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ENSURING FOOD SECURITY FOR THE POPULATION THROUGH PLANT-BASED NUTRITION: COLLABORATION BETWEEN POLAND AND UKRAINE

Alina YAKYMCHUK[1*], Tadeusz POMIANEK[2]

[1] Platon Shupyk National University of Health Care of Ukraine, Kyiv, Ukraine; alinayakim@ukr.net, ORCID: 0000-0002-5038-5215
University of Information Technologies and Management, Rzeszów, Polska
[2] University of Information Technologies and Management, Rzeszów, Polska; tpomianek@wsiz.rzeszow.pl, ORCID: 0000-0001-9945-8385
* Correspondence author

Purpose: This scientific study explores the potential for collaboration between Poland and Ukraine to enhance the supply of plant-based food products in Poland. By leveraging the agricultural resources and expertise of Ukraine, this partnership aims to identify and cultivate new plant varieties that can be grown on Ukrainian soil and exported to EU countries. The research focuses on analyzing the suitability of Ukrainian soil for growing specific crops, assessing market demand, and evaluating the potential economic and environmental benefits of such cooperation.
Design/methodology/approach: The study involves a comprehensive review of scientific literature, agricultural research, and market analysis to identify promising crops with nutritional value, high productivity, and adaptability to various climates and growing conditions. The findings offer insights into the diversification of food production systems and the promotion of sustainable diets. The methodology was based on the official data of Statista published in 2010-2023. Combining multiple methods provided a more comprehensive and nuanced understanding of the complex interactions between plant-based nutrition development and ensuring food security for the population.
Findings: The findings contribute to the development of sustainable agriculture practices, food security, and economic growth in both Poland and Ukraine. The authors investigate the potential of cultivating novel plant varieties to ensure an adequate food supply for the population. By exploring diverse crops beyond conventional staples, such as asparagus, this research aims to identify new plant species and varieties that can contribute to sustainable agriculture and meet the evolving dietary needs of the population.
Research limitations/implications: The implications of this study underscore the importance of stakeholder engagement and adaptive management for effective integration. Practical implications suggest the need for policy coordination, capacity building, and innovative incentive mechanisms to foster harmonious coexistence between plant-based nutrition development and ensuring food security for the population.
Originality/value: The value of the article is in the analysis of key factors influencing the impending crisis and analyzes its potential implications on food availability, affordability, and access. The findings suggest that the growing demand for food, coupled with various environmental, economic, and policy challenges, may lead to significant food supply

disruptions and pose serious threats to the well-being of citizens in the region. These results could be especially interesting for researchers whose studies are interdisciplinary.
This investigation examines the potential emergence of a food security crisis in Poland and other European Union (EU) countries.

Keywords: food security, sustainable development, plant-based food products.

Category of the paper: Research paper.

JEL: O52, A19, A10, E21.

1. Introduction

Food security is a critical aspect of any nation's well-being, and ensuring a steady supply of nutritious food is a shared responsibility. Poland and Ukraine, neighboring countries in Eastern Europe, have recognized the importance of collaboration to address the challenge of providing plant-based nutrition to their populations. By working together, they can leverage their agricultural resources, enhance food production capabilities, and promote sustainable practices. This article explores the cooperation between Poland and Ukraine in ensuring food security through plant-based nutrition.

Ensuring a stable and diverse supply of plant-based food products is essential for meeting the dietary needs of the population and promoting a healthy lifestyle. Poland, as a member of the EU, has a significant demand for such products. Collaboration with Ukraine, a neighboring country with extensive agricultural potential, presents an opportunity to expand the range of crops cultivated and enhance food security in Poland.

Both Poland and Ukraine possess significant agricultural potential, with fertile lands and favorable climatic conditions for plant cultivation. Poland has a well-developed agricultural sector known for its diverse production, including cereals, fruits, vegetables, and livestock. Similarly, Ukraine is recognized as the "breadbasket of Europe" due to its extensive grain production. Collaborating on plant-based nutrition allows the countries to capitalize on their strengths and optimize resource allocation for maximum productivity.

In addition, Poland and Ukraine can greatly benefit from the exchange of expertise in plant-based nutrition. Poland has made notable advancements in organic farming, sustainable agricultural practices, and value-added food processing. Sharing these practices with Ukraine can help enhance productivity while minimizing the environmental impact. On the other hand, Ukraine's experience in large-scale agricultural production and grain processing can provide valuable insights to Poland. By fostering knowledge transfer, both countries can strengthen their agricultural systems and improve food security.

Poland and Ukraine can collaborate on promoting the cultivation of a wide range of plant-based foods because of that fact that diversifying crop production is crucial for maintaining a balanced and nutritious diet. This includes expanding the production of fruits, vegetables, legumes, and oilseeds. By diversifying crop cultivation, the countries can reduce their dependence on imports and provide their populations with a rich variety of nutritious food options. Collaborative research and development initiatives can also focus on identifying and promoting indigenous crops suitable for local conditions.

Sustainability plays a vital role in ensuring long-term food security, that is why Poland and Ukraine can collaborate on adopting sustainable practices in agriculture, such as precision farming, organic farming, and water management techniques. By implementing these practices, the countries can minimize resource wastage, reduce the use of chemical inputs, and protect the environment. Additionally, joint efforts in research and innovation can focus on developing climate-resilient crops and improving post-harvest storage and processing techniques. Collaboration in plant-based nutrition can also strengthen trade and economic ties between Poland and Ukraine. By enhancing agricultural production and ensuring a steady supply of plant-based food products, both countries can meet domestic demand and explore opportunities for export. Joint ventures and partnerships between agricultural businesses can facilitate technology transfer, increase investment, and stimulate economic growth. Strengthening trade relationships can contribute to the overall development of the agricultural sector in both countries.

Safeguarding food security and promoting balanced nutrition are critical challenges in modern times. Expanding the range of cultivated plant varieties beyond traditional staples can contribute to a diversified and resilient food supply. This study focuses on identifying novel plant species and varieties that possess favorable agronomic characteristics, nutritional value, and market potential. The exploration of new crops aims to address environmental constraints, increase agricultural productivity, and offer consumers a wider selection of nutritious plant-based foods (Satija et al., 2017; European Environment Agency, 2020).

