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CONTROL OF BIOLOGICAL THREATS IN WARTIME AND POST-WAR PERIODS

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INTRODUCTION

One of the main tasks facing Ukraine is its integration into the global economic space. Further integration imposes new requirements on the national economy for the development of all its sectors and necessitates the consideration of modern global market trends. Amidst wartime conditions, the primary objective of the Ukrainian agricultural sector has become the reliable provision of the population with agricultural products and food. Farmers and private rural households have demonstrated their key role in maintaining and developing local markets and food supply chains. With the onset of the war, the control of diseases and the spread of zoonoses in the livestock sector has become a critical issue. Many agricultural enterprises have been destroyed during hostilities, with the most affected regions including Chernihiv, Kharkiv, Sumy, Kyiv, Donetsk, Luhansk, Mykolaiv, Kherson, and Zaporizhzhia. Losses due to the death of animals and damage or destruction of livestock farms amount to approximately 3 billion UAH.

In the current conditions, there is an intensification of epidemic processes, the global spread of emerging, re-emerging, and previously eradicated infectious diseases. Increased cross-border movement of people, goods, and vehicles, uncontrolled transportation of animals and infected livestock products, the absence of a registry of hazardous infectious diseases considering the unstable epidemic and epizootic situation worldwide, the heightened risk of terrorist incidents, and the armed conflict in the east of the country all contribute to an increased risk of the introduction and spread of dangerous disease pathogens and related emergencies within the state.

Biological threats necessitate the development, implementation, verification, and maintenance of national biosafety and biosecurity standards, as well as effective measures for animal and human health protection, food quality, and safety. Of particular concern is the threat posed by multidrug-resistant bacterial strains, which is a critically global problem.

1. Alternative Means of Preventing Infectious Diseases

The epizootic situation in Ukraine remains tense, and the biosafety and biosecurity system is inadequate due to the lack of clearly defined control and prevention measures for zoonoses using domestically produced

pharmaceuticals. Monitoring zoonotic outbreaks and developing new environmentally safe preparations for the control and prevention of infectious diseases is a pressing issue today. Success in combating zoonoses and their prevention largely depends on the quality of veterinary and sanitary measures[1].

A significant role in the prevention and treatment of infectious diseases is played by antibacterial drugs. However, their uncontrolled use leads to the emergence of pathogens that are insensitive and resistant to antimicrobial agents. The speed at which microbial resistance to antibacterial drugs develops and spreads is alarming. Medications that were effective just a few years ago are now losing their effectiveness, and their use is being forcibly restricted.

According to the World Health Organization, the rapid increase in microbial resistance to antibacterial drugs threatens to undermine the foundations of healthcare established by veterinary and medical science over the past 50 years. Currently, there are two main solutions to this situation: intensifying the development and implementation of new biocides and drugs that regulate the protective systems of the macroorganism, specifically immunomodulators, anti-stress agents, hepatoprotectors, and vitagens[2].

An important role in the system of veterinary and sanitary measures aimed at disinfecting the environment from infectious disease pathogens is played by the sanitation of water bodies and water supply systems[3]. Systematic monitoring of infectious disease pathogens during wartime and post-war periods, along with the assessment of their antibiotic resistance, remains highly relevant. There is a growing need to study the physiological properties of ticks as vectors of zoonoses. Additionally, increasing concerns about environmental safety must be taken into account. The expansion of disinfection efforts should not be accompanied by a rise in emissions of hazardous chemical substances into the environment[4].

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It should also be noted that research on the impact of modern biocides on the immune system of humans and animals is conducted fragmentarily and does not cover various classes of disinfectants and sanitizing agents. The development of antibacterial drug rotation schemes is highly relevant. These schemes should be based on the veterinary and sanitary conditions of animal and poultry housing, which can only be achieved through the use of reliable rotational programs for veterinary drug application[5].

The immune status of animals is critically important, and the timely use of immunomodulators, hepatoprotectors, and vitagens as anti-stress agents is key to ensuring veterinary well-being in livestock and poultry. The interrelationship between immunomodulators, vitamins, and hepatoprotectors remains largely unexplored and represents a pressing issue.

