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Activation of innovative development of poultry farming and meat livestock farming industries on the food market of Ukraine

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► **Abstract.** This article studied the peculiarities of integrating innovative technologies into poultry farming and meat livestock farming – essential elements of the Ukrainian food market. The goal was accomplished through the contextual analysis of industry reports, examination of the European legislation, and assessment of the Ukrainian poultry and meat production segments in terms of the Food Demand Index, Food Supply Index, and Regional Trade Development Index. Despite the military time turbulence, the Ukrainian meat production industry stood resilient and demonstrated potential for sustainable development, with poultry accounting for 56.3% of the total segment. However, integration of the Ukrainian meat production into the European segment remained modest, despite 38,481 TRACES NT certificates obtained: in 2024, the share of poultry exports decreased by 37.2% compared to 2023. The econometric analysis revealed a statistically significant relationship between innovation and output in the national meat production segment, with 66.4% variations in annual poultry and beef consumption attributed to innovative technologies. Connection was also discovered between the use of innovative technologies and reduced production cost, as well as between innovative approaches and an adherence to sustainable development practices. The integration of innovative technologies was not uniform throughout the country: the central regions of Kyiv and Vinnytsia had the highest innovation rankings, with the potential of receiving integral index values of up to 8.13. It was

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further discovered that the use of technologies could facilitate rational allocation of resources: one robot can serve up to 70 animals, hence, free human resources to address more technological tasks. The obtained findings could be used to increase performance effectiveness, enhance competitiveness, and support sustainable development of the Ukrainian food market

▸ **Keywords:** innovative technologies; cattle breeding industry; econometric dependence; supply chain; fuzzy modelling

▸ Introduction

Military operations in Ukraine and limited access of Ukrainian producers to resources have a negative impact on the production of agricultural products in all regions of the country and might trigger a range of food security issues. Moreover, the threat remains relevant to all segments of the national agricultural sector, including poultry farming and meat livestock farming. The existing threat might be reduced through the introduction of innovative solutions to the Ukrainian food market with an aim to allocate resources, cut costs, restructure logistics chains, and maintain sustainable development. Nevertheless, integration of technology into specific food market segments remains an under-researched issue, which indicates relevance of the selected topic.

Z. Hussain *et al.* (2025) acknowledged that the global food market has undergone major transformations to meet evolving customer preferences and growing demand for sustainable development. The authors further stressed that the growing use of technology has become an integral element of this change process and pointed to a range of technological advances in the field. The study of S. Kimani (2024) stressed the relationship between the integration of innovation in specific sectors, including crop breeding, enhanced productivity, and food availability. Considering this relationship, the researcher concluded that innovative development might become the key to fighting food insecurity in some areas, for example, Sub-Saharan Africa. K. Malec *et al.* (2024) discovered that investments in agricultural innovation preconditioned an increase in food security. Similar to Z. Hussain *et al.* (2025), the authors asserted the relationship between innovations and food security was moderated by the productivity growth. E.D. Farsani *et al.* (2024) examined 36 academic sources and detected eight factors preconditioning innovation in agriculture – human capital, research, institutional frameworks, market sophistication, infrastructure, knowledge and technology outputs, and creative and innovative endeavours. The cited sources emphasised the role of innovation in sustainable development of the agricultural sector and solution of pressing socio-economic problems.

Several studies, including the research of J.N. Ocran (2025) underlined the significance of innovation for poultry and meat livestock farming. The cited researcher, in particular, studied the use of artificial intelligence (AI) tools in livestock and poultry production. The author concluded that AI tools transformed traditional animal husbandry practices by improving animal welfare, enhancing performance efficiency, and supporting animal farms' sustainability. S. Wongtangtintharn *et al.* (2025) stressed that the use of innovative approaches and tools might facilitate the effective integration of certain national agricultural segments, for instance, Thai, into the global food market. The experts argued such integration was possible due to the use of innovative technologies, like precision-farming and AI-driven systems, to support strategic decision-making and ensure alignment with international food market standards. V. Beck *et al.* (2024) examined the role of innovative technologies in transforming livestock and meat value chains. The authors argued that innovative tools, for example, big data analytics, enhanced value chains' efficiency through product variation and horizontal diversification. R.B. Bist *et al.* (2024) stressed the significance of innovative technologies for promoting poultry welfare and increasing the segment's competitiveness. The cited experts argued that these goals were accomplished through the integration of technology into resource allocation, nutrient recycling and promotion of climate-smart agricultural practices. C. Krampe *et al.* (2024) assessed the role of innovative technologies through a comparative analysis of 367 pig and dairy farmers in three European countries – Finland, the Netherlands, and Spain. Based on collected data, those researchers concluded that farmers used innovative technologies, including digital tools, to manage their data, monitor farm animals, and share information with value-chain actors to optimise business innovation and certification. The collected evidence suggested that the integration of innovative technologies into strategic planning and business management processes can transform poultry and meat livestock farming to enhance the segment's performance and increase its competitiveness (Taishykov *et al.*, 2025).

Despite sufficient research in the field, specific national contexts, including Ukrainian remain a relatively unexplored terrain. Little was known about maintaining innovative development of poultry and meat livestock farming under the martial law and associated limitations. Considering the detected gap, this paper studied the peculiarities of activating innovation in Ukrainian poultry and meat livestock farming. The goal was accomplished through examining the factors shaping the integration of innovative tools in the selected segments, assessing hindrances to the integration process, and proposing strategies to overcome them.

▸ Materials and methods

This research relied on the data of 2021-2024 retrieved from the industry reports of the OECD-FAO Agricultural Outlook 2024-2033 (2024), State Statistics Service of Ukraine (2024), Data browser (n.d.), Statistics (n.d.). Also, it was analysed data from sources M. Bogonos *et al.* (2024), V. Afanasyev *et al.* (2024), I. Guzhva (2025). The data was used to assess the state of poultry and meat livestock farming in the Ukrainian regions: Dnipropetrovsk, Kyiv, Kirovohrad, Mykolaiv, Odesa, Kharkiv,

Vinnytsia, Volyn, Zhytomyr, Lviv, Poltava, Rivne, Sumy, Ternopil, Khmelnytskyi, Cherkasy, Chernivtsi, Chernihiv, Zakarpattia, and Ivano-Frankivsk. In addition to industry reports, the following pieces of European legislation were examined: Commission Delegated Regulation (EU) No. 2021/1374 (2021), Regulation (EU) of the European Parliament and of the Council No. 2022/870 (2022), Commission Delegated Regulation (EU) No. 2023/2652 (2023).