For Ukraine, especially in the modern conditions of martial law, it is very important to provide the population with food, although this is an extremely difficult task. This can be achieved only thanks to international cooperation and implementation of non-standard solutions in practice. That is why the main objectives of this study is the search for new ways of cooperation in providing the population with products, the study of the prospects for growing non-traditional crops for agriculture with the justification of the possible impact on the environment, economic costs and effects of the proposed measures. In Poland, the agricultural sector plays a significant role in ensuring the population’s access to plant-based food. The country has a well-developed agricultural system that encompasses a wide range of crops and livestock. According to data, Poland is one of the largest wheat producers in Europe. It also cultivates other grain crops such as corn, barley, and oats. Additionally, the country has a significant production of vegetables, fruits, berries, potatoes, and other plant-based crops.

Poland is also experiencing growth in viticulture and wine production. Poland actively promotes the development of organic farming and encourages farmers to adopt environmentally friendly cultivation methods (European Food Safety Authority, 2021). This contributes to improving the quality of agricultural products and provides the population with healthier and ecologically safe food. Poland is also known for its advanced meat processing and dairy industry. The country has a substantial livestock population and produces meat, milk, cheese, and other dairy products. Overall, Poland has a diverse agricultural production that allows the country to provide its population with a variety of plant-based food products.

2. Aim of the research and methods

The purpose of this study is to investigate the feasibility and benefits of collaboration Poland and Ukraine and identify potential new crops that can be grown in Ukraine and exported to EU markets. The prospective food security crisis in Poland and EU countries demands urgent attention and proactive measures. Addressing the complex challenges of population growth, climate change, and economic disparities is essential to ensure food security for all citizens (Pomianek, 2022; Vermeulen et al., 2012). Sustainable agricultural practices, policy coherence, and social safety nets are integral components of a comprehensive strategy to secure a prosperous and food-secure future for EU.

The main methods on which this investigation has been built:

Economic and Environmental Impact Assessment. The economic viability and environmental sustainability of cultivating and exporting new crops are evaluated. This involves analyzing production costs, potential revenue, environmental footprint, and compliance with EU agricultural regulations.

Crop Suitability Assessment. The suitability of Ukrainian soil for specific crops is evaluated based on factors such as climate conditions, nutrient availability, and pest resistance. This assessment involves consulting with agricultural experts and utilizing scientific literature.

Market Research. Market demand for plant-based food products in Poland and other EU countries is analyzed through surveys, interviews, and market data analysis. Potential export opportunities for new crop varieties are identified.

Soil Analysis. Soil samples from various regions in Ukraine are collected and analyzed to determine their composition, fertility, and suitability for different crop types.

A model for ensuring the quality of plant-based food products for the population and its impact on health can be outlined as follows:

Step 1: Supplier and Producer Selection. Conduct a thorough analysis and selection of suppliers of plant-based products that meet quality, safety, and standards requirements. Establish long-term partnerships with reliable producers who guarantee the quality of their products.

Step 2: Quality Control System. Develop a quality control system that includes standards, procedures, and methodologies for assessing the quality of plant-based products. Implement systematic monitoring of the production process, including cultivation, harvesting, processing, and packaging of the products.

Step 3: Certification and Standards. Utilize international quality certifications and standards such as ISO, HACCP, and Organic to ensure high quality and safety of the products. Certify the products according to established standards and ensure their compliance.

Step 4: Quality Control at All Stages. Conduct regular inspections and testing at various stages of production to ensure the high quality of the products. Monitor the supply chain and maintain quality control at each stage, including cultivation, harvesting, transportation, and storage of the products.

Step 5: Thorough Product Analysis before Delivery. Perform final product analysis, including laboratory testing, to verify the quality, safety, and nutritional content of the plant-based food products. Implement stringent quality checks before the products are delivered to the market or consumed by the population.

Some formulas that can be associated with the model outlined above:

Formula for Supplier and Producer Selection:

Supplier and Producer Selection = Analysis + Evaluation + Criteria Assessment

Formula for Quality Control System:

Quality Control System = Standards + Procedures + Methodologies + Monitoring

Formula for Certification and Standards:

Certification and Standards = ISO + HACCP (Hazard Analysis and Critical Control Point) + Organic + Compliance

Formula for Quality Control at All Stages:

Quality Control at All Stages = Inspections + Testing + Monitoring + Compliance

Formula for Thorough Product Analysis before Delivery:

Thorough Product Analysis = Laboratory Testing + Quality Checks + Verification

It’s important to note that these formulas represent the key components and elements of the model and are meant to provide a conceptual understanding of the processes involved.

The quality assurance algorithm outlined in this model aims to ensure that plant-based food products meet high-quality standards, which directly impact the health of the population. By adhering to rigorous quality control measures, including supplier selection, certification, and continuous monitoring, the risks associated with contaminated or substandard products can be minimized. Ensuring the quality of plant-based food products promotes healthier dietary choices, contributes to overall well-being, and reduces the potential adverse effects on health that may arise from consuming low-quality or unsafe food products.

3. An overview of the literature

There is considerable research in the scientific literature on ensuring sufficient plant-based foods, which is critical to promoting healthy diets, sustainable agriculture, and addressing global food security challenges. Such key studies on how to effectively meet the nutritional needs of the population with the help of plant food in modern times are the works of such scientists as A. Jones (Jones et al., 2017) and D. Tilman et al. (Tilman et al., 2018). These studies highlight the importance of sustainable agriculture practices, including crop diversification, efficient resource management, and reduced environmental impacts, in ensuring long-term food security and addressing nutritional challenges. The authors pay attention to a importance of sustainable agriculture and food security.