Therefore, coordinated rotational schemes for the use of biocides, immunomodulators, anti-stress agents, hepatoprotectors, and vitagens will allow for reliable control of infectious animal diseases and ensure the production of safe and high-quality livestock products. This is essential for maintaining national security within the framework of sustainable territorial development, which serves as the foundation for Ukraine's agricultural sector recovery strategy[6]. To address the issues of national security and environmental restoration, taking into account the impact of military actions on the agricultural and veterinary sectors, a comprehensive set of measures needs to be implemented. The main measures are as follows:

– **Integration of the "One Health" concept**: Measures should focus on both the veterinary and medical sectors to ensure the health of both humans and animals. The "One Health" approach will allow for effective control of biological threats at various levels, from local agricultural enterprises to nationwide security networks.

– **Development of environmentally safe solutions**: Measures include the creation and implementation of new environmentally safe products to combat infectious diseases, which will reduce the negative environmental impact and increase the effectiveness of pathogen destruction. This is

Р.В. Петров, А.В. Березовський, Н.Є. Гриневич, Г.А. Фотіна, О.І. Шкромада, І.С. Данілова, А.І. Фотін, Л.В. Плюта, О.В. Фотін. Одеса, 2024. 312 с.

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especially important in wartime and post-war conditions, where environmental threats significantly increase.

– **Antibiotic rotation programs**: One of the key aspects of the measures is the development of rotation schemes for the use of antibiotics and biocides, which will help prevent the development of microbial resistance to medical products. This approach is based on modern scientific research that confirms the importance of controlling the use of antibacterial drugs.

– **Control of antibiotic resistance and biosafety**: As part of the system of measures, regular monitoring of antibiotic resistance in infectious disease pathogens should be conducted. This will ensure the timely detection of dangerous pathogens and the development of effective measures to combat them. Additionally, the project aims to improve the national biosafety system by introducing new regulations and control mechanisms.

Stimulating the sustainable development of the agricultural sector: the system of measures should contribute to the development of agriculture through the implementation of innovative methods for combating diseases, which will ultimately increase the productivity of farming enterprises and ensure stability in food supply chains. This aligns with European standards for rural development and the adaptation of the agricultural structure to EU conditions.

– **Multidisciplinary approach**: The system of measures should unite experts in various fields–veterinary medicine, biology, agricultural sciences, ecology, and public health. Such cooperation will allow for the implementation of innovative approaches that go beyond traditional methods of controlling biological threats, especially considering post-war challenges.

– **Adaptation to wartime conditions**: The uniqueness of the measures lies in their consideration of the specifics of agricultural production and infectious disease control in the context of military conflict. The proposed solutions must be adapted to the real conditions of Ukraine, particularly in regions most affected by military actions.

The issue of biological safety is causing increasing concern among the public, politicians, and scientists due to the real growth of biological threats. The "One Health" approach will enable effective control of biological threats at various levels, from local agricultural enterprises to national security networks. Biological threats can be either unintentional or intentional. Unintentional threats include epidemics and outbreaks of infectious diseases in humans, epizootics (high animal morbidity), epiphytotics (spread of infectious plant diseases over large areas), accidents at biologically hazardous facilities, natural reservoirs of pathogenic microorganisms, and transboundary transmission of pathogenic microorganisms, as well as harmful flora and fauna for ecological systems.

Intentional threats include sabotage at biologically hazardous facilities, biological terrorism, and the use of biological weapons by states. A separate issue is the biological threat related to biological terrorism and the use of biological weapons, which is particularly relevant in wartime. Biothreats also include the deliberate or accidental creation of dangerous microorganisms, toxins, or biologically active substances during biological research, biotechnological activities, or in the pharmaceutical or food industries. Deliberate creation or use of biothreats against humans, animals, or plants forms the basis of bioterrorism. Biosafety primarily concerns the emergence and combating of diseases caused by particularly dangerous pathogens, as well as the physical protection of collections of these pathogens to prevent their intentional (bioterrorism) or unintentional spread beyond storage areas.

In this context, it is urgent to conduct monitoring of infectious disease pathogens in Ukraine during wartime and post-war conditions, and to develop a system for controlling and preventing animal diseases as a prevention of zoonotic epidemics. This will enable forecasting the potential impact of disease introduction, determining the likelihood of biological and economic consequences of its fixation, spread, and dissemination, and developing adequate countermeasures in accordance with the "One Health" concept and the "Biosafety and Biological Protection Strategy." The main stages include:

– Based on preliminary monitoring of the epizootiological situation in livestock farming during wartime and post-war periods, determining the risks of zoonotic disease introduction and spread in Ukraine.