The data from Yu. Lupenko *et al.* (2021), T. Nakelse & E. Dennis (2024), and J. Rittirong *et al.* (2024) was used to create a system of indicators to assess innovative development of the poultry and meat livestock industries in the food market: food demand index (I_{dem})) – characterised the level of meeting consumer needs in poultry and meat livestock products, provided that the financial activity of agribusiness entities increased and capital was invested in innovative technologies; food Supply Index (I_{offer}) – characterised the level of production capabilities and the degree of market saturation with poultry and meat livestock products, its competitive positions in production and sale using innovative technologies, in time space; Regional Trade Development Index ($I_{reg.trade}$) – determined opportunities for the sale of poultry and meat livestock products produced and sold using innovative technologies through trade networks, provided an opportunity for producers to reduce sales costs due to the volume of product batches. When forming a dependence between the indicators, a mathematical equation was determined to find the integral indicator of innovative development of the poultry and meat livestock industries in the food market ($I^{In}_{reg.market}$):

$$I^{In}_{reg.market} = v_{i1} \times I_{i1} + v_{i2} \times I_{i2} + \ldots + v_{in} \times I_{in},$$
$$\text{or} \quad I^{In}_{reg.market} = UNa_{i1} + UNa_{i2} + \ldots + UNa_{in}, \qquad (1)$$

where v_{i1}, v_{i2}, v_{in} – the weight of each i-th indicator of innovative development of the poultry and meat livestock industries in the food market; I_{i1}, I_{i2}, I_{in} – indicators of innovative development of the poultry and meat livestock industries in the food market; UNa_{i1}, Na_{i2}, UNa_{in} – weighted normalised assessment of each individual *i*-th indicator of innovative development of the poultry and meat livestock industries in the food market. Whereas, UNa_{in} was calculated by the formula:

$$UNa_{in} = Na_{in} \times v_{in}, \qquad (2)$$

where Na_{in} – normalised estimate per person of the *i*-th indicator of innovative development of the poultry and meat livestock industries in the food market. In this case, (Na_{in}) was calculated by the formula:

$$Na_{in} = \frac{I_{in} \times 10}{I_i max}, \qquad (3)$$

where I_{in} – indicator per capita of the *i*-th indicator of innovative development of the poultry and meat livestock industries in the food market; Na_{in} – the maximum indicator per capita of the *i*-th indicator of innovative development of the poultry and meat livestock industries in the food market, which was found empirically through a comparison of all indicators of the *i*-th indicator in a specific region. To determine the mathematical dependence between the indicators, correlation-regression analysis was used:

$$r = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n}(x_1 - \overline{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \overline{y})^2}}. \qquad (4)$$

The correlation coefficient ranged from $-1 \le r$ to $\le +1$ indicating statistically significant negative and statistically significant positive correlation, respectively. The formula was used to calculate the correlation between the trade development indicator and the demand indicator, as well as between the demand indicator and the supply indicator. If the obtained results showed a close correlation between the indicators, then the importance of these indicators was determined:

$$v_i = \frac{r_i}{\sum r_i + r_2 + \ldots + r_n}, \qquad (5)$$

where v_i – the weight of the i-th indicator of the innovative industries of poultry farming and meat cattle breeding in the food market; r_i – the correlation of the *i*-th indicator of the innovative industries of poultry farming and meat cattle breeding in the food market; $r_i + r_2 + \ldots + r_n$ – the sum of the possible calculated correlations. The logarithmic function was used to assess the structure of the poultry meat food supply in Europe in 2021-2024; compare the structure of food supply of poultry and beef in the Ukrainian, European, and global markets; detect the econometric relationship between the trade development indicator and the food supply indicator of the Ukrainian meat market since 2021:

$$y = a \cdot \ln(x) + b, \qquad (6)$$

where ln(x) – natural logarithm (logarithm base a); a – coefficient controlling the steepness, and b – y-intercept.

The forecast assessment of the integral index was carried out on the basis of accounting data and non-financial reporting on the signs of a stable state of innovative development of entities in the poultry farming and meat cattle breeding industries considering a sufficient retrospective of indicators for constructing fuzzy-multiple parameters by weight indicators not as a fuzzy logic by a sample of factors, but as a convolution of the current levels of these factors in the interval from 0 to 1, taking into account stability states. In the reverse order, the sign of the crisis of innovative development of industries changes (very low, low, medium, high and very high). The fuzzy set methodology was described using the composition of individual indicators $X = \{X_i\}$, which most closely corresponded to the assessment objectives: X_1 – innovation autonomy coefficient; X_2 – innovation provision coefficient with own funds; X_3 – intermediate innovation coefficient; X_4 – innovation coefficient by cash flows; X_5 – innovation turnover in the operating cycle; X_6 – profitability of operating activities. Basic sets were introduced, which were explained as follows: a) a complete set of states Q_i by industry entities; b) a set Q_i of levels of the crisis of innovative development W_i; c) for an arbitrarily separate indicator X_i a set of its values P_i.

A universal factor for the variables q, p and w was the interval from 0 to 1, and the factor of the values involved the sets $Q = \{Q_1, Q_2, Q_3, Q_4, Q_5\}$, $P = \{P_1, P_2, P_3, P_4, P_5\}$ and $W = \{W_1, W_2, W_3, W_4, W_5\}$ respectively. The sets of the linguistic variable "State of innovative development of the subject of the industry" were divided into five fuzzy subsets that will intersect. These subsets had the following form (four corner points of the trapezoid): $Q_1 = (0; 0; a_1; a_2)$; $Q_2 = (a_1; a_2; a_3; a_4)$; $Q_3 = (a_3; a_4; a_5; a_6)$; $Q_4 = (a_5; a_6; a_7; a_8)$; $Q_5 = (a_7; a_8; 0; 0)$. Each subset had its own membership function μ(X), with trapezoidal membership functions being the most commonly used in this case. The one-to-one

correspondence of the linguistic variables "State of innovative development of the subject of the industry" and "Sign of the crisis of the innovative development of the subject of the industry" was given in Table 1.

Table 1. Correspondence of linguistic variables Q_i and W_i

Value of the variable Q_i – "State of innovative development of the industry entity"	Value of the variable W_i – "Sign of crisis of innovative development of the industry entity"
Unstable boundary (Q_1)	Highest (W_1)
Low stability state (Q_2)	High (W_2)
Medium stability state (Q_3)	Average (W_3)
Sufficient stability state (Q_4)	Low (W_4)
Very stable boundary (Q_5)	Very low (W_5)

Source: based on The European Union officially abolished tariffs on Ukrainian goods (2022), E.S. Aljohani *et al.* (2024), K.M. Kang *et al.* (2024)

The method of the fuzzy-multiple approach took into account the relationship between the forecast of the steady state of innovative development of the poultry and meat livestock industries with their probabilistic crisis, and the developed model was characterised by flexibility and adaptability to changing environmental conditions, where it was possible to rank the regions of the country by the value of the integral index.