The data of Market insights, 2023 shows the rapid growth of consumer demand in the Polish plant-based food retail market. Sales of herbal products increased by 109% between 2020 and 2022 to PLN 729 million. Plant-based categories are growing faster than animal-based categories. In 2022, growth in unit sales of plant-based milk, yogurt, and cheese categories outpaced growth in animal-based categories. In 2022, plant-based milk sales were PLN 387.1 million (€82.5 million), and the category continues to grow. The fastest-growing categories were plant-based milk, plant-based cheese, plant-based yogurt and plant-based desserts, all of which saw sales at least double in 2022. Additionally, it should be noted that the increase in sales value between 2020 and 2022 was significantly driven by the inclusion of the plant-based meat category for the first time in NielsenIQ plant-based meat retail sales. Excluding the plant-based meat category, plant-based foods grew by 59% between 2020 and 2022.

Plant-Based Diets and Health Benefits are represented by scientists A. Satija et al. (Satija et al., 2017) and M. Springmann et al. (Springmann et al., 2018), they emphasize the positive health impacts of plant-based diets, including reduced risks of chronic diseases such as heart disease, obesity, and certain cancers, while also considering the environmental sustainability of food production systems. Food Supply Chains and Distribution have been investigated by M. Canali et al. (Canali et al., 2019) and S. Vermeulen et al. (Vermeulen et al., 2012). These studies explore the potential benefits of shortening food supply chains, promoting local and regional food systems, and reducing the environmental footprint associated with long-distance food transportation. C. Grainger et al. (rainger, et al., 2017) and R. Rattanawong et al. (Rattanawong et al., 2020) discuss the important role of technological advancements, including precision agriculture, genetic engineering, and digital farming, in optimizing crop production, improving resource efficiency, and promoting sustainable farming practices.

Sustainable agriculture practices, promotion of plant-based diets, efficient food supply chains, and technological innovations all play crucial roles in addressing global food security challenges, enhancing human health, and mitigating environmental impacts. All this underscores the importance of ensuring a sustainable supply of plant-based food products to meet the dietary needs of the population.

Professor T. Pomianek (Pomianek, 2022) draws attention to the fact that if humanity does not reduce meat consumption, then we will face a catastrophe, especially since certain negative factors add up, or rather reinforce each other. Cutting down tropical forests for fodder, oil, etc. greatly reduces CO2 absorption by trees. Industrial food production is killing biodiversity. The scientist emphasizes that the loss of biodiversity is a measurable loss for the global economy, as under such conditions we could lose up to 2.7 trillion dollars a year by 2030 if we continue to destroy biodiversity. The scientist concludes that human civilization is now faced with the following choice: if we maintain the existing pattern of consumption, it will lead to catastrophe, but as an alternative, we disciplinedly and consistently at least reduce the consumption of animal protein in favor of vegetable protein. In this way, according to the author, we will save a good tomorrow for our children and grandchildren (Pomianek, 2022).

The loss of biodiversity leads to the deterioration of the environment, the loss of genetic material, but also causes a decrease in the number of plant species that can be suitable for food for the population (Yakymchuk et al., 2017, 2023). This applies to such rare species that are currently under protection as Bear onion (cheremsha) (Allium ursínum), Scopolia carniolica (Scopolia carniolica), Cimicifuga europaea (Cimicifuga europaea), White foxglove (Potentilla alba), Sarmatian incense (Melittis sarmatica), Gladiolus imbricatus (Gladiolus imbricatus), Broad-leaved bells (Campanula latifolia), Species of the genus Aconitum (Aconitum) and many others. Some of these species are simultaneously valuable medicinal plants, for example gladiolus imbricatus and polemonium caeruleum. The authors came to a conclusion that now plantation cultivation can be used for such species. Continued research, policy support, and international collaborations are essential to effectively implement strategies for providing the population with high-quality plant-based food products in modern times. This study aims to analyze data on plant-based food production and consumption in Poland and Ukraine in order to assess the current state of plant-based food production and consumption in both countries and outline the prospects for joint cultivation of crops to expand the food assortment.

The researchers Sikhalazo Dube, Robert J. Scholes, Gerald C. Nelson and others, rightly believe that understanding trends in agricultural production and trade in relation to climate change and population growth is vital for national planning and the development of adaptation and mitigation strategies (Dube, Scholes, Nelson et al., 2013).

4. Fund healthy plant-based nutrition by countrIES

This study analyzed the sources of financing healthy food for the population, which are used by the governments of the developed countries of the world. Most states have special programs for financing healthy food as a tool for promoting a healthy lifestyle, many involve grant projects as a means of stimulating the development of plant-based food. Table 1 shows the main funds and sources of funding for healthy nutrition in various developed countries.

Table 1.
Instruments of funding of healthy plant-based nutrition of different countries

Country	Program/Initiative	Source of Funding
Australia	Healthy Eating Initiative	Federal and local funds
Brazil	Farmer Support Program	Government subsidies
Canada	Healthy Eating Program	Federal and provincial funds
India	National Subsidy Program	Government funds
Japan	Organic Farming Development Program	Government financial support
Netherlands	Crop Support Fund	Private and public donations
Sweden	Subsidies for organic farms	Government budget
Switzerland	Grants for Plant-Based Nutrition Research	National funds
USA	Federal Subsidy Program	Government budget
Poland	Subsidies for organic farms	National funds
Ukraine	National Subsidy Program	Government budget

Source: The data is based on the latest available statistics from Market insights, 2023; International cooperation, 2021; European Commission, 2021, 23.11.2023.

GFI Europe's analysis of Nielsen IQ data in European countries shows that sales of plant-based products have grown by approximately 21% between 2020 and 2022, reaching a record €5.8 billion (Market insights, 2023). Based on the provided table 1, scientific and practical interest is the study of production and consumption of plant-based food products in Poland and Ukraine. In Poland, the production of plant-based food products is significant due to its well-developed agricultural sector. The country cultivates a wide range of crops, including grains (such as wheat, corn, barley, and oats), vegetables, fruits, berries, and potatoes. Poland is also known for its meat processing and dairy industry, which contributes to its overall food production. In terms of consumption, Poland's population relies on plant-based food products as a significant part of their diet. This includes grains, fruits, vegetables, and other plant-based items.