– Analyzing global and domestic experiences with alternative methods for preventing bacterial diseases proposed for livestock.

– Justifying and developing formulations for new agents with a disruptive effect on microbial biofilms.

– Providing production justification for the effectiveness of proposed concentrations of working solutions of new agents in different technological schemes for the prevention of bacterial infections in animals.

– Determining the effectiveness of the developed system for controlling infectious diseases in animals as a prevention of zoonotic epidemics in the conditions of agro-industrial production[7].

2. Monitoring of Disease Pathogens and Development of Disinfectants

Monitoring the pathogens of infectious animal diseases and studying their biological properties play a crucial role in the prevention of biological threats and the scientific and experimental justification of measures to control and

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prevent animal diseases in wartime and post-war conditions. The veterinary service of the country is tasked with preventing outbreaks of infectious diseases and their further spread. To achieve this, a comprehensive set of anti-epizootic measures is implemented, with a key focus on the disinfection of livestock facilities, equipment, containers, inventory, etc. These measures involve the creation and implementation of new eco-friendly products for the prevention and treatment of infectious diseases.

Over time, microorganisms may develop resistance to disinfectants. To prevent this, systematic rotation of disinfecting agents, based on different active substances, should be carried out at each livestock enterprise. An urgent task for veterinary medicine is the search for modern disinfectants and cleaning-disinfecting agents, relying on the achievements of both domestic and foreign science and practice, as well as the use of the latest disinfecting substances that are harmless to humans, animals, and birds, environmentally safe, and accessible to consumers. Cleaning and disinfection at large enterprises are carried out by specialized sanitation teams.

Veterinary disinfectants, or antiseptic agents in veterinary medicine, are substances that help reduce the overall number of microorganisms and eliminate pathogens to ensure healthy living conditions for agricultural and domestic animals. The choice of disinfectant depends on the purpose of the treatment and the type of infection it is meant to prevent or eliminate. Veterinary antiseptics must meet several requirements: they should have a broad spectrum of antimicrobial and antiviral action, a short exposure time, and allow disinfection in the presence of animals. Furthermore, they should not cause corrosion of metals or damage to other materials (such as rubber, plastic, etc.), retain activity in the presence of organic substances, and not exert toxic or allergic effects on animals and personnel.

To address these needs, a new disinfectant, "Kombiyod," based on povidone-iodine and sodium selenite, has been developed and experimentally proven to be effective.

Povidone-iodine is a complex of iodine with polyvinylpyrrolidone, which exhibits bactericidal (against both gram-positive and gram-negative bacteria), virucidal, fungicidal, sporicidal, and antiprotozoal activities. When it comes into contact with mucous membranes and damaged tissues, active iodine is released from the iodine-polymer complex. This iodine reacts with the oxidative sulfide (SH–) and hydroxyl (OH–) groups of amino acids present in enzymes and structural proteins of microorganisms, inactivating or destroying them.

Due to the large size of the complex molecule, povidone-iodine does not easily penetrate biological barriers, and systemic iodine effects are minimal. In combination with auxiliary substances, it provides antiseptic and anti-

inflammatory effects. Microorganisms do not develop resistance to povidone-iodine[8]. Long-term use of the drug can lead to partial absorption of iodine in the small intestine. Within two hours of absorption, iodine distributes in the intercellular space, accumulating in the thyroid gland, kidneys, stomach, mammary, and salivary glands. The concentration in blood plasma can reach up to 10 ng/ml. The iodine content in milk, saliva, and gastric juice is 30 times higher than its concentration in plasma. Iodine is primarily excreted through urine, with lesser amounts expelled via the lungs and feces.

Iodine is an essential component of thyroid hormones–thyroxine (T4) and triiodothyronine (T3), which regulate nearly all major metabolic processes. Thyroxine controls energy metabolism and heat production in the body and catalyzes the formation of energy in cells. Selenium plays a crucial role in the formation of over 30 essential hormones, enzymes, and other biologically active substances, stimulating erythropoiesis and enhancing cellular oxygenation.