▸ Results

The production of poultry and meat products is one of the leading areas in solving the food security problems and providing the population of Ukraine with high-quality dietary protein. Based on the analysis of trends in the Ukrainian and European food markets since 2021, it was important to timely determine the vector of the poultry and meat industries' revival. First, even in European countries, producers need to focus on the demand of various population groups with different income levels, including low ones. Second, certain trends have been identified in the dynamics and structure of the global meat consumption towards an increase in the share of poultry meat. This has had a particularly noticeable impact on the structure of meat consumption in the European countries. Third, in non-European countries, the share of cheaper meat production was increasing, namely poultry and pork meat have an advantage, and the most expensive was cattle meat (Diachenko, 2020). The historical overview of the meat market emergence, development, and major actors was shown in Figure 1.

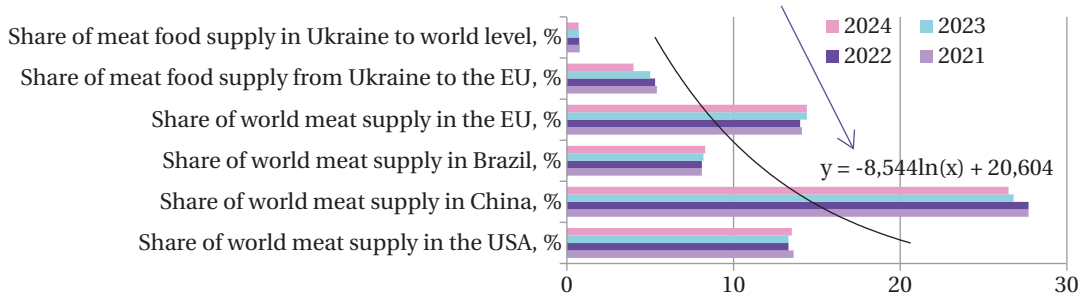

Figure 1. Share of meat food supply in the EU and Ukraine from the world level for 2021-2024
Source: based on OECD-FAO Agricultural Outlook 2024-2033 (2024), State Statistics Service of Ukraine (2024), P. Pyvovar & O. Rozhkov (n.d.)

The provided figure suggested that 26.5% of the global meat supply was contributed by China, while 16.6% were due to the USA – these two countries have been obtaining the largest shares of the world meat supply since 2021. In the analysed period, Ukraine's contribution to the global food market remained relatively low, but showed minor fluctuations; as for the country's share in the European food market, it was identified as modest. A logarithmic trend line suggested a gradual decline in Ukraine's relative share over the observed period, reflecting ongoing challenges amid external pressures, including economic crisis and functioning in wartime mode. The structure of the food supply of poultry meat in Ukraine differed from the EU countries. As seen from Figure 2, Ukraine has a significantly higher share in poultry (50.8%) compared to the EU (30.5%) and the global average. However, Ukraine's beef supply share of 16% lags slightly behind the European (16.5%) and the world average. Logarithmic trend lines showed a steeper upward trend for Ukraine in poultry production, suggesting accelerated growth in this segment. Based on the figure, Ukraine specialised in poultry, while beef production remained more aligned with broader regional and global patterns.

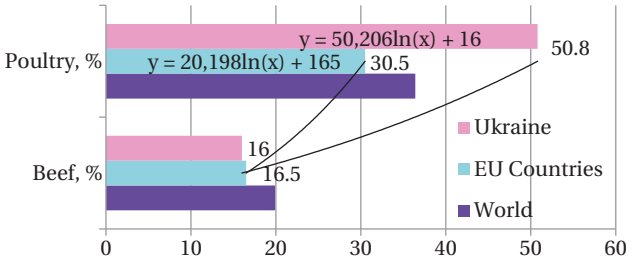

Figure 2. Structure of food supply of poultry and beef in the markets of Europe and Ukraine in 2024
Source: based on the OECD-FAO Agricultural Outlook 2024-2033 (2024), P. Pyvovar & O. Rozhkov (n.d.)

The growing Ukrainian share in the global poultry meat supply has become possible due to changes in the EU legislation, according to which batches of poultry and beef intended for human consumption can be imported into the EU only from enterprises approved by the State Food and Consumer Protection Service. As a part of its European integration strategy, Ukraine has switched in 2024 to using TRACES NT – the online platform of the European Commission for certification and support of export, import, and transit of animals, products of animal and plant origin, food, feed – which has significantly simplified the formal procedures for the export and transit of food products to the EU territory, when crossing the state border (The right to export livestock products to the EU…, 2025). As of 2023, specialists of the territorial bodies of the State Service for Food Safety and Consumer Protection were able to issue 20 types of certificates in TRACES NT, which allowed significantly shortening the issuance procedures and reducing the burden on exporters (Trusova *et al.*, 2023). In 2024, 38,481 certificates were issued using TRACES NT for goods sent to or through the EU territory, including 18,649 certificates for import into the EU, and 19,832 certificates for transit.

Commission Delegated Regulation (EU) No. 2021/1374 (2021) laying down specific hygiene requirements for food of animal origin provided for new possibilities adapted to the 2025 and to address the identified problems regarding the sale of poultry and meat products on the food market. Among other aspects, the main changes were relevant to the following aspects: the meat of ungulates criteria was introduced to avoid possible problems during transportation, regulating the slaughter of a small number of animals on the farm; "approval of a veterinarian" was replaced by "official veterinarian"; the food donation requirements were established for the freezing of meat of ungulates, poultry and lagomorphs in retail trade if they were intended for donation.

Regulation (EU) of the European Parliament and of the Council No. 2022/870 (2022) had supplemented the opportunities available to Ukrainian exporters under the Association Agreement between Ukraine and the EU. This decision, among other things, suspended all tariff quotas for agricultural products, which had become an incentive for Ukrainian producers. The liberalisation of trade relations, in turn, implied that Ukraine will comply with European rules: the origin of goods and relevant procedures within the framework of the Association Agreement, refraining from any new restrictions on imports from the EU, Ukraine's respect for democratic principles, human rights and fundamental freedoms, the rule of law, and the fight against corruption. These new rules will help Ukrainian producers and exporters withstand the burden of war and strengthen their positions on the European market.