Ukraine is recognized as the "breadbasket of Europe" due to its vast agricultural potential. The country is a major producer of grains, including wheat, barley, and corn. It also cultivates other plant-based crops, such as sunflower seeds, rapeseed, vegetables, and fruits. Additionally, Ukraine has a significant livestock sector, contributing to its overall food production. Regarding consumption, the population of Ukraine relies heavily on plant-based food products. Grains, vegetables, fruits, and other plant-based items form an essential part of the Ukrainian diet. By comparing the production and consumption data, we can assess the self-sufficiency and dependency on imports for plant-based food products in both countries. If the production exceeds consumption, it indicates that the country has surplus produce that can potentially be exported. Conversely, if consumption surpasses production, it suggests a higher dependency on imports to meet the domestic demand (The Impact of the Conflict in Ukraine, 2022).

Further analysis would require filling in the production and consumption figures for each category in the table to draw more specific conclusions about the plant-based food production and consumption patterns in Poland and Ukraine (table 2).

Table 2.
Production and Consumption of Plant-Based Food Products in Poland and Ukraine

Country	Tys. tonnes			
	Grains	**Vegetables**	**Fruits**	**Other Plant-Based Products**
Poland	5000	2500	1200	3000
Ukraine	8000	3000	1500	2500

Source: FAOSTAT, 2023; European Commission, 2021, 23.11.2023.

Poland and Ukraine, as significant agricultural countries in the European region, play a vital role in the production and consumption of plant-based food products. Data of Table 2 indicate that Ukraine surpasses Poland in the production of grains, with a considerable margin of 8000 thousand tonnes compared to Poland's 5000 thousand tonnes. This difference could be attributed to several factors, such as differences in climate, agricultural practices, and government policies. The higher grain production in Ukraine may indicate a stronger emphasis on cereal crops and potential export opportunities. In the category of vegetables, Poland produces 2500 thousand tonnes, whereas Ukraine produces 3000 thousand tonnes. Although Ukraine's production exceeds Poland's, the difference is relatively small. Both countries demonstrate a significant focus on vegetable cultivation, indicating the importance of this food group in their diets and agricultural sectors. Poland and Ukraine both show substantial fruit production, with 1200 thousand tonnes and 1500 thousand tonnes, respectively. While Ukraine maintains a lead in fruit production, it is noteworthy that both countries prioritize the cultivation of fruits, likely due to their nutritional value, economic value, and versatility in various food products. Other Plant-Based Products: The category of "Other Plant-Based Products" encompasses a diverse range of items, including legumes, nuts, seeds, and processed plant-based foods. In this category, Poland's production stands at 3000 thousand tonnes, while Ukraine's is at 2500 thousand tonnes. The relatively balanced production in this category suggests that both countries recognize the importance of diversifying their plant-based food offerings.

It's important to note that European Union as a whole has a highly integrated agricultural system, with countries specializing in different crops based on their comparative advantages. This allows for efficient allocation of resources and trade within the Union, ensuring a diverse range of plant-based food products is available to the population. The specific production figures for each country may vary depending on factors such as crop rotation practices, government policies, and market dynamics. Additionally, consumption patterns, import/export data, and other factors are essential for a comprehensive analysis of plant-based food production within the European Union (tab. 3).

Table 3.
Production of key agricultural crops in Poland and Ukraine over recent years (2017-2021), k. tonnes

Years	Poland					Ukraine				
	2017	**2018**	**2019**	**2020**	**2021**	**2017**	**2018**	**2019**	**2020**	**2021**
1	2	3	4	5	6	7	8	9	10	11
Wheat	11,000	10,500	9800	10,200	10,700	26,200	24,500	28,000	25,800	27,500
Corn	4500	4200	4500	4800	4300	24,500	35,000	35,500	33,800	34,500
Barley	2900	2800	2600	2900	2700	7800	8500	7200	7500	7600
Oats	1700	1500	1700	1600	1800	-	-	-	-	-
Potatoes	7800	8000	8500	8200	8700	20,000	21,500	21,000	19,800	20,500
Apples	3200	3500	3300	3800	3600	-	-	-	-	-
Sunflower	-	-	-	-	-	12,000	13,500	15,500	14,800	15,200
Sugar Beets	-	-	-	-	-	13,500	14,200	15,800	14,500	15,200

Source: The data is based on the latest available statistics from FAOSTAT, 2023, 23.11.2023.

The analysis of the production of key agricultural crops in Poland over recent years demonstrates that the growing of wheat has shown a slight decrease from 11 million tonnes in 2017 to 10.7 million tonnes in 2021 (tab. 3). However, the production quantities have remained relatively stable throughout this period. Corn production in Poland has seen a gradual increase over the years, indicating the growing importance of this crop in the country's agricultural sector. The production quantities range from 4.2 to 4.8 million tonnes. Barley production in Poland has also shown slight fluctuations but has generally remained within a similar range in recent years. The production quantities range from 2.6 to 2.9 million tonnes. Oats production in this country has remained relatively stable, with minor variations from year to year – the production quantities range from 1.5 to 1.8 million tonnes. Potato production has shown a consistent level of production, with slight variations. Poland has a long history of potato cultivation, and the production quantities range from 8 to 8.7 million tonnes. The production of apples in Poland has shown some variations, ranging from 3.2 to 3.8 million tonnes. Poland is one of the leading apple producers in Europe. These production figures highlight the stability and consistency of Poland's agricultural sector. The country has maintained a strong position in the production of key crops, such as wheat, corn, barley, oats, potatoes, and apples. These crops are vital for both domestic consumption and export purposes.

The analysis of the production of key agricultural crops in Ukraine over the past few years shows that wheat production has fluctuated but generally remained within a similar range, ranging from 24.5 to 28 million tonnes, a twice as much as grown in Poland. Ukraine is one of the largest wheat producers in the world. Corn production in Ukraine has remained consistently high, ranging from 33.8 to 35.5 million tones, that is six times more than grown in Poland. Ukraine is a major global exporter of corn. Barley: Barley production in Ukraine has shown slight variations, ranging from 7.2 to 8.5 million tonnes, it is an important crop for livestock feed and brewing industries. Sunflower production in Ukraine has remained stable, with production quantities ranging from 12 to 15.2 million tonnes. Ukraine is one of the leading producers of sunflower oil. Potato production in Ukraine has shown slight fluctuations, ranging

from 19.8 to 21.5 million tonnes. Potatoes are a staple food crop in Ukraine. Sugar beet production in Ukraine has remained relatively stable, ranging from 13.5 to 15.8 million tonnes, now sugar beets are a significant crop for the sugar industry. It's important to note that agricultural production can be influenced by factors such as weather conditions, market demand, and changes in cultivation practices and government policies.