The iodine-based disinfectant is effective for sanitizing water systems in livestock facilities, breaking down microbial biofilms. It is recommended for use at a 0.2% concentration with a two-hour exposure time. Disinfection of bedding and soil on livestock farm premises is also essential.

A significant current issue is the large number of dead animals, poultry, and enemy corpses. Decomposing remains cause substantial harm, as all pathogens that affected the animals or humans are released. Handling these bodies with unprotected hands is dangerous, as even the corpse itself can carry pathogens. Proper disposal of this large number of corpses must adhere to specific regulations.

A new disinfectant, "Sukhoz," has been developed and studied. It contains copper sulfate, kaolin, chloramine, iron sulfate, calcium sulfate dihydrate, zeolite, and thymol[9]. The product acts bactericidally against *Escherichia coli*, *Staphylococcus aureus*, *Salmonella spp.*, and fungicidally against *Candida albicans*. It absorbs moisture, neutralizes ammonia, hydrogen sulfide, methane, and other harmful vapors and gases, and has a repellent effect. Prior to disinfection, thorough mechanical and sanitary cleaning of surfaces is required. Then, surfaces are disinfected by evenly sprinkling the powder at a rate of 50-100 g/m², with an exposure time of 3 hours.

Before placing poultry or animals in the premises, the product is applied once at a dose of 100 g/m² for the area. During preventive disinfection in the

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presence of animals and poultry, the product is used once a week at a dose of 50 g/m² of surface area. If outbreaks of disease occur, the product is used daily at a dose of 100 g/m² (for ongoing disinfection) until signs of disease disappear. Delivery rooms, facilities for raising young animals, and resting areas for livestock should be treated daily at a dose of 50 g/m².

In livestock facilities with deep bedding[10] the product is applied before replenishing the bedding once a week at a maximum dose of 100 g/m². In areas where animals are temporarily kept (for mating, grazing grounds, yards, etc.), it is applied once a week at a dose of 50 g/m². For transport vehicles used to transport animals and poultry, the product is applied at a dose of 50-100 g/m², with an exposure time of 3 hours.

For animal or human burial sites, the disinfectant "Suho Dez" powder is spread at a rate of 200 g/m².

3. Development and Implementation of Alternative Drugs to Antibiotics

The primary reason for the decreasing effectiveness of antimicrobial agents (sulfonamides, antifungal, antitrichomonal drugs, antibiotics, and others) is microbial resistance. Combating microbial resistance to antimicrobial drugs is the main task of both human and veterinary medicine. Today, antibiotic resistance goes beyond the scope of human and veterinary medicine; it has enormous socio-economic significance and is regarded as a national security threat in developed countries. Unfortunately, humanity does not fully grasp the scale of this catastrophe, although in many developed countries, government bodies have long been concerned about this issue. For example, in the United Kingdom, the House of Lords has a special committee dedicated to antibiotics, and in Western Europe, the problem of resistance frequently appears in mainstream media. The scale of the problem is also reflected in the fact that the World Health Organization (WHO) has developed a document called the **"WHO Global Strategy for Containment of Antimicrobial Resistance."** This issue significantly reduces the effectiveness of the prevention and treatment of infectious diseases.

One of the solutions to this problem is the development of alternative means for disease prevention. The effectiveness of a new drug, **"Inkombivit,"** has been developed and experimentally confirmed. It contains methionine, vitamin B5 (pantothenic acid), copper sulfate, lysine, zinc sulfate, vitamin B2 (riboflavin), vitamin B4 (choline chloride), vitamin B7 (biotin), vitamin B12 (cyanocobalamin), vitamin B1 (thiamine), vitamin E (alpha-

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tocopherol acetate), vitamin B6, vitamin A (retinol), vitamin B9 (folic acid), vitamin B3 (PP, nicotinamide), vitamin D3, and manganese sulfate.

This **combined** preparation contains fat– and water-soluble vitamins, microelements, and amino acids that normalize metabolism, increase overall resistance, and improve productivity, survival, and reproductive functions in animals.

– **Vitamin A** participates in redox reactions, regulates insulin activity, carbohydrate and fat metabolism, enhances calcium and magnesium metabolism, oxygen absorption in biochemical processes, and interaction between proteins and lipids in cell membranes. It prevents the formation of keratohyalin granules in the lipid layer of cell membranes, maintains cell elasticity, supports the function of vision, skin, respiratory tract, gastrointestinal tract, and uterus, and stimulates reproductive functions– spermatogenesis, oogenesis, embryonic growth, sexual maturity, and sex hormone synthesis.

– **Vitamin D3** is involved in calcium and phosphorus metabolism, affects bone development, regulates calcium and phosphorus levels in blood and bone tissue, ensures their physiological balance in the body, and influences tissue respiration and carbohydrate oxidation. When calcium levels in the blood decrease, it facilitates calcium release from bone tissue.

– **Vitamin E** is an antioxidant that regulates oxidation during protein biosynthesis, supports ATP metabolism, protects red blood cells from hemolysis and oxidation, prevents fatty acid oxidation, maintains the stability and activity of epithelial cells in reproductive, gastrointestinal, and conjunctival tissues, regulates spermatogenesis, reduces the number of morphologically altered sperm, prevents epithelial degeneration in seminiferous tubules in males, and improves fertilization and embryonic development in females.

– **B vitamins** are components of various enzymes involved in carbohydrate, lipid, protein, and amino acid metabolism. They ensure energy supply, erythropoiesis, hemoglobin synthesis, tissue respiration, central nervous system function, skin and vision structure maintenance, and prevention of fatty liver infiltration.

– **Copper and manganese** are essential microelements involved in hematopoiesis, stimulating hemoglobin and myoglobin synthesis, erythropoiesis, and functioning as components of tissue respiration enzymes and antioxidant defense systems. They are also necessary for bone tissue formation.

– **Zinc** plays a role in nucleic acid metabolism and protein synthesis, influencing key life processes such as hematopoiesis, reproduction, animal development, and carbohydrate and energy metabolism.

Lysine and methionine are essential amino acids found in nearly all proteins. They participate in the synthesis of biologically active substances, hormones, enzymes, carnitine, choline, phospholipids, and collagen formation. This newly developed **Inkombivit** preparation provides an effective alternative to antibiotics, helping to enhance disease resistance, improve metabolic functions, and promote overall health and productivity in animals [11].

The use of the **"EvitSel"** preparation has shown good effectiveness.

Vitamin E and selenium are naturally highly active antioxidants with different mechanisms of action that effectively complement each other. They counteract the formation of free radicals and their destructive effects on cell membranes. **Vitamin E** prevents lipid oxidation in cell membranes by inhibiting hydrogen peroxide formation. **Selenium**, through hydroxylation, participates in the creation of glutathione peroxidase, which not only converts hydrogen peroxide into less harmful alcohols but also prevents the formation of free radicals.

Vitamin E stimulates the synthesis of many enzymes, participates in the metabolism of nucleic acids and prostaglandins, improves tissue respiration, stimulates protein synthesis, protects **vitamin A** from oxidation, inhibits cholesterol synthesis, and normalizes lipid levels in the blood.

Selenium is involved in the formation of more than 30 essential hormones, enzymes, and other biologically active substances, stimulates erythropoiesis, and enhances cellular oxygen supply.

Together, **Vitamin E and selenium** indirectly activate the protective functions of both cellular and humoral immunity, as well as the immune system as a whole. They also enhance animal reproductive performance by improving spermatogenesis in males, increasing uterine activity, and restoring normal ovarian function after childbirth in females[12].

It has antifibrotic, antioxidant, and hepatoprotective effects, preventing the penetration of hepatotoxic substances into cells, stimulating hepatocyte regeneration, and normalizing liver function.

Carnitine is an amino acid similar in function to B vitamins, synthesized in the liver. It plays a crucial role in the transport of fatty acids across the mitochondrial membrane, helps maintain coenzyme A levels in all cell types, has anabolic properties, stimulates muscle protein synthesis, mobilizes lipids from fat stores (liver, muscles, adipose tissue), improves appetite, enhances

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digestive enzyme activity and the secretory function of the gastrointestinal tract, and increases nutrient absorption from feed. It reduces cell apoptosis, enhances Krebs cycle activity (preventing acidosis and ketosis), and improves muscle tone and myocardial function, aiding in recovery from stress and physical exertion.

Silymarin, a mixture of flavonoids from milk thistle (*Silybum marianum*), is a powerful antioxidant that blocks receptors and transport systems responsible for transferring toxins into cells. It reduces macrophage activity, lowers gamma-globulin synthesis, and inhibits lipoxygenase and cyclooxygenase, providing anti-inflammatory, immunomodulatory, and anticancer effects. By interacting with cell membranes, flavonoids inhibit cAMP activity, suppress phospholipase activation, and ensure cytoprotective effects on hepatocytes. Due to its structural similarity to steroid hormones, silymarin stimulates protein synthesis and hepatocyte regeneration.

Betaine is a trimethyl derivative of glycine, crucial for methylation reactions and serving as a methyl group donor. It has choleretic, hepatoprotective, and lipolytic effects, enhances fat metabolism, aids in toxin neutralization, improves liver function, promotes cell hydration, increases cell tone, and stimulates digestive processes.

Methionine is an essential amino acid with metabolic and hepatoprotective properties, serving as a methyl group donor. It is necessary for choline synthesis, which is essential for the formation of phospholipids from fats and prevents neutral fat accumulation in the liver. Methionine is involved in sulfur-containing amino acid metabolism, the synthesis of adrenaline and creatinine, and the activation of hormones, vitamins (cyanocobalamin, ascorbic and folic acid), enzymes, and proteins. It also reduces cholesterol levels and increases blood phospholipid concentrations, while neutralizing certain toxins through methylation.

Sorbitol has detoxifying and choleretic properties, helps maintain circulating blood volume, accumulates in the liver as glycogen, and participates in energy metabolism.

As part of disease prevention, the use of probiotics is considered a promising approach for preventing and controlling infectious diseases, thanks to their antimicrobial and immunomodulatory properties and positive effects on animal and human health.

Reducing antibiotic use and increasing probiotic utilization[13] in **human and veterinary medicine** will help **decrease the prevalence of antibiotic-**

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resistant pathogenic microorganisms in the environment and prevent **side effects associated with antibiotic use**[14]. Although the use of probiotics and probiotic-based products will not fully resolve the issue of antibiotic resistance[15], they have the potential to serve as an alternative to traditional antibiotics or as an adjunct therapy against multidrug-resistant pathogens.

CONCLUSIONS

Thus, the development and implementation of alternative means for preventing infectious diseases are currently relevant to ensure high-quality and safe food products in accordance with the "One Health" concept and to maintain national security. The development of rural areas requires a shift in agricultural policy towards sustainability, ensuring equal development opportunities for all participants in agricultural production. This includes transparent access to agricultural and other lands, production resources, free market access, and fair competition.

In this structure, control and monitoring of zoonotic disease outbreaks, as well as the development of new environmentally safe agents for controlling and preventing infectious animal diseases, are crucial. The immune status of animals is also of great importance; therefore, the timely use of immunomodulators, hepatoprotectors, and vitagens as anti-stress agents is essential for ensuring the veterinary well-being of livestock and poultry.

One of the key aspects of these measures is the development of rotational schemes for the use of antibiotics and biocides to prevent microbial resistance to pharmaceuticals. This approach is based on modern scientific research, which confirms the importance of controlling the use of antibacterial agents.

The system of measures should integrate experts from various fields, including veterinary medicine, biology, agricultural sciences, ecology, and public health. This aligns with European standards for rural development and the adaptation of the agricultural sector to European Union conditions. The uniqueness of the proposed measures lies in their consideration of the specifics of agricultural production and infectious disease control in the context of an armed conflict.

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SUMMARY

Currently, the development and implementation of alternative methods for preventing infectious diseases are highly relevant to ensuring the production of high-quality and safe food products in line with the "One Health" concept and national security needs. In the context of wartime and post-war recovery, rural development requires a transition to a sustainable agricultural policy that guarantees equal development opportunities for all stakeholders involved in agricultural production. This includes transparent access to agricultural and other lands, production resources, and fair market competition.

The adoption of these approaches will lead to structural changes in agriculture, allowing family farms to utilize their production potential for generating public goods and local development while facilitating Ukraine's agricultural adaptation to EU standards. This agricultural and rural revival scenario requires the establishment of a new institutional framework to support domestic food security, the implementation of an EU-oriented agricultural policy, responsible strategic planning, continuous monitoring of the sector, and systematic data collection.

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