As explained by Yu. Lupenko *et al.* (2021), the poultry and meat livestock industries of Ukraine, despite the instability of innovative activity, were trying to integrate advanced developments and adapt them to their own production. J. Rittirong *et al.* (2024) suggested that the emphasis was on the use of innovative and energy-renewable technologies utilising solar energy, wind energy, biogas plants, rational and efficient use of feed and improving its quality, the introduction of energy-saving and intensive technologies, modernisation, technical re-equipment and automation of the feeding process. Researchers T. Katkova & Y. Kravchik (2022) noted about the impact of the introduction of digital technologies at enterprises on production efficiency. Strategic task in the field of animal sciences involved the creation of intelligent farms, where the feeding processes and livestock management were combined. In meat livestock, an essential example and one of the basic concepts of Smart Farm involved the use of robotic animal feeding boxes, which encompassed the principles of building a balanced farm and fit the environmental requirements of safe production. The main working element of the robotic feeding system was a multifunctional manipulator, designed according to the principle of a human hand, which ensured the feeding process, regardless of the various shapes and locations of feed objects; for example, one robot was capable of serving an average of up to 70 animals (Ibatullin *et al.*, 2022). The mentioned approach allowed for equally effective control of many other technological factors in both large and small farms with an aim of enhancing animal productivity. Despite the martial law-related limitations, the introduction of innovative technologies in the beef cattle breeding segment preconditions an increase in the supply of products to the food market. This was evidenced by the data on the grouping of regions by the number of cattle per 100 hectares of agricultural land (Table 2).

Table 2. The impact of the density of livestock in beef cattle breeding on the volume of food supply of beef produced using innovative technologies in 2024

Indicators	Group of regions by number of livestock of meat cattle per 100 hectares of agricultural land			Total
	I	II	III	
	to 10	10.1-20	20.1 and more	
Number of regions in the group	8	10	2	20
Average livestock density by group, head	6.7	13.5	30.6	10.1
Food supply of beef using innovative technologies per capita, kg	5.6	12.6	15.7	8.8
Food supply of beef using innovative technologies per 100 hectares of agricultural land, kg	6.7	13	46.1	10.2
Beef consumption per capita, kg	7.2	10.8	11.1	8.1

Note: group I regions: Dnipropetrovsk, Kyiv, Kirovohrad, Mykolaiv, Odesa, Kharkiv; group II regions: Vinnytsia, Volyn, Zhytomyr, Lviv, Poltava, Rivne, Sumy, Ternopil, Khmelnytskyi, Cherkasy, Chernivtsi, Chernihiv; group III regions: Zakarpattia, Ivano-Frankivsk

Source: based on Organisation for Economic Co-operation and Development (2024), M. Bogonos *et al.* (2024)

According to the Table 2, for every 1% increase in beef cattle density, the food supply of beef produced with innovative technologies grows by 0.7% per person and by 0.9% per unit of land area. It was discovered that an enhancement in the livestock contributes to a statistically significant increase in the use of organic fertilisers, improvement of soil fertility and obtaining environmentally friendly agricultural raw materials. Thus, with an increase in the density of beef cattle per 100 hectares of agricultural land from 6.7 to 30.6 heads, the manure yield per 1 hectare of arable land increases by 7.8 times, respectively. Therefore, in regions, where livestock density was low – fewer than 10 heads per 100 hectares of agricultural land (specifically 6.7 heads) – there was a need to implement innovative measures to boost meat production and strengthen the country's food potential. The production of poultry meat was among the essential components contributing to the meat market supply in Europe. Commercial value was mainly represented by chickens, turkeys, ducks, or geese. Chickens have became the most widespread among domestic birds in Europe; the share of their meat has exceeded 85% of the total poultry meat production for more than 20 years (Fig. 3).

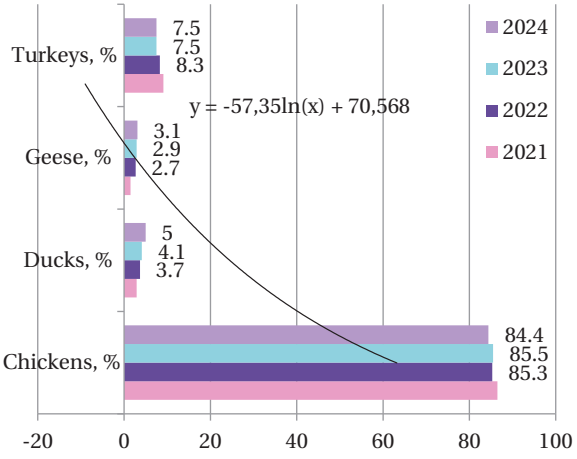

Figure 3. Structure of poultry meat food supply in Europe for 2021-2024
Source: based on Statistics (n.d.), State Statistics Service of Ukraine (2024), Data browser (2024)

The Figure 3 suggested that chicken meat production had remained the main segment of the European poultry meat supply chain. However, there was noticed a slight decrease in the share of this particular segment of the European poultry meat market – from 85.3% in 2021 to 84.4% in 2024. Decrease was also seen in the production of turkey meat – from 8.3% to 7.5%. However, upward trends were identified in the production of duck and goose meat – from 3.7% in 2021 to 5% in 2024 and from 2.7% in 2021 to 3.1% in 2024, respectively. Therefore, it was concluded that the European poultry meat supply had undergone some changes since 2021.

As of 2024, the poultry meat market in Ukraine remained among the key segments of the agricultural sector (State Statistics Service of Ukraine, 2024). Although the Russian military aggression against Ukraine had significantly affected the industry, especially in areas with major production facilities, most large producers could resume operations, and the market was gradually stabilising. The poultry meat market was showing positive changes by adapting to new conditions, in particular, through support from state and international programmes contributing to the restoration of the agricultural sector. The Ukrainian products were in demand in foreign markets, in particular in the EU and the Middle East, which added opportunities for export. However, the share of exports in total production decreased to 37.2% in 2024 compared to 2023 (Afanasyev *et al.*, 2024). Considering the structure of meat production in Ukraine using modern innovative technologies, the largest share (56.3%) fell on the poultry industry (BDO in Ukraine on poultry farming…, 2024). However, during military operations, poultry farms in regions, where innovations were actively implemented and production had increased still experienced negative impacts on their efficiency (Fig. 4).

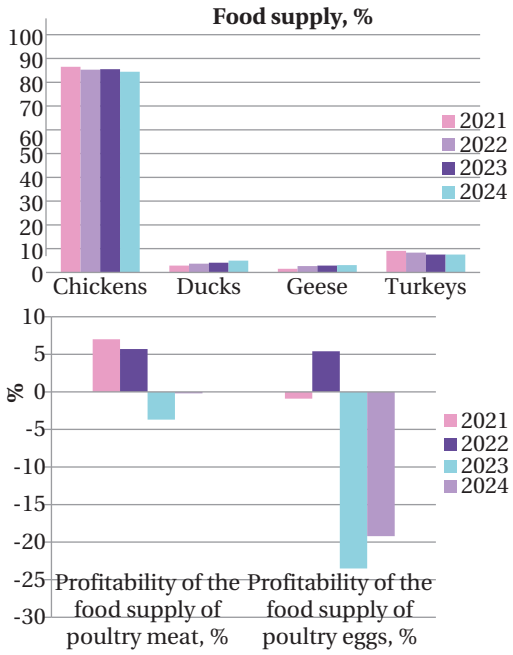

Figure 4. Efficiency of food supply in the poultry industry of Ukraine by innovative technologies in 2021-2024
Source: based on BDO in Ukraine on poultry farming: Market status, forecasts and opportunities for export (2024), V. Afanasyev *et al.* (2024)

Logistics in the poultry industry since February 24, 2022 has faced challenges due to the disruption of traditional transport routes, in particular in the South and East of Ukraine. At the same time, Ukrainian producers were actively using western border crossings and alternative routes through European countries, which allowed maintaining stability in the supply of products. However, poultry meat prices in Ukraine remained below the world level, which helped maintaining demand in both domestic and foreign markets. To a large extent, the formation of meat prices was influenced by the ratio of supply and demand for it and the solvency of the population. In 2021-2024, average prices across all sales channels changed significantly – to USD 1,578 per ton of poultry meat in live weight, or 2.1 times compared to 2021. Poultry meat sales prices by region of Ukraine were presented in Figure 5.

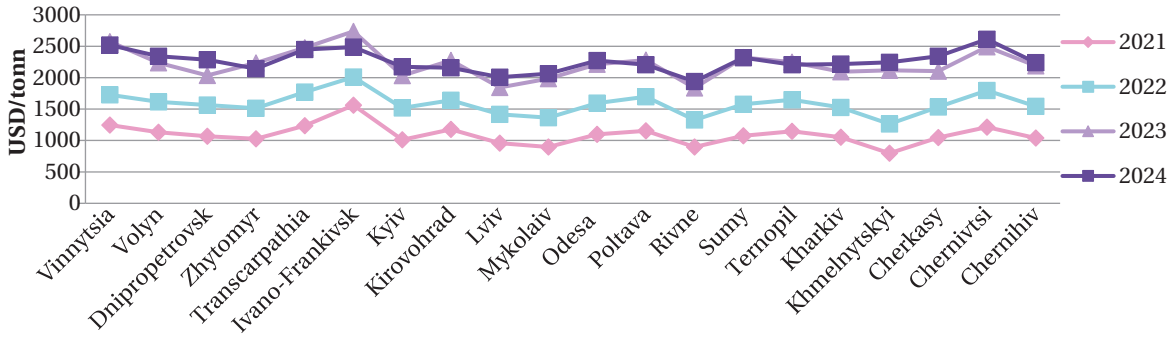

Figure 5. Selling price of 1 ton of poultry meat for 2021-2024
Source: based on BDO in Ukraine on poultry farming: Market status, forecasts and opportunities for export (2024), Organisation for Economic Co-operation and Development (2024), M. Bogonos *et al.* (2024)

Innovative technologies in the poultry industry continued to develop, despite safety challenges and economic hurdles. Large enterprises tend to modernise equipment, optimise production processes, and introduce new approaches and tools, including automation, to increase efficiency and reduce costs (Samoichuk *et al.*, 2016). One example suggested that work on poultry farms was a labour-intensive and monotonous process, which involved cleaning and disinfection, egg collection, and other operations, and that can be intensified and automated with the help of robots (Sychov *et al.*, 2024). The use of robots allowed cleaning and disinfecting poultry houses and created a map indicating the places, where the work is or was being performed. A constantly moving robot encouraged birds to move and teaches chickens not to lay eggs on the floor. In addition, the robot worked autonomously, constantly emits light and, if necessary, produced sounds or music. Another important aspect was the movement towards biosecurity of the farm, as human contact with birds was reduced. The econometric dependence of the innovative development indicators of the poultry and meat livestock industries in Ukraine was determined (Table 3).

Table 3. Data for determining the econometric dependence between the indicators of innovative development of the poultry and meat livestock industries of Ukraine

Years	Volume of retail turnover of poultry and beef by brand technologies, USD thousand	Volumes of consumption of poultry, thousand tons	Volumes of consumption of beef, thousand tons	Volume of food supply of poultry by innovative technologies, thousand tons	Volume of food supply of beef by innovative technologies, thousand tons
2021	148,301	2,112	1,874	2,517.8	2,047.8
2022	155,528	2,184	2,074	2,762.8	2,298.5
2023	246,604	2,178	2,178	2,809.4	2,244.7
2024	198,227	2,070	2,277	2,747	2,369.4

Source: based on M. Bogonos *et al.* (2024), T. Nakelse & E. Dennis (2024), Organisation for Economic Co-operation and Development (2024)

The econometric dependence and consequences of the correlations between the trade development indicator and the demand indicator were demonstrated in Figure 6. The graph illustrated a statistically significant relationship, suggesting that shifts in demand were closely associated with changes in trade dynamics. This correlation implied that an increase in consumer or market demand may serve as a driving force behind trade expansion. Understanding this interdependence helped to better predict economic outcomes and formulate responsive trade policies.

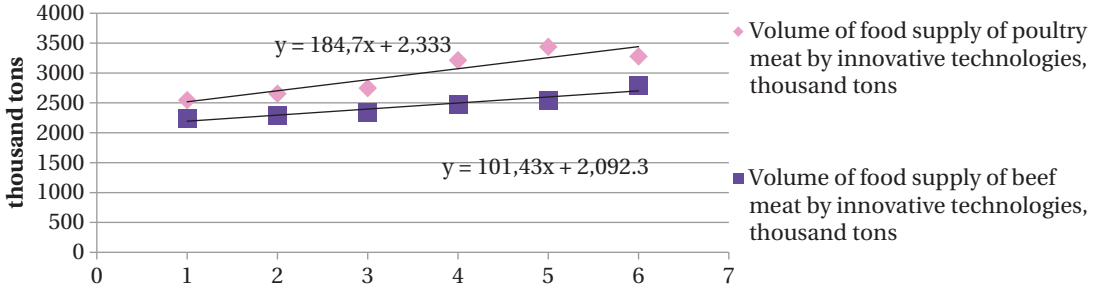

Figure 6. Econometric relationship between the trade development indicator and the food supply indicator of poultry and beef in Ukraine on average for 2021-2024
Source: based on P. Pyvovar & O. Rozhkov (n.d.), M. Bogonos *et al.* (2024)

The econometric dependence and effects of the correlations between the demand indicator and the supply indicator were demonstrated in Figure 7. The figure revealed a clear interrelationship, where changes in demand were closely mirrored by adjustments in supply levels. This suggested a dynamic equilibrium mechanism, in which supply responds to demand fluctuations over time. Such patterns were essential for understanding market stability and forecasting future trends in production and consumption.

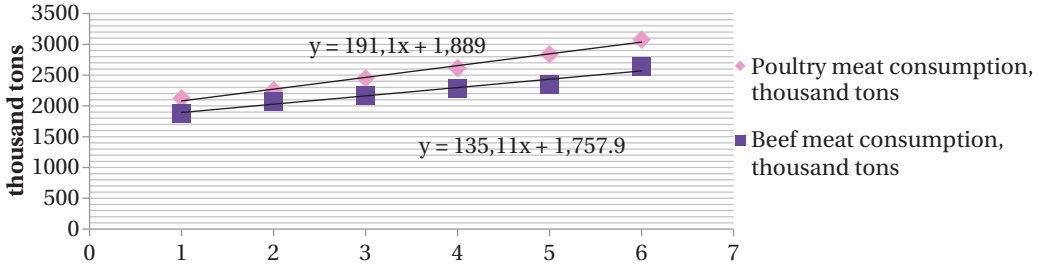

Figure 7. Econometric relationship between the demand indicator and the food supply indicator for poultry and beef in the markets of Ukraine on average for 2021-2024
Source: based on V. Afanasyev *et al.* (2024), P. Pyvovar & O. Rozhkov (n.d.), M. Bogonos *et al.* (2024)

At the same time, linear variables of poultry and beef consumption volume changed the annual production volume of products through the use of innovative technologies by 42.9%, respectively. The econometric dependence and consequences of correlations between the food supply indicator and the trade development indicator (retail turnover of poultry and beef by brand technologies in 2021-2024) were shown in Figure 8.

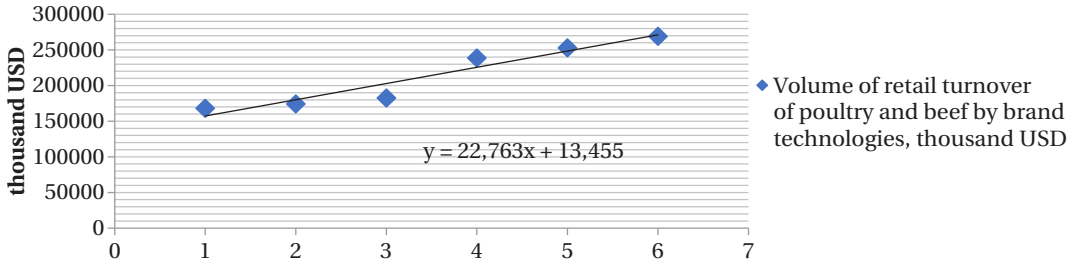

Figure 8. Econometric relationship between the food supply indicator and the trade development indicator in the poultry and beef market in Ukraine on average for 2021-2024
Source: based on Statistics (n.d.), V. Afanasyev *et al.* (2024), State Statistics Service of Ukraine (2024)

The linear regression model indicated that variations in poultry and beef consumption volumes explain 66.4% of the variance in annual meat production levels based on innovative technologies (R^2=0.664). The weight of each indicator of innovative development of the poultry and beef industries in the food markets of poultry and beef (v_i) will be as follows:

$$v_{reg.trade} = \frac{0.45}{1.93} = 0.23; v_{dem} = \frac{0.66}{1.93} = 0.34; v_{offer} \frac{0.82}{1.93} = 0.42, \quad (7)$$

$$\sum r = 0.45 + 0.66 + 0.82 = 1.93. \quad (8)$$

The calculation of each individual indicator of innovative development of the poultry and beef industries in the food markets of poultry and beef, on average per person, allows determining the reference region for each indicator, namely:

1. v_{dem} max = 30.2 kg – Dnipropetrovsk region (Southern region) ≈10 points.

2. v_{offer} max = 298.58 kg – Vinnytsia region (Central region) ≈10 points.

3. $v_{reg.trade}$ max = 14294.37 thousands USD – Kyiv region and Kyiv city (Central region) ≈10 points.

The mathematical expression for calculating the normalised score of each of the three indicators for the *i*-th region will be calculated as follows:

$$Na^i_{dem} = \frac{I^i_{dem} \times 10}{30.2}; Na^i_{offer} = \frac{I^i_{offer} \times 10}{298.58};$$

$$Na^i_{reg.trade} = \frac{I^i_{red.trade} \times 10}{14,294.37}. \quad (9)$$

The calculation of the weighted normalised score of each of the three indicators for the *i*-th region will be as follows:

$$UNa^i_{dem} = Na^i_{dem} \times 0.34; UNa^i_{offer} = Na^i_{offer} \times 0.42;$$

$$UNa^i_{reg.trade} = Na^i_{reg.trade} \times 0.23. \quad (10)$$

Taking into account the previous calculations, a mathematical model of an integral indicator of innovative development of the poultry and meat livestock industries in the food markets of poultry and beef has been formed:

$$I^i_{RMD} = \sum UNa^i_{dem} + UNa^i_{offer} + UNa^i_{reg.trade}, \quad (11)$$

where – separate *i*-th region in the food market of poultry and beef in the country.

The calculation of the integral index of innovative development in the poultry and meat livestock industries among the food markets of the Central, Northern, Southern and Western regions of Ukraine was shown in Figure 9.

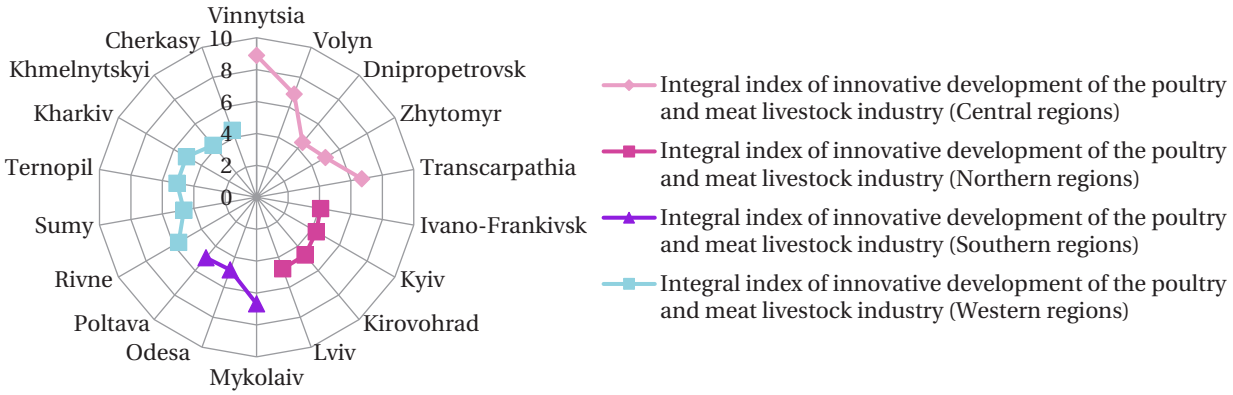

Figure 9. Integral index of innovative development of poultry farming and meat cattle breeding industries among the Central, Northern, Southern and Western regions of Ukraine on average for 2021-2024
Source: calculated by the authors

Regions with the highest poultry and beef consumption were the most attractive for producers. Conversely, the highest degree of market competition was observed in regions, where food products were widely supplied using innovative technologies. However, in these particular regions, the supply of such products surpassed the level of consumption. Accordingly, the lowest prices for products were observed, which, in turn, also stimulated the consumption of poultry and beef among other types of meat. The central region of Ukraine was the first in the rating for innovative development of the poultry and meat livestock industries, as it included two regions at once – Vinnytsia region as the leader in the volume of food supply of poultry and beef using innovative technologies, and Kyiv region being the leader in the volume of retail trade. The predictive assessment of the signs of a stable state of innovative development of entities in the poultry and meat cattle industries of the Central region of Ukraine took into account sufficient retrospective of indicators of the financial component in business entities to construct fuzzy-multiple parameters by weight indicators (Fig. 10).

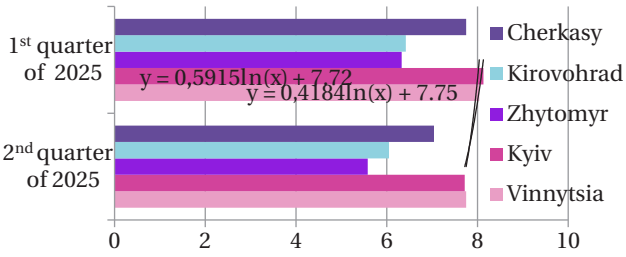

Figure 10. State of innovative development of poultry and meat cattle breeding entities in the Central regions of Ukraine for the 1st-2nd quarter of 2025
Source: based on I. Guzhva (2025), P. Pyvovar & O. Rozhkov (n.d.)

The results suggested that in the first quarter of 2025, only 52 business entities from three regions of the Central part of Ukraine – Vinnytsia, Kyiv, and Cherkasy – had a sufficiently stable state of innovative development of the poultry and meat livestock industries – 7.75; 7.72; 7.04, respectively. Among the regions in the central part of Ukraine, two regions – Vinnytsia and Kyiv regions – retained their leading positions in the food market. For the second half of 2025, a significant application of the financial component of the innovative development of the poultry and meat livestock industries was planned, where business entities in these regions were actively adapting to the European market requirements for meat products. Such adaptation made it possible to increase the index to a very stable state through the regulation of strategic positions and strengthening of competitive advantages within the values of 8.04 and 8.13, respectively.

Thus, establishing a stable trajectory of innovative development over time and determining optimal conditions for its support in the poultry and meat livestock industries can shift the balance of influencing factors. Depending on the time dimension, the state of innovative development may follow one of three possible scenarios: a decline, a stable level, or a growing equilibrium. Accordingly, changes in innovative development were likely to occur gradually, influenced by moderate structural adjustments in financial components – particularly under the most favourable scenario, which assumed successful mitigation of the post-war crisis in the poultry and meat livestock sectors.

Discussion

Among the key ideas introduced in this paper, one was about the growing global demand for poultry and meat and the role of technology in addressing it. The idea was, for instance, reflected in Figure 1 of this paper comparing the share of meat supply in Ukraine, the EU, Brazil, China, and the USA. The case of Ukraine also illustrated that integration into the European or global market was connected with the need to increase meat production volumes. Several examples introduced in the paper suggested that Ukraine had already made a step toward integrating innovative approaches to meat production by, for example, using robots to clean chicken coops, make chickens move, and control the hatching of eggs so to increase production volumes. The significance of technology in maintaining or growing the volume of meat production was further confirmed in previous studies, including A. Suychinov *et al.* (2024). While using Slovakia as

a context, the cited experts acknowledged the significance of AI-powered strategies, including precision biotechnology, for addressing consumer needs in certain amount of meat. The study of the researcher was considered relevant to the this research, considering economic, cultural, and other similarities between the Ukrainian and Slovak contexts. Some consistency was also detected between the study of Q. Sun *et al.* (2025) and this research, since both examined the use of innovative strategies and tools in growing meat production volume. The study of Chinese meat production context allowed Q. Sun *et al.* (2025) to conclude that the integration of AI agents into supply chain management and intelligent control systems leads to a 26.89% increase in overall profits. The work of scientist was relevant to this study because according to the above cited data, Chinese agricultural segment accounts for around one-third of the global meat production. The data meant that Chinese farmers had accumulated sufficient experience in the meat production segment, which can be partly or completely adapted to the Ukrainian context. Another reason was that the study of Q. Sun *et al.* (2025) introduced strategies to increase overall profits without compromising production quality standards; and the obtained insights might be partly integrated into the Ukrainian agrarian segment striving to maintain resilience amidst the war-era turbulence.

This paper also elaborated on the idea that integrating the Ukrainian agrarian segment into the European food market implied an adherence to the EU production standards and quality requirements. This idea, which was examined in the context of the EU legislative acts, rests on the assumption that customers tend to buy foods produced in compliance with universal quality, ethics, and sustainability requirements (Karatieieva *et al.*, 2024). In this regard, there was noticed a consistency between this research and the study of P. Castellani *et al.* (2025) examining customers' motivation for purchasing lab-grown meat. Experts discovered that, while the relationship between the perceived higher environmental sustainability and customers' intention to buy lab-grown meat remained unclear, peculiarities of the meat production process still play an essential role in a purchasing decision-making process. A partial consistency was found between the work of P. Castellani *et al.* (2025), focused on the lab-grown meat production, and this work exploring the peculiarities of sustainable poultry and meat production in the context of technological advances. The idea of using technology for sustainable meat production was also explored by L. Woelken *et al.* (2024), who interviewed 11 experts to detect the factors shaping the cultivated meat production. Based on the interview data, the experts argued that the use of innovative practices lowers production costs and cultural barriers. The latter effect of particularly important for the Ukrainian agrarian segment seeking flexibility as a way to navigate the turbulent market, stay competitive, and maintain sustainable development.

This paper further took an in-depth look into the role of technology in cutting costs of meat production, since this strategic goal was considered relative in the Ukrainian context. Lowering costs and toxicological evaluation of meat not only helps to maintain an adequate standard of living for the population affected by the war, but also to stay competitive, while integrating into the European and global market (Tkachuk *et al.*, 2023). The idea of a relationship between technology and meat production cost was confirmed in previous research, including the work of A. Samad *et al.* (2024). The authors argued that the use of technology can cut costs by producing restructured meat with increased shell life. Despite some consistency noticed, it was worth stressing that compared to the present research, the study of this researchers had a considerably narrower focus on restructured meat, the pricing features of which might be somewhat different from the pricing features of the traditional meat production. Logical parallels were also drawn between this research and the study of Y. Deng *et al.* (2024) exploring the use of technology in processing of rabbit meat. Scientists argued that innovative tools might be applied in such critical processes as deodorisation, texture adjustments, and water retention, where any transformation was closely related to the end-product price. In spite of existing similarities, it should be stressed that this study and the research of Y. Deng *et al.* (2024) differed in their focus, which might affect the transferability of obtained results. L.K. Hernandez-Murillo & F. Galan-Mendez (2024) argued that integrating technology into meat production and processing processes can cut costs through the adoption of sustainable practices. As explained by this researchers, advances in thermal and non-thermal treatments increase productivity, yield, and quality, while ensuring effective allocation of available resources. The study extended the scope of the present discourse by elaborating on the strategies to cut costs in the meat processing, which follows immediately after the meat production process. Hence, most obtained results found their confirmation in previous research studies, which meant this work has fit into the already existing academic discourse. This paper, however, had also made its own contribution to the field due to its specific focus on the poultry and meat production segment of the Ukrainian food market. While exploring the Ukrainian context, this paper had provided insights into maintaining competitiveness and sustainable development of certain economic segments amidst turbulence.

▸ Conclusions

The research revealed that the Ukrainian poultry industry was gradually stabilising despite the war-caused disruptions. As of 2024, poultry accounted for 56.3% of the total meat production in Ukraine, indicating its dominant role in the sector. The export capacity remained resilient, with 38,481 TRACES NT certificates issued for goods exported or transited through the EU. However, the share of poultry exports had decreased to 37.2% since 2021, reflecting wartime limitations and market shifts. Econometric analysis confirmed a strong relationship between innovation and output: variations in poultry and beef consumption volumes explained 66.4% ($R^2 = 0.664$) of the variance in annual meat production through innovative technologies. Additionally, every 1% increase in livestock density per 100 hectares resulted in a 0.7% rise in per capita beef supply and a 0.9% increase per land unit. The data also suggested a positive ecological outcome, with manure yield per hectare increasing 7.8 times as livestock density rose from 6.7 to 30.6 heads.

The study also identified regional leaders in innovation: central regions, especially Vinnytsia and Kyiv, ranked the highest in terms of food supply, retail trade, and overall innovative development index. The analysis further highlighted the role of robotic automation, AI-driven livestock monitoring, and smart farming systems in transforming both large-scale and smallholder operations. For instance, robotic feeding systems can serve up to 70 animals per robot, enhancing productivity and aligning with EU biosecurity standards. Hence, innovation in Ukraine's poultry and meat livestock industries was not only feasible, but also vital for economic recovery, food sovereignty, and international competitiveness. Strategic investments, coupled with regulatory alignment and region-specific support, can ensure a sustainable and resilient future for the sector. Limitations of the study include restricted access to primary data from regions directly impacted by military actions, which may affect the representativeness of some regional comparisons. Future research should explore the long-term effects of technology adoption on cost-efficiency and environmental sustainability in meat production under martial law conditions, with a focus on modelling different integration scenarios into the European food market.

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Conflict of Interest
None.

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Активізація інноваційного розвитку птахівництва та м'ясного тваринництва на продовольчому ринку України

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► **Анотація.** У цій статті досліджено особливості впровадження інноваційних технологій у птахівництві та м'ясне тваринництво – важливі елементи українського продовольчого ринку. Мета була досягнута шляхом контекстуального аналізу галузевих звітів, вивчення європейського законодавства та оцінки сегментів птахівництва та м'ясного виробництва України з погляду індексу попиту на продовольство, індексу пропозиції продовольства та індексу розвитку регіональної торгівлі. Незважаючи на військову кризу, українська м'ясна промисловість продемонструвала стійкість та потенціал для сталого розвитку, причому птахівництво становило 56,3 % від загального сегмента. Однак інтеграція українського м'ясного виробництва в європейський сегмент залишалася скромною, незважаючи на отримання 38481 сертифікатів TRACES NT: у 2024 році частка експорту птиці зменшилася на 37,2 % порівняно з 2023 роком. Економетричний аналіз виявив статистично значущий зв'язок між інноваціями та обсягом виробництва в національному сегменті м'ясопереробної промисловості, причому 66,4 % коливань у річному споживанні птиці та яловичини пов'язані з інноваційними технологіями. Також було виявлено зв'язок між використанням інноваційних технологій і зниженням виробничих витрат, а також між інноваційними підходами і дотриманням принципів сталого розвитку. Інтеграція інноваційних технологій не була однаковою по всій країні: центральні регіони Києва та Вінниці мали найвищі рейтинги інноваційності, з потенціалом отримання інтегральних значень індексу до 8,13. Крім того, було виявлено, що використання технологій може сприяти раціональному розподілу ресурсів: один робот може обслуговувати до 70 тварин, що звільняє людські ресурси для виконання більш технологічних завдань. Отримані результати можуть бути використані для підвищення ефективності діяльності, посилення конкурентоспроможності та підтримки сталого розвитку українського продовольчого ринку

► **Ключові слова:** інноваційні технології; галузь скотарства; економетрична залежність; ланцюг постачання; нечітке моделювання