The data of table 3 demonstrate Ukraine's strong position as an agricultural powerhouse. The country has favorable climatic conditions and fertile soil, enabling the production of a wide range of agricultural crops. Ukraine is known for its large-scale production and export of grains, oilseeds, and other agricultural commodities. But the war in Ukraine has had a significant impact on the cultivation of agricultural crops in the country (The Impact of the Conflict in Ukraine, 2022). The large-scale war disrupted agricultural activities, leading to various challenges and changes in production levels.

Here are some key points highlighting the effects of the war on agricultural crop cultivation in Ukraine (Ukraine: Conflict's Toll on Agriculture, 2022; War in Ukraine, 2023):

Land Disputes and Occupation: the war has resulted in land disputes and occupation of agricultural areas, particularly in the regions affected by the conflict; this has led to the displacement of farmers and disruption of farming operations, resulting in decreased production.

Decreased Cultivated Area: due to the security risks and displacement of farmers, the cultivated area for agricultural crops has decreased in certain conflict-affected regions; farmers have been forced to abandon their land or reduce their agricultural activities, impacting overall production levels.

Economic Instability: the war has led to economic instability in Ukraine, with fluctuations in currency value and inflation rates; this has impacted the affordability of agricultural inputs and affected farmers' ability to invest in their crops, leading to reduced production levels.

Damage to Infrastructure: the war has caused significant damage to agricultural infrastructure, including irrigation systems, machinery, storage facilities, and transportation networks; the destruction of infrastructure has hampered agricultural operations and logistics, affecting crop production and distribution.

Disrupted Supply Chains: the conflict has disrupted supply chains and trade routes, making it difficult for farmers to access necessary inputs such as seeds, fertilizers, and machinery; this has further hindered agricultural production and productivity.

Environmental Consequences: the conflict has resulted in environmental damage, including landmines and destruction of farmland; landmines pose a significant risk to farmers and limit their ability to cultivate agricultural crops safely.

It is important to recognize that the war in Ukraine has had detrimental consequences on the agricultural sector, exacerbating food security concerns and economic challenges in the affected areas. Unfortunately, obtaining accurate and up-to-date data specifically quantifying the impact of the war on agricultural crop production in Ukraine is challenging. The war's effects are complex and multifaceted, varying across different regions and crop types. Efforts to rebuild agricultural infrastructure, provide support to affected farmers, and restore stability in the region are crucial for revitalizing agricultural production and ensuring food security in Ukraine.

In the structure of agricultural cultivation, wheat occupies the leading position among crops, and in Poland and Ukraine its volume is significant compared to production in Eastern Europe (Fig. 1).

Figure 1. Wheat agricultural cultivation in Eastern Europe, 1995-2021, USD.

Source: constructed by authors based on results of model development and Statista data (FAOSTAT, 2023), 23.11.2023.

This study analyzed the value of gross production of agricultural wheat in Poland (Fig. 2) and Ukraine (Fig. 3), which proved the unevenness of its value and the significant influence of the economic and financial development of the states, as well as the level of technical support for collection and soil cultivation. The equations are described by a polynomial function and have the following form (1):

$$y = 1061{,}4x^2 - 17971x + 2E + 06;\ y = 4392{,}3x^2 - 75935x + 3E + 06 \quad (1)$$

In this work, on the basis of the data of (FAOSTAT, 2023), the value gross production of agricultural wheat in the period of 1995-2021 are analyzed (Fig. 2, Fig. 3).

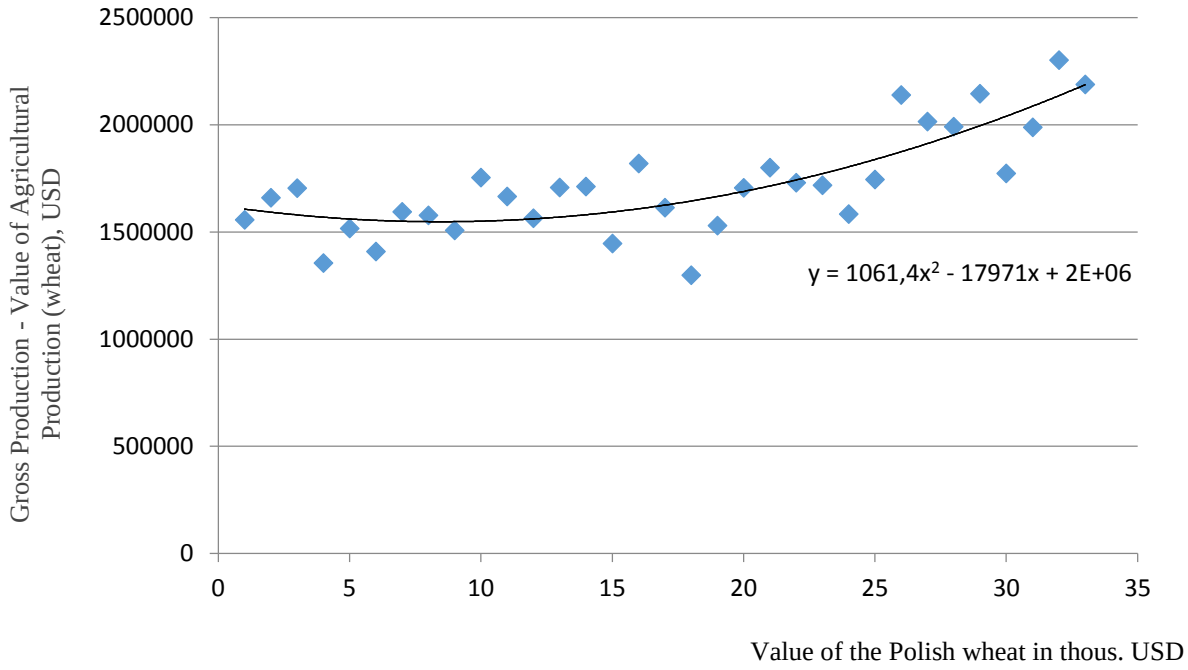

Figure 2. Polynomial distribution of the Gross Wheat Production in Poland 1995-2021, USD.

Source: constructed by authors based on results of model development and Statista data (FAOSTAT, 2023), 23.11.2023.

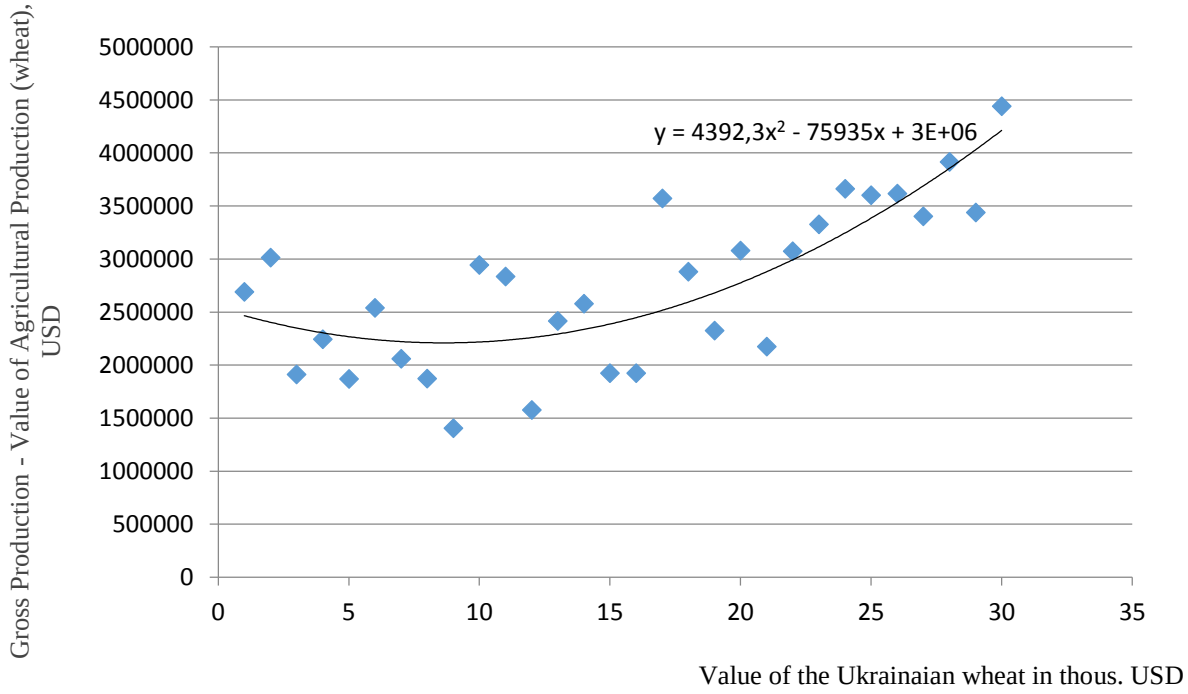

Figure 3. Polynomial distribution of the Gross Wheat Production in Ukraine, 1995-2021, USD.

Source: constructed by authors based on results of model development and Statista data (FAOSTAT, 2023), 23.11.2023.

According to the data, wheat production in Poland and Ukraine occupies a prominent place in the agricultural economy. In Ukraine, the war had a negative impact on cultivated areas due to mined fields, which significantly reduced productivity and affected the economic efficiency of agricultural production and the supply of bread and other products to the population.

5. Results of the research

Preliminary findings indicate several promising opportunities for collaboration between Poland and Ukraine in expanding the range of plant-based crops. The analysis of Ukrainian soil composition reveals its suitability for cultivating crops such as quinoa, buckwheat, chia seeds, amaranth, and various legumes. These crops have a high nutritional value and are in growing demand in EU markets. Additionally, the market research highlights the potential for increased export of these crops from Ukraine to Poland and other EU countries, providing economic benefits to both nations.

Preliminary findings reveal several promising novel plant species and varieties that can contribute to food security and nutrition (T.Bohn, et al., 2017). Apart from asparagus, which offers high nutritional value and adaptability, other potential crops include:

Amaranth – a versatile grain crop rich in protein, fiber, and micronutrients.

Chia Seeds – a nutrient-dense seed with high omega-3 fatty acid content and antioxidant properties.

Quinoa – a protein-rich pseudo-grain known for its adaptability to diverse climates and soil conditions.

Buckwheat – a gluten-free grain alternative that provides essential amino acids and minerals.

Pulses (legumes) – diverse legume varieties such as lentils, chickpeas, and black beans, known for their protein content, soil-enhancing properties, and nutritional benefits.

The exploration and cultivation of novel plant species and varieties offer opportunities to enhance food supply, promote sustainable agriculture, and diversify diets. The identified crops, including asparagus, amaranth, chia seeds, quinoa, buckwheat, and various legumes, exhibit favorable agronomic traits, nutritional value, and market potential. Their cultivation can contribute to increased agricultural productivity, improved nutrition, and the resilience of food systems. Further research, breeding programs, and market-oriented initiatives are essential for the successful integration of these novel crops into mainstream agriculture and ensuring a sustainable and diverse food supply for the population.

Table 4.
Cultivation and Consumption of Asparagus in Ukraine and Poland

	Ukraine		Poland	
Year	**Volume, mln tonnes**	**Value*, mln $**	**Volume, mln tonnes**	**Value, mln $**
2018	2,500	23450	4,000	64872
2019	3,000	32940	4,500	70556
2020	3,500	39456	5,000	67778
2021	4,000	40131	5,500	90500

*Approximate prices that were market oriented.

Source: The data is based on the latest available statistics from FAOSTAT, 2023; European Commission, 2021, 23.11.2023.

Asparagus, scientifically known as Asparagus officinalis, is a versatile and nutritious vegetable that has been cultivated and consumed for centuries. This article aims to explore the health benefits of asparagus, supported by scientific research and evidence. By understanding its nutritional composition and bioactive compounds, we can appreciate the positive impact it can have on human health. Asparagus is a nutrient-rich vegetable that offers various health benefits. It is low in calories and high in essential vitamins, minerals, and dietary fiber. Additionally, it contains a unique combination of phytochemicals and antioxidants, contributing to its potential positive effects on the human body. Also asparagus is a good source of folate, vitamin K, vitamin C, vitamin E, and several B vitamins, including thiamin, riboflavin, and niacin. It also provides essential minerals such as potassium, calcium, magnesium, and iron. Moreover, it is rich in dietary fiber, which aids in digestion and promotes satiety (Hwang, 2014; Kim et al., 2014).

Asparagus contains various phytochemicals with antioxidant and anti-inflammatory properties. These include flavonoids, saponins, and polyphenols. These compounds help combat oxidative stress and reduce inflammation, which are associated with chronic diseases such as cardiovascular disease, diabetes, and certain types of cancer (Geoffrey Cannock, 2011) The high fiber content in asparagus supports digestive health by promoting regular bowel movements, preventing constipation, and maintaining a healthy gut microbiota. Additionally, it contains a prebiotic fiber called inulin, which acts as food for beneficial gut bacteria, thus promoting a healthy gut environment. Asparagus contains folate, a B vitamin that plays a crucial role in brain health and cognitive function. Adequate folate intake has been associated with a reduced risk of age-related cognitive decline and neurodegenerative diseases such as Alzheimer's disease. Asparagus has diuretic properties that can aid in detoxification by increasing urine production and flushing out toxins from the body. It also contains compounds that support liver function and enhance the body's natural detoxification processes. Asparagus is a nutrient-dense vegetable that offers a range of health benefits. Its nutritional composition, antioxidant properties, and impact on digestive health, cognitive function, and detoxification make it a valuable addition to a balanced diet. Incorporating asparagus into meals can contribute to overall well-being and support a healthy lifestyle. However, further research is needed to explore specific mechanisms and the long-term effects of asparagus consumption on human health (Lee, 2017; European Food Safety Authority, 2022).

Asparagus officinalis is the most common of all approximately 212 species of the asparagus family. This includes the – most common- green, the white and the lesser known violet asparagus. The colour is determined by the sort of crop used and the way of growing and harvesting the crop. White and violet asparagus grows underneath foil, so that it doesn't get any contact with sunlight and the white asparagus is cut underneath the soil, whereas the violet and green asparagus are cut above the soil. It best grows in loose, sandy and not too wet soil (Asparagus Production - Worldmapper, 2023). The country that is considered the world's largest producer of asparagus is China (89%, near 6 mld $), followed by Peru (4.3%, near 300

mln $). The main export markets (US and EU) also have an important domestic production sector (European Commission, 2021; Cannock, 2011). It is actively consumed mainly in Europe, the USA and Asia.

Based on the official information, Figure 3 shows a comparison of the yield of asparagus in different countries of the world from 2015 to 2021. The data was constructed by the authors using results from a model development and information from Statista data, specifically FAOSTAT for the year 2023. The main focus of this analysis appears to be the yield of asparagus in various countries over a span of seven years. Here are some points that could be analyzed based on the given information: until 2018, Poland was the world leader in terms of asparagus productivity per unit area (Fig. 4).

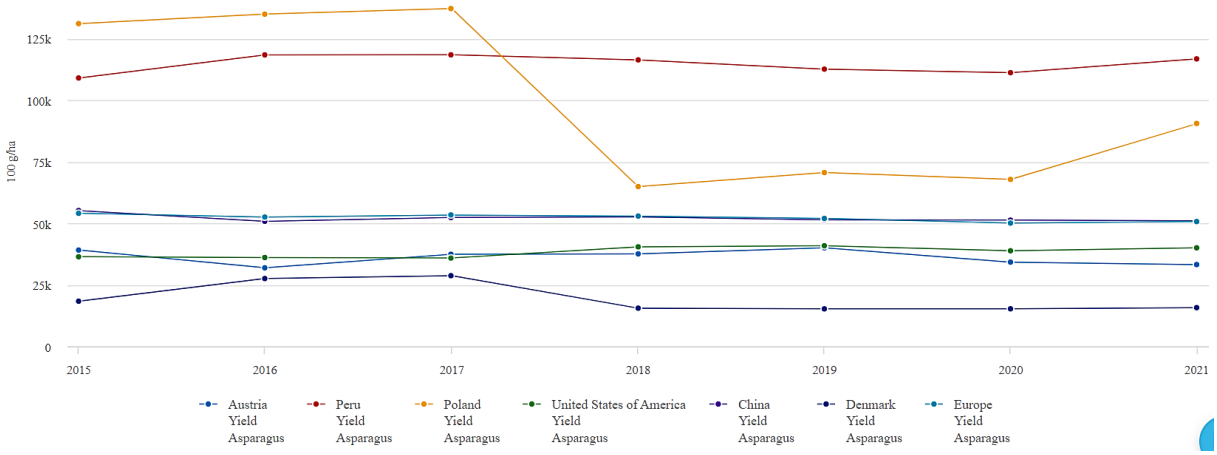

Figure 4. Yield of Asparagus comparison in different countries of the world, 2015-2021.

Source: constructed by authors based on results of model development and Statista data (FAOSTAT, 2023), 23.11.2023.

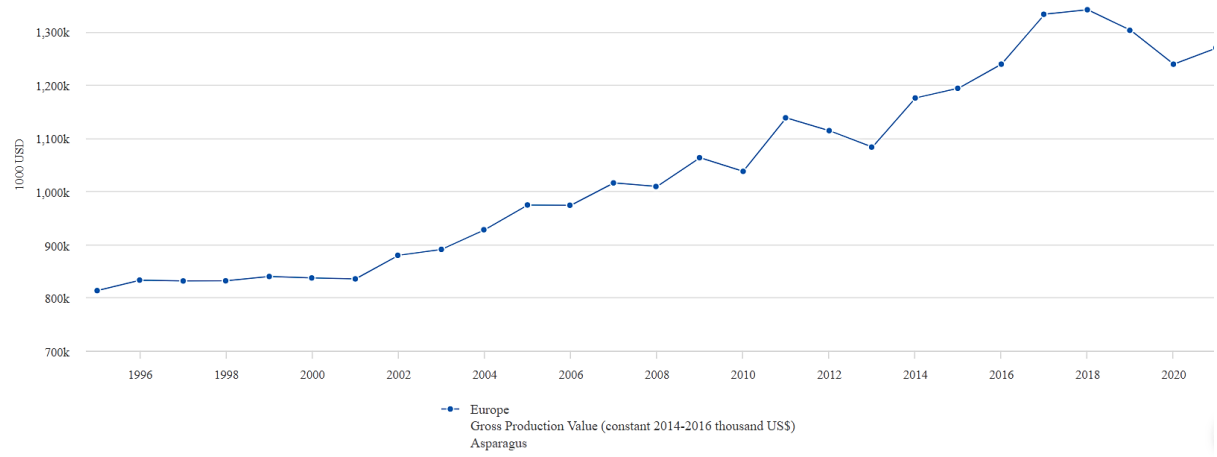

Figure 5. Gross Production Value of Asparagus in Europe, 1995-2021, USD.

Source: constructed by authors based on results of model development and Statista data (FAOSTAT, 2023; European Commission, 2021), 23.11.2023.

The amount of new plant varieties required to provide food for the population in terms of tonnage can vary depending on several factors such as the size of the population, dietary patterns, and agricultural productivity. It is challenging to provide an exact figure as it would

require detailed analysis and considerations of various factors. However, according to the Food and Agriculture Organization of the United Nations (FAO), global food production needs to increase by approximately 50% by 2050 to meet the demands of a growing population. This increase includes the cultivation of new plant varieties and improved agricultural practices to enhance productivity and efficiency (FAOSTAT, 2023).

It's important to note that specific tonnage requirements for new plant varieties would depend on individual country demographics, consumption patterns, and agricultural capacities. It is recommended to refer to agricultural research, food security reports, and relevant statistical sources for more specific data related to the tonnage of new plant varieties required to meet the food needs of different populations.

5. Conclusions

As a result of the research conducted by the authors, the following achievements were obtained and the following conclusions were formulated.

1. The collaboration between Poland and Ukraine in ensuring food security through plant-based nutrition holds great promise. By leveraging their agricultural potential, exchanging expertise, diversifying crop production, adopting sustainable practices, and promoting trade and economic cooperation, both countries can enhance food security and improve the well-being of their populations. Continued collaboration and joint initiatives will pave the way for a sustainable and resilient food system that meets the nutritional needs of present and future generations.
2. The provision of plant-based agricultural products plays a crucial role in ensuring food security and meeting the dietary needs of the population. Cooperation between Poland and Ukraine in this area can have numerous benefits for both countries. Poland has shown significant agricultural production capacity, particularly in crops like wheat, corn, barley, potatoes, apples, and cabbages. This highlights its potential to contribute to the provision of plant-based food to its population. Additionally, fostering cooperation between Poland and Ukraine in the agricultural sector, including knowledge sharing, trade partnerships, and investment, can contribute to the development and provision of plant-based food for both populations.
3. The war in Ukraine has had a detrimental impact on agricultural activities, including the cultivation of plant-based agricultural products. Land disputes, decreased cultivated areas, damaged infrastructure, disrupted supply chains, and economic instability are some of the challenges faced by Ukraine's agricultural sector. These factors have affected the production levels and food security in the country. Efforts to rebuild agricultural infrastructure, support affected farmers, and restore stability during war are crucial to revitalizing agricultural production in Ukraine.

4. The exploration and cultivation of novel plant species and varieties offer opportunities to enhance food supply, promote sustainable agriculture, and diversify diets. The identified crops, including asparagus, amaranth, chia seeds, quinoa, buckwheat, and various legumes, exhibit favorable agronomic traits, nutritional value, and market potential. Their cultivation can contribute to increased agricultural productivity, improved nutrition, and the resilience of food systems. Further research, breeding programs, and market-oriented initiatives are essential for the successful integration of these novel crops into mainstream agriculture and ensuring a sustainable and diverse food supply for the population.
5. Collaboration between Poland and Ukraine in the field of plant-based food production offers significant opportunities to enhance food security, diversify agricultural production, and foster economic growth. By leveraging Ukraine's agricultural potential and cultivating new crops suited to Ukrainian soil, Poland can expand its range of plant-based food products and meet the evolving demands of EU markets. This collaboration can contribute to sustainable agriculture practices, strengthen bilateral relations, and improve the overall well-being of the populations in both countries. Further research, investment, and policy support are essential for realizing the full potential of this collaboration and ensuring a successful transition to sustainable and diverse plant-based food production.

Our future research will focus on effective management models of world-class ecologically balanced nutrition that work well in developed countries and help preserve and restore biodiversity. The authors of the article also propose to develop a state program for compensation of interest on loans to cover any costs of farmers who grow vegetable food products in ecological conditions according to the requirements of environmental protection related to agricultural activities. State regulation of agricultural activity is also important. All this will make it possible to adjust the structure of sown areas of ecological types of agricultural crops in accordance with the priorities of providing domestic and foreign markets with important social food products. The authors will conduct further research in the direction of improvement and implementation of the strategy of providing the population with plant-based food products based on the justification of the economic efficiency of growing types of crops that have high caloric and medicinal properties (amaranth, chia seeds, quinoa, buckwheat, legumes), are subject to protection (bear onion, scopolia carniolica, polemonium caeruleum, asparagus, melittis sarmatica, gladiolus imbricatus) as valuable species and have a positive impact on the environment. Prospective further research will also be applied when forming applications for participation in grant projects and programs.

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