2021 році було на 6,3% більшим, ніж у 2020 році, а у 2020 році – на 8,7% більшим, ніж у 2019 році. Визначена динаміка середньодобового споживання білка, жирів, заліза, ніацину, аскорбінової кислоти, тіаміну, рибофлавіну, кальцію, ретинолу, еквівалентів  $\beta$ -каротину, еквівалентів ретинолу та  $\beta$ -каротину (RET+ 1/6 B-CARQ) у складі харчових продуктах дає змогу визначити дефіцит та профіцит макро- та мікронутрієнтів у харчуванні споживачів. Загалом використання оздоровчих харчових продуктів, включаючи дитяче та дієтичне харчування є перспективним та конкуруючим, також підтверджується доцільність використання рослинної сировини в оздоровчому харчуванні та розробці нових оздоровчих продуктів

**Ключові слова:** функціональне харчування; плоди; овочі; продовольство; харчове виробництво