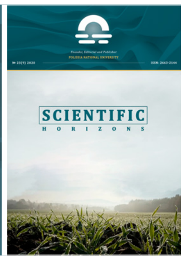
SCIENTIFIC HORIZONS

Journal homepage: https://sciencehorizon.com.ua

Scientific Horizons, 28(8), 192-205

UDC 338.436:636.085

DOI: 10.48077/scihor8.2025.192



Economic efficiency of preservation and utilisation of livestock products in the agrarian sector of the economy

Elmira Kuzenbayeva

Doctoral Student
Zhetysu University named after Ilyas Zhansugurov
040009, 187A Zhansugurov Str., Taldykorgan, Republic of Kazakhstan
https://orcid.org/0000-0002-8696-5027

Gulnara Tuleshova*

PhD in Economic Sciences, Head of Department
Zhetysu University named after Ilyas Zhansugurov
040009, 187A Zhansugurov Str., Taldykorgan, Republic of Kazakhstan
https://orcid.org/0000-0002-4567-4418

Article's History:
Received: 27.01.2025
Revised: 25.07.2025
Accepted: 27.08.2025

Abstract. The purpose of this study was to investigate the ways of increasing the economic efficiency of agricultural production by improving the systems of preservation and rational use of livestock products. The methodological framework of the study included a comprehensive approach, as well as the analysis of statistical data, structural-dynamic and comparative analysis, and elements of system and factor analysis. Gross output of livestock production in Kazakhstan increased from KZT 2,066.4 bn in 2015 to KZT 3,012.5 bn in 2023. Therewith, the number of cattle increased from 6.18 mn heads in 2015 to 7.98 mn heads in 2024, while the number of horses more than doubled from 2.07 mn heads to 4.35 mn heads over the same period. The analysis results showed that despite the steady growth in herd numbers and gross output, the efficiency of conservation is still at an average level. This is related to the deterioration of refrigeration infrastructure, poor development of the cold chain, lack of qualified personnel, insufficient digitalisation of logistics processes, and specific climatic features of the regions. Milk production volumes have almost halved. Losses at the storage and transport stages are also reflected in the decline in egg production from 5.59 bn eggs in 2018 to 4.48 bn in 2024. The study substantiated those investments in the modernisation of storage infrastructure, digitalisation of logistics, and development of deep processing are not excessive costs, but a tool to optimise the production process and increase the sustainability of agribusiness. The following strategic development areas were also proposed: development of agro-industrial clusters, development of cooperation, improvement of personnel skills, expansion of state support, and introduction of environmentally sustainable technologies. It was concluded that increasing the level of safety of livestock production in Kazakhstan can not only reduce losses, but also increase the profitability of farms, strengthen the food security of the country, and its export potential

Keywords: storage infrastructure; logistical constraints; digitalisation; climatic conditions; quality control

Suggested Citation:
Kuzenbayeva, E., & Tuleshova, G. (2025). Economic efficiency of preservation and utilisation of livestock products in the agrarian sector of the economy. *Scientific Horizons*, 28(8), 192-205. doi: 10.48077/scihor8.2025.192.

**Corresponding author*

INTRODUCTION

The agricultural sector of the economy plays a key role in ensuring food security, providing jobs and sustainable development of rural areas. One of its crucial elements is animal husbandry, which is a source of high-quality protein, raw materials for processing, and the key element in the structure of agricultural production. However, despite major efforts aimed at the development of this sector, the problems of preservation and utilisation of livestock products are still topical and require a comprehensive approach. A prominent aspect is that a considerable part of products is lost at various stages – from collection to processing and transport. This is related to both insufficiently developed storage technologies and inefficient logistics, which leads to quality losses and increased costs. All these factors directly affect the economic efficiency of livestock production and constrain its potential for growth. Thus, effective management of the preservation and utilisation of livestock products becomes a prerequisite for increasing the competitiveness of agriculture, reducing losses, and increasing the profitability of agricultural enterprises.

In the scientific environment, there has been a steady growth of interest in the issues of increasing efficiency in the agricultural sector through improving the processes of storage and utilisation of livestock products. L. Zhang *et al.* (2021) focused their research on meat deep freezing technologies and found that the introduction of low-temperature controlled atmosphere chambers reduced specific product losses to a minimum. The researchers emphasised that such investments pay off not only by stabilising product quality, but also by reducing returns from retailers and expanding geographical distribution. T. Espolov *et al.* (2020) complemented these findings by focusing on weak links in supply chains in agricultural regions, especially in remote and hard-to-reach farms. The researchers proved that improving transport infrastructure and reducing the delivery time from processing to the consumer can improve the profitability of dairy production and increase the realisation period of products. G. Kandeepan and A. Tahseen (2022) investigated active packaging methods and concluded that the use of oxygen-isolating and modified gas media in packaging of meat products helps to maintain organoleptic properties, nutritional value, and microbiological stability over a sustained period. M.A.F.M. Fadzli and S.W.B. Nawawi (2024) proposed the design and implementation of automated systems for monitoring storage parameters such as temperature, humidity, and ventilation, showing that such solutions markedly reduce storage losses, especially in large agro-industrial complexes with large volumes of products.

D. Wang *et al.* (2022) considered the influence of climatic and seasonal factors on product preservation and proposed adaptive storage strategies depending on climatic zone and seasonal variations. This ensured more efficient utilisation of storage facilities, reduced energy costs, and reduced risks of product spoilage during periods of hot temperature or high humidity. J. García-Díez *et al.* (2023) showed the high significance of veterinary and sanitary control as a factor that indirectly but substantially affects economic losses: prompt detection of diseases in animals reduces the risks of rejects at the slaughter and processing stage and prevents the spread of infections that threaten the integrity of the entire lot. M. Taifouris and M. Martín (2022) investigated economic models for integrating livestock farms with processors and argued that such a system allows logistics and storage to be organised without the losses and costs that occur at the interface of the value chain. The researchers emphasised that vertically integrated structures are more resilient to external shocks and reallocate resources more efficiently. R. Gabdualiyeva *et al.* (2024) focused on digitalisation of processes – their modelling showed that farms that implemented digital residue management, predictive analytics, and real-time quality control had fewer losses due to product spoilage and more accurate forecasts of production and sales volumes.

A.S. George and A.S.H. George (2023) investigated automated climate systems in storage warehouses and found that their use had a significant effect on the quality stability of meat products during long-term storage. The researchers emphasised that precise microclimate control avoids microbiological risks, preserves the marketability of products, and avoids added costs for sorting and processing of spoiled batches. R.S. Alibekov *et al.* (2024) supported an analogous view, focusing on technologies for deep processing and recycling of meat residues. The researchers concluded that the processing of by-products and by-product components into semi-finished products and feed not only reduces losses, but also allows obtaining products with high added value, thereby increasing the profitability of production.

Thus, the accumulated scientific experience demonstrates a steady tendency to recognise the value of preservation and rational use of products as key factors in increasing the overall efficiency of agricultural production. Despite great strides in the field of increasing the efficiency of preservation and utilisation of livestock products, several key aspects are still understudied. There is a lack of comprehensive research that would integrate innovative technologies of storage and processing of products considering the specifics of agrarian enterprises. Little attention is paid to the economic consequences of introducing environmentally friendly and energy efficient preservation methods, which could reduce costs and increase competitiveness. Thus, the purpose of the present study was to analyse the methods of increasing the economic efficiency of preservation and use of livestock products in the agricultural sector.

MATERIALS AND METHODS

The study employed a comprehensive methodological approach that combines quantitative and qualitative analyses of the livestock production safety system in the agrarian sector of the Republic of Kazakhstan. Official statistical materials of the Bureau of National Statistics (n.d.) for 2015-2023, as well as for 2024 – for certain types of indicators, for which updated data were available at the time of the study, were used as the primary source. Indicators of gross output of agricultural production overall and livestock production specifically, as well as the number of farm animals were analysed up to 2023 inclusive. This is because the data on these categories require further processing, reconciliation with administrative sources, and are often published with a time lag. At the same time, such indicators as volumes of production of the key types of livestock products – meat (in slaughter weight), milk, eggs, and wool – were considered up to 2024 inclusive. This is conditioned by the fact that data on these categories are published earlier and have a lower degree of detail. Additionally, the analysis included regulatory documents of the Ministry of Agriculture of the Republic of Kazakhstan (n.d.), including Order of the Minister of Agriculture of the Republic of Kazakhstan No. 3-4/617 (2014). This helped to compare actual and normative levels of losses, identify potential deviations, and assess the level of technological support of the industry.

The method of factor analysis was employed to assess the impact of individual elements of storage infrastructure on the overall level of safety of livestock products. Within the framework of the analysis, the study used data from reports of the Ministry of Agriculture of the Republic of Kazakhstan (n.d.). Storage conditions in different climatic zones of the country were analysed, considering the high continental nature of the climate, seasonal temperature fluctuations, and the length of transport routes. Qualitative analysis was aimed at identifying organisational, managerial, and institutional constraints affecting the efficiency of livestock products use. The mechanisms of interaction between producers, transport operators, and processors, the presence or absence of cooperation, problems of planning logistics routes, and compliance with sanitary norms were considered. State support measures were also analysed: subsidies for modernisation of storage facilities, the programme "Auyl – El besigi" (Improving the quality…, 2019), soft loans, investment subsidies, and digitalisation of agricultural product management.

Practices demonstrating the influence of climatic and infrastructural factors on the safety of livestock products, as well as the effectiveness of digital solutions and development programmes in the agricultural sector were investigated. Case studies were used as a basis for the study, including the ColdHubs project in Nigeria (How can sustainable…, 2022), as well as the Sustainable Livestock Development Programme in Kazakhstan for 2022-2026 (Kazakhstan: Sustainable livestock…, 2021) and the implementation of SAP S/4HANA in Eurasia Group Kazakhstan to optimise logistics and inventory management (SAP S/4HANA migration…, n.d.). Furthermore, initiatives on advanced processing of products were considered: Kraft cheese making in Zhambyl region (42 farms of Zhambyl…, n.d..) and processing of meat products in East Kazakhstan (Construction of a deep…, 2025). The study also analysed examples of vertical integration – the structure of Zhaiyk Et (n.d.) and the closed production cycle at Aknar PF (n.d.). Additionally, data from a Carrier Global Corporation report indicating meat losses in countries with poor cold infrastructure were used (BIO Intelligence Service for the Global Food Cold, 2015). As a result, the combination of statistical, regulatory, and expert-analytical sources helped to reasonably identify key constraints and growth points in the sphere of ensuring the safety of livestock products in Kazakhstan.

RESULTS

Product safety in the agricultural sector is a multidimensional economic and technological phenomenon characterised by the ability of economic entities to minimise both quantitative and qualitative losses at all stages of the agro-production chain – from the moment of production to final consumption. This problem is especially relevant for livestock products, which have a limited shelf life, are sensitive to external influences and subject to rapid biochemical decomposition (Casino *et al.,* 2021). That is why the issues of preservation require a comprehensive, systematic, and scientifically based approach, including both technological solutions and organisational and economic measures. From the economic standpoint, product safety is the crucial factor determining the level of efficiency of agricultural production. Losses resulting from violations of temperature conditions, sanitary norms, technological failures, or deficiencies in logistical organisation led to increased production costs, reduced marketable yields and, as a consequence, lower farm profits (Focker & van der Fels-Klerx, 2020). Thus, investments in increasing the level of preservation are not considered as excessive costs, but as an effective mechanism to optimise the production process and strengthen the financial sustainability of agricultural enterprises.

Furthermore, a prominent level of product preservation provides agricultural producers with more opportunities within the framework of implementing a flexible marketing strategy. Modern storage infrastructure allows not only reducing the share of losses, but also regulating the volumes and terms of deliveries, adapting to market conditions. This allows building inventories for sales during periods of peak demand, expand sales channels, and enter distant markets. In an environment of price volatility and high competition, such flexibility becomes a valuable tool for profitability management (Nayak & Bagchi, 2022). Hence, preservation acts not only as a means of reducing losses but also as a factor for sustainable agribusiness development. From a macroeconomic standpoint, the conservation of livestock products contributes to sustainable resource utilisation and food security. Each unit of lost production means not only economic loss, but also inefficient use of invested resources – labour, feed, water, energy, and capital. In this context, losses in the agricultural sphere become an indicator of systemic imbalances that hinder the transition to sustainable and resource-efficient agriculture. Increasing the level of conservation, on the contrary, forms the prerequisites for greening production, improving the food balance and increasing the competitiveness of products in internal and external markets (Qian *et al.,* 2022).

The factors that determine the level of losses of livestock products have both biological and technical-economic nature. One of the most significant is the microbiological instability of products of animal origin, which causes their high sensitivity to even minor deviations from the recommended temperature, humidity, and sanitary storage conditions. In the absence of effective cooling, freezing, and hermetic packaging systems, the risk of biochemical decay, deterioration of organoleptic characteristics and, as a consequence, commercial unsuitability of the product increases significantly (Neethirajan, 2020). This is especially critical for dairy and meat products, which require strict adherence to temperature standards at all stages of transport and storage (Sattarov *et al.*, 2025).

Apart from biological constraints, technical and infrastructural constraints play a major role. In many countries, especially in developing regions, small and medium-sized farms face a shortage of modern refrigeration facilities with automatic climate control. This constraint substantially reduces the resilience of agricultural supply chains, forcing farmers to sell products at shorter lead times and at less favourable prices, which, in a volatile market environment, reduces their profitability and increases losses. One example is the ColdHubs initiative in Nigeria, where farmers rent solar-powered cold rooms at around USD 0.50 per day per plastic crate. This has saved over 42,000 tonnes of agricultural produce, minimising spoilage losses and increased the income of 5,240 smallholder farmers, retailers, and wholesalers by 50% (How can sustainable..., 2022). A comparable situation was observed in Rwanda, where the lack of infrastructure for cold storage resulted in high post-spoilage losses. In response, the government and international organisations started to actively adopt energy efficient technologies, including solar-powered refrigeration, to improve food security and income stability for farmers (Twilley, 2022).

Organisational and management aspects also considerably influence product safety. Inadequate staff qualifications, lack of internal quality control standards, inconsistent logistics processes, and planning errors lead to the accumulation of losses at production and marketing interfaces. Furthermore, poorly developed inter-linkage mechanisms between producers, transport operators, and processing organisations substantially hinder the prompt marketing and processing of products, reducing their commercial value (Shepherd *et al.,* 2018). Natural and climatic conditions drastically affect the safety of livestock products, as extreme temperature fluctuations create stressful conditions for animals and complicate the maintenance of optimal microclimate in the places where they are kept. In Kazakhstan, sharp seasonal temperature fluctuations, when summer heat can reach 41°C and winter frosts can drop to -48°C, cause temperature imbalance, which leads to poor health and reduced productivity of animals. In southern regions with hot summer temperatures above 30°C and relatively mild winters down to -3°C, farmers face the need for constant cooling and ventilation to prevent overheating or overcooling of produce (Syzdykova, 2024). Despite the use of shade canopies, fans, and water spray systems, these methods may not be sufficiently effective and may require extensive energy inputs, which hinders stable climate control and increases the risk of spoilage, reducing product quality and shelf life.

Modern approaches to the rational use of livestock products, which include the introduction of smart storage technologies with automatic microclimate control, the use of biotechnology to improve product quality and shelf life, the use of digital systems for monitoring and controlling production processes, and the development of integrated processing, imply not only minimising losses but also increasing economic returns through deeper processing, technological innovation, and digitalisation of management. In an increasingly competitive and resource-constrained environment, the transformation of production models from raw material-oriented to value-added production is of particular relevance (Leah *et al.,* 2023). Deep processing of meat and dairy raw materials produces a wide range of finished products, from semi-finished products to specialised food and feed products.

Modern software solutions, including Enterprise Resource Planning (ER) systems, implemented in agricultural enterprises of Kazakhstan, contribute to a marked increase in the efficiency of inventory management and reduction of product losses. For instance, Eurasia Group Kazakhstan, an official dealer of agricultural machinery, successfully implemented a project to migrate to SAP S/4HANA platform, which allowed it to upgrade its IT infrastructure and stabilise critical business processes. According to the company, it is expected to increase data accuracy by up to 15% and reduce order processing and warehouse transaction times. This transition enabled the integration of new SAP functions and tools, improving resource management and data processing agility (SAP S/4HANA migration…, n.d.). Additionally, the Sustainable Livestock Development Programme for Kazakhstan 2022-2026, supported by the World Bank, makes provision for the introduction of an improved animal recording and tracking system. This will improve the efficiency of veterinary services and livestock resource management, which helps to reduce losses and improve product quality (Kazakhstan: Sustainable livestock…, 2021)

In Kazakhstan, where many farms are located in remote or sparsely populated areas, advanced processing helps to significantly increase profitability by creating long-life products such as cheese, dried meat, and milk concentrates, which reduces dependence on perishables (Bogoyavlenskiy *et al.*, 2022). For example, farmer cooperatives in Zhambyl region are introducing the production of kraft cheeses, which not only allows them to preserve products longer, but also to enter new markets with higher added value (42 farms of Zhambyl…, n.d.). A large deep meat processing project is underway in East Kazakhstan, which helps to reduce logistics costs and minimise losses during long-distance transport. Construction of a KZT 7.7 bn industrial complex has begun in the village of Chekoman, Zhanasemey district, Abay region. The project envisages processing up to 35 tonnes of meat products per shift, including beef, mutton, and horse meat, with the production of high-quality sausages, canned goods, semi-finished products, and meat delicacies. The complex will be equipped with modern Australian and European technologies ensuring zero-waste production and compliance with environmental standards (Construction of a deep…, 2025).

The development of biotechnologies and waste-free processing should be emphasised among the promising solutions. The use of enzymatic and microbiological methods allows using animal waste – blood, fat, bones – to produce fodder, biologically active additives, and fertilisers. These approaches not only reduce the environmental load but also form closed production cycles that meet the requirements of sustainable agricultural development (Lainawa *et al.,* 2024). The digitalisation of storage and marketing processes is also becoming a key element of product stewardship. The implementation of automated systems for monitoring shelf life, temperature conditions, and logistics flows in agricultural enterprises can markedly improve the accuracy of management decisions. For example, the use of big data-based platforms such as IBM Food Trust or SAP Business Network for Logistics enables real-time monitoring of product condition and storage conditions, which reduces losses and optimises the distribution of goods. Thanks to analytical tools, companies can predict demand fluctuations and adapt production and logistics, which reduces costs and increases efficiency.

Organisational forms of cooperation, such as agro-industrial clusters, logistics centres, and agricultural cooperatives, ensure a more efficient allocation of resources and bring producers and processors together. There are already successful examples of vertical integration in Kazakhstan, where unified value chain management ensures quality control at all stages, from farm to consumer. One such example is Zhaiyk Et (n.d.), which covers all regions of the country and demonstrates the effectiveness of vertical integration, ensuring economic sustainability, and quality control of products. Another example is Aknar PF Group (n.d.), which rehabilitated and modernised a poultry farm in the Karaganda region, introducing the concept of a closed production cycle 'from field to fork'. In regions with extreme climatic conditions, the development of cold chain infrastructure is critical to ensure the safety of livestock products. Key elements that must be prioritised included refrigerated warehouses, refrigerated transport, and energy-independent plants that can maintain a stable microclimate during transport and storage. A study by Carrier Global Corporation indicates that in developing countries, including Kazakhstan, meat losses due to inefficient or non-existent cold chains are around 10%. This results not only in economic losses for producers, but also in lower quality products, which affects their market value and safety for consumers (BIO Intelligence Service for the Global Food Cold, 2015). The development of cold infrastructure, including the construction of modern refrigerated warehouses and the introduction of refrigerated transport, will significantly reduce product losses, improve product quality, and increase shelf life.

Greening of the agricultural sector is also becoming a vital area. Sustainable use of resources, waste minimisation, optimisation of logistics, reduction of water, and energy consumption – all this is becoming part of the modern paradigm of agricultural production (Mamenko *et al.*, 2024). The implementation of international environmental standards and certifications not only improves internal efficiency but also opens access to external markets where demands for sustainable products are increasing (Bhatti *et al.,* 2024). The livestock industry in the Republic of Kazakhstan occupies a prominent place in the agrarian sector of the country's economy. It has historically been one of the key branches of agriculture, providing a sizeable share in agricultural production (40%) and being of great significance for food security and sustainable economic growth. Table 1 presents the gross output of agricultural products (services).

Analysis of the data in Table 1 shows a stable trend of growth in gross output of agricultural products in the Republic of Kazakhstan in the period from 2015 to 2022, with an increase in volumes from KZT 3,307 bn to KZT 8,367.7 bn. However, in 2023, a decrease in the indicator to KZT 7,576.5 bn was recorded, which may suggest the influence of external economic or climatic factors. The dynamics of livestock production shows a positive trend throughout most of the period, with particularly notable growth observed in 2020-2021. However, there is a decline in volumes in 2022, followed by a recovery in 2023 to KZT 3,012.5 bn. This underscores the vulnerability of the industry to organisational, economic, and natural conditions. Against the background of considerable growth in crop production, livestock farming demonstrates less sustainable rates of development, which necessitates the need to improve the efficiency of storage, logistics, and processing of livestock products as a reserve for stabilisation and strengthening of the sector. Table 2 presents the gross output of livestock products by type.

***Table 1**. Gross output of agricultural products (services) in Kazakhstan for 2015-2023, KZT bn*

	2015	2016	2017	2018	2019	2020	2021	2022	2023
Agriculture	3,307	3,684.4	4,070.9	4,474.1	5,151.2	6,334.7	7,515.4	8,367.7	7,576.5
Horticulture	1,825.2	2,047.6	2,249.2	2,411.5	2,817.7	3,687.3	4,387.2	5,808.3	4,552.4
Animal husbandry	1,469.9	1,621.5	1,810.9	2,050.5	2,319.5	2,637.5	3,117.0	2,545.3	3,012.5
Agricultural services	11.8	15.3	10.8	12.1	14.0	9.9	11.2	14.2	11.6

***Source:** compiled by the author of this study based on Bureau of National Statistics (n.d.)*

***Table 2**. Gross output of livestock products in Kazakhstan for 2015–2023, KZT bn*

	2015	2016	2017	2018	2019	2020	2021	2022	2023
Livestock products	1,469.9	1,621.5	1,810.9	2,050.5	2,319.5	2,637.5	3,117	2,545.3	3,012.5
Dairy cattle breeding	597.3	661.1	729.3	822.4	928.9	1,069.5	1,283	812	1,000.6
Breeding of other cattle and buffalo breeds	386.7	412.7	464.8	532.1	627.9	705.9	825	649.9	724.5
Breeding of horses and other ungulate breeds	121.5	131.5	154.1	187.9	211.1	241.6	279.2	326.2	385.3
Breeding of camels and camelids	12.2	14.4	14.4	16.8	18.7	21.1	25.5	29	31.7
Sheep and goat breeding	163.5	167.5	175.4	198.2	217.4	245.2	269.7	257.3	285.5
Pig and piglet breeding	55.8	65.7	75.3	72.4	64.9	69.5	76.5	61.4	65
Poultry breeding	123.6	157.6	183.7	206.3	238.5	271.4	344	396.2	505.4
Breeding of other animal species	597.3	661.1	729.3	822.4	928.9	1,069.5	1.283	812	1,000.6

***Source:** compiled by the author of this study based on Bureau of National Statistics (n.d.)*

Among all areas, the contribution of dairy cattle breeding is particularly notable, which also showed growth to KZT 1,283.0 bn in 2021, but recorded a sharp decline to KZT 812.0 bn in 2022, followed by a partial recovery in 2023. The "other cattle and buffalo breeds" category showed comparable dynamics, with fluctuations in the last two years. Poultry is the most stable and fastest growing, rising from KZT 123.6 bn in 2015 to KZT 505.4 bn in 2023, indicating that this sub-sector is highly attractive for investment and technologically advanced. The growth in the production of sheep and goats, horses and camels is also positive, although with smaller absolute values. At the same time, pig breeding demonstrates stagnation with insignificant changes, which may be associated with both consumer preferences and epizootic restrictions. Overall, the structure of livestock output continues to be diversified, but requires attention to fluctuations in key areas, especially in dairy farming, in terms of sustainability and effective resource management. Table 3 summarises the production of the key livestock products.

***Table 3**. Volume of production of the main types of livestock products in Kazakhstan for 2015-2024*

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Meat (live weight), thsd t	1,651.1	1,702	1,794.4	1,871.6	1,975	2,058.5	2,162.2	1,799.1	1,920.3	1,994.9
Meat (in slaughter weight), thsd t	931	960.7	1,017.6	1,059.4	1,120.6	1,168.6	1,231.1	1,044.7	1,120	1,168.7
Milk, thsd t	5,182.4	5,341.6	5,503.4	5,686.2	5,864.9	6,051.4	6,247.2	3,354.6	3,472.9	3,628.5
Eggs, mn pcs	4,737	4,757.2	5,103	5,591.4	5,531.4	5,065.8	4,838.1	4,526.7	4,420.6	4,478.1
Wool, thsd t	38	38.5	39	39.2	39.5	40.2	41.2	35.6	36.6	36.3
Karakul, thsd pcs	7.1	4.3	8.1	3	1.4	1.3	2.1	0.5	0.3	0.2

***Source:** compiled by the author of this study based on Bureau of National Statistics (n.d.)*

Analysis of Table 3 suggests that the country's livestock industry has developed unevenly: there was a general increase in meat and milk production until 2021, but in 2022 there was a sharp decline in all major items, especially milk (almost doubled), which may reflect systemic problems in the industry, ranging from logistical failures to feed shortages or declining productivity. Volumes subsequently started to recover but have not reached previous highs. Egg production showed a steady decline after 2018, from 5,591.4 mn eggs to 4,478.1 mn eggs in 2024, while wool production stayed relatively stable. Particularly notable was the almost complete phasing out of Karakul breeding, reflecting a structural transformation of livestock production and a shift in focus towards more profitable or prioritised areas. Table 4 presents the number of the key types of farm animals.

Table 4*. Number of livestock and poultry in Kazakhstan for 2015-2024, thsd heads*

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cattle	6,183.9	6,413.2	6,764.2	7,150.9	7,436.4	7,850	8,192.4	6,536.3	6,616.8	7,976.7
Sheep and goats	18,015.5	18,184.2	18,329	18,699.1	19,155.7	20,057.6	20,876.8	18,843	18,667.4	20,224.4
Pigs	887.6	834.2	815.1	798.7	813.3	816.7	776.1	509.8	483.3	479.7
Horses	2,070.3	2,259.2	2,415.7	2,646.5	2,852.3	3,139.8	3,489.8	3,790.2	3,851.2	4,353
Camels	170.5	180.1	193.1	207.6	216.4	227.7	243.4	253.7	264.9	280.5
Poultry, mn heads	35.6	36.9	39.9	44.3	45	43.3	47.9	45.7	44.2	45.7

Source: *compiled by the author based on Bureau of National Statistics (n.d.)*

The data in the table show stable positive dynamics in the number of most types of farm animals in Kazakhstan, reflecting the overall expansion of the livestock sector. Cattle and horses show the most significant growth, with cattle numbers increasing from 6,183.9 thsd heads in 2015 to 7,976.7 thsd heads in 2024, and horses more than doubling, which can be attributed to increased demand for meat and dairy products, as well as expanding exports. The sheep and goat population also increased despite a slight decline in 2022-2023, which is likely related to unfavourable weather or economic conditions. At the same time, a steady decline in pig numbers was observed, from 887.6 thsd heads in 2015 to 479.7 thsd heads in 2024, reflecting a structural shift in consumer preferences, religious and cultural factors, and low profitability of pig production. Camel numbers are gradually increasing, continuing to be a niche but stable growth area. Poultry numbers show volatility with a peak in 2021 and a subsequent decline, possibly caused by epizootics or changes in housing and feeding conditions.

Conservation efficiency of livestock production in Kazakhstan continues to be at an average level, demonstrating contradictory results due to a complex of structural, infrastructural, technological, organisational, and management factors. On the one hand, there is a stable growth in gross output of livestock products and an increase in the number of cattle, sheep, goats, and horses. This may suggest an improvement in the basic conditions of livestock breeding, growth of production potential, and certain investments in the agricultural sector. Furthermore, there is a positive dynamic in the volume of meat production (in slaughter weight), which also suggests partial modernisation of the processing and storage infrastructure. On the other hand, against the backdrop of these achievements, significant systemic constraints persist, which hinder further growth in preservation efficiency. The deterioration of the material and technical base, especially in the segment of small and medium-sized farms, limits the possibilities of long-term storage and compliance with temperature regimes. Problems with the 'cold chain' – lack of modern refrigeration facilities, automated control systems, and logistics centres – lead to product losses at the stages of shipment, transportation, and storage. Insufficient digitalisation and poor integration of information technology into inventory management and logistics processes limit the ability to react quickly to changes in demand, which is especially critical for perishable products.

Furthermore, fluctuations in milk, egg, and wool production with an overall increase in animal numbers indicate an inefficient post-production handling system. Such volatility may be the result of underestimation of losses due to storage irregularities, lack of staff, poor veterinary and sanitary controls, and poor coordination between production and logistics links. This is especially true during periods of seasonal temperature fluctuations, when there is an increased risk of product spoilage without proper climatic adaptation of warehouses and transport vehicles. According to the regulations of the Ministry of Agriculture of the Republic of Kazakhstan, the natural loss of meat products during storage and transport can vary: for instance, when transporting chilled meat for a distance of up to 100 km, losses of up to 0.05-0.08% are allowed depending on the season, and when transporting frozen meat for a distance of over 1,000 km – up to 0.35% of the cargo weight (Order of the Minister of..., 2014). These standards factor in shrinkage, shaking and spoilage of products, but in real conditions losses may be higher due to the wear and tear of refrigeration equipment, lack of modern storage facilities, and non-compliance with sanitary norms.

To improve the efficiency of the agricultural sector and, specifically, to ensure the safety of livestock products, the Republic of Kazakhstan is implementing a number of government support measures aimed at stimulating the modernisation of production and logistics infrastructure, improving the technological equipment of farms and reducing product losses at all stages of the agro-production chain. One of the key instruments is state subsidies. In the livestock sector, they cover support for fodder production, pedigree cattle breeding, construction, and modernisation of storage facilities, including refrigeration and processing complexes. The current state programme "Auyl – El besigi" and other initiatives make provision for preferential credit and leasing mechanisms (Improving the quality..., 2019). This allows agricultural producers to purchase modern equipment for storage and processing of livestock products with deferred payments and at reduced interest rates.

The state is also actively promoting investment subsidies aimed at reimbursing part of the costs of building cold storage facilities, logistics centres, and processing facilities. Additionally, work is underway to form agro-industrial clusters and cooperatives, which ensures more efficient allocation of resources, sharing of infrastructure and access to larger markets. Special attention is paid to the digitalisation of the agricultural sector. Systems of monitoring and electronic accounting of agricultural products are being introduced, which allows tracking their movement, condition, and storage periods, thereby helping to reduce losses. Specifically, the Unified State Subsidy System (USSS), the Farm Animal Identification System (FAIS), and the Unified Automated Management System for the Agro-Industrial Sector (e-Agriculture) were introduced. These systems allow tracking the movement, condition, and storage periods of agricultural products, which helps to reduce losses (Kazakhstan intensively introducing..., 2025). The development of transport logistics and export infrastructure are also among the priority areas of state policy. The creation of veterinary and sanitary checkpoints, certification laboratories and specialised transport routes helps to ensure compliance with international quality standards in the transportation and storage of products.

To increase economic efficiency in the sphere of livestock products safety in the Republic of Kazakhstan, it is necessary to implement a targeted and multidimensional strategy focused on both technological modernisation and institutional transformation. One of the key areas is the development of modern infrastructure for storage and processing of products. A major part of losses in livestock production is associated with the lack of proper storage conditions, especially in rural areas and remote regions. In this regard, it is advisable to invest in the construction and modernisation of refrigerated warehouses, dairy, and meat processing complexes, as well as the introduction of mobile cooling systems adapted to the climatic features of Kazakhstan. The use of energy-efficient solutions and equipment providing automatic microclimate regulation will help to increase shelf life and preserve the nutritional properties of products.

An equally significant aspect is the digitalisation of logistics, accounting, and product quality control processes. Implementing real-time monitoring systems – such as temperature sensors, radio frequency identification (RFID) tags, and automated batch tracking platforms throughout the supply chain – will not only minimise losses but also increase the transparency of production processes. Modern software solutions, including ERP-systems for agricultural enterprises, allow forecasting demand, managing stocks more efficiently, and promptly responding to the risks associated with the violation of storage conditions. These measures are especially relevant in the context of growing volumes of livestock products and increasing complexity of logistics routes. Special attention should be paid to deepening the processing of raw materials. Animal products should be used as much as possible, including by-products, bones, blood, and fat, which can be converted into meat concentrates, feed additives, gelatine, collagen, and organic fertilisers. Such approaches reduce waste, add value, and open new markets. This is particularly relevant in Kazakhstan, where there is often a disconnect between production and processing. Government subsidies for the purchase of equipment, tax breaks for processors, and support in accessing export markets would be a major incentive for the development of this industry.

It is also necessary to develop human resources. It is essential to expand professional education and training programmes, including courses for farmers and refrigeration system operators, training in modern methods of inventory and handling of animal products. Educational institutions should interact more actively with business and the state, forming applied programmes focused on the real needs of the agricultural sector. The next area is the improvement of logistics. To reduce losses during transportation, it is necessary to organise logistics centres that follow all sanitary and temperature requirements. In regions with extreme climatic conditions, especially in the southern and western regions of Kazakhstan, it is vital to develop "cold chain" infrastructure. This includes not only the purchase of specialised transport with refrigerated trucks, but also the establishment of transshipment points where short-term storage and transshipment can be provided without risk of product spoilage.

Finally, institutional development – expanding opportunities for cooperation between small and medium-sized producers – is of great significance. The creation of agro-industrial clusters that bring together farmers, processors, and logisticians will increase economic sustainability and reduce costs through economies of scale. It is also vital to ensure a favourable regulatory framework that establishes clear requirements for the conditions of storage, transportation, and sale of products. Strengthening state control and incentives (including grants and tax breaks for compliance with standards) will create incentives for investment in product preservation. Overall, the improvement of economic efficiency in the sphere of livestock product safety should be based on the integration of innovative solutions, support from the state, and active involvement of all participants in the agro-production chain. Such a model will ensure not only reduction of losses and growth of profitability but also strengthening of Kazakhstan's position as an export-oriented agrarian power.

DISCUSSION

The analysis revealed that the current infrastructure for storing livestock products is still not adapted to modern requirements. Despite the availability of production facilities, the obsolescence of storage equipment and non-compliance with sanitary and technical standards limit the possibilities of effective storage. The identified correlation between the level of preservation and the state of infrastructure suggests that problems are stored not so much in production as in the post-production cycle. This means that further development of the sector should be focused not only on increasing output, but also on ensuring post-production quality through the renewal of the logistics and warehousing base. O.A. Chukwu and M. Adibe (2022) emphasised that even with limited technical capacity, acceptable product safety can be achieved through accurate adherence to sanitation and storage standards. They emphasised operational discipline as a major factor of efficiency. In contrast, the current findings showed that without renewing the infrastructure itself and eliminating wear and tear, organisational measures have only a temporary effect. Thus, the present study expressed greater confidence in the need for physical modernisation, whereas the researchers proposed a strategy of adaptation to existing conditions.

Regional differences in climatic conditions such as extreme temperatures, sharp seasonal variations, and irregular rainfall create a challenging environment for the storage and transport of products (Vovkotrub *et al.*, 2024). These factors particularly influence products with a high degree of sensitivity to external conditions. The analysis results emphasised the need for flexible logistics models adapted to concrete climatic zones. The presence of remote farms and long delivery routes exacerbate the problem of cold conditions, necessitating the development of regionally orientated storage and transport standards. M. Wróbel-Jędrzejewska and E. Polak (2021) emphasised climate as a background, but not a determining condition. In their opinion, with proper technological support (use of mobile refrigerators, modular storage facilities) the influence of climatic conditions is minimised. Current data, on the contrary, reflect a substantial influence of continental climate and geographical remoteness on the level of losses, especially during transportation. The difference here lies in the scale of the assessment: the researchers analysed individual pilot projects in limited regions rather than a nationwide system.

The high level of physical deterioration of storage equipment and the low level of technological equipment of storage facilities reflect chronic underinvestment in this part of the agro-industrial complex (Kazhymurat *et al.*, 2021). Additionally, the lack of qualified personnel capable of operating modern refrigeration and logistics equipment exacerbates the problem. Without a systematic training programme focused on logistics and storage, even extensive capital investments will have limited effect. Thus, modernisation must be accompanied by a parallel digital and educational transformation. D. Perkumienė *et al.* (2022) argued that the shortage of qualified personnel had a more devastating effect on the storage system than the technical ageing of facilities. The researchers emphasised that even modern equipment would not be effective without competent operators. D.E. Ufua *et al.* (2022) concluded that improved staffing yields results faster and cheaper than comprehensive technical modernisation. The present study agrees with this, but there is a problem in the complex: not only staffing shortages, but also the deterioration of the base itself limits efficiency.

Poor integration between actors in the logistics chain, from producer to processor, continues to be a systemic problem. Poor coordination leads to irrational use of transport resources, disruption of delivery times and, as a result, increased losses (Danchuk *et al.*, 2023). The problem also lies in the lack of transparent contractual relations and uniform logistics standards. Addressing these challenges requires institutionalisation of interaction between supply chain participants, creation of cooperation platforms, and logistics consolidation centres. T. Perdana *et al.* (2023) investigated horizontal linkages between farmers, processors and logisticians within localised clusters. Their findings demonstrated that losses are almost halved at high cooperative densities. A.-R. Alhassan and M.A. Akudugu (2020) also found that in the absence of centralised infrastructure, cooperation replaces government or corporate logistics solutions. This echoes the current findings on the significance of establishing cooperative chains. However, the present study focused on systemic failures (lack of centralised planning and digital platforms), while the cited study relied on self-regulating cooperative models.

Government support measures aimed at modernising infrastructure and logistics have a positive but limited impact due to their uneven coverage and weak targeting. The results showed that subsidy and concessional financing programmes often do not account for the specificity of regional logistics needs. Furthermore, administrative barriers and lack of transparency in resource allocation reduce the motivation of sector players to modernise. This points to the need not only for financial injections, but also for a revision of support implementation mechanisms towards greater flexibility and efficiency. U. Sekaran *et al.* (2021) argued that current forms of state support are working effectively, especially investment subsidy programmes. Their analysis was based on data from regions with active implementation of such programmes. The current study, on the other hand, criticised the support for being fragmented and poorly adapted to regional needs.

Despite declarations about the need for digitalisation, in practice, technologies are applied point-by-point and unsystematically. Temperature monitoring, route tracking, and metering automation are in most cases either absent or used in a fragmented manner (Uazhanova *et al.*, 2024). This limits opportunities to manage risks and improve the efficiency of logistics processes. Digitalisation should be a key element of the development strategy: from cargo tracking systems to platforms for coordinating the actions of all supply chain participants. This is the only way to ensure the accuracy, transparency, and sustainability of logistics infrastructure. M. Khanna (2021) explored the digital transformation of the agricultural sector. The researcher analysed the implementation of GPS tracking of trucking, automated temperature and humidity control systems in storage facilities, and digital supply management platforms. M. Khanna highlighted the growing interest of agribusiness in digitalisation as a way to optimise costs and improve product safety. According to M.A. Dayıoğlu and U. Turker (2021), the level of digitalisation is increasing faster than expected and forms the prerequisites for integrated logistics platforms. The current study, on the contrary, indicated the fragmentation and sporadic application of digital solutions. The present study indicated that digital solutions are implemented in a fragmented manner, most often in pilot projects or at the level of large farms, while the vast majority of small and medium-sized agribusinesses do not have access to such technologies.

A cumulative analysis of all factors confirmed that the safety of livestock production cannot be ensured by efforts in one direction, whether it is machinery, organisation, or legislation. A comprehensive transformation is needed, combining investments in infrastructure, human resources, digital technologies, institutional change, and adaptation to natural conditions. Such an approach will not only reduce losses but also improve the overall competitiveness of the sector, creating the conditions for sustainable development of agricultural logistics. W. Munro and R. Schurman (2022) considered that a systems approach is not possible without changes in the institutional architecture of the agribusiness sector – first of all, reforms in storage ownership, responsibility allocation, and inter-institutional interaction. The present study supported the idea of systematicity but proposed it as a result of the integration of infrastructural, managerial, and human resource solutions. The analysis of the results obtained in comparison with alternative approaches revealed that the efficiency of the system of storage of livestock products in the agricultural sector depends on a combination of institutional, technical, and human factors. The integrated approach continues to be the key condition for increasing product safety and sustainability of logistics chains.

CONCLUSIONS

Based on the analysis, the study found that extensive product losses at various stages – from production to consumption – are conditioned by both biological properties of animal products and technical and infrastructural limitations. Problems in the area of cooling, packaging, and transport are particularly critical. The lack of modern storage facilities with automatic climate control results in the need to sell products quickly, limiting flexibility in supply management and increasing the share of write-offs. From 2015 to 2023, there was an increase in gross livestock production from KZT 1,469.9 bn to KZT 3,012.5 bn with marginal fluctuations that suggest the sector is vulnerable to logistical and climatic risks. Despite an increase in cattle (from 6.18 mn heads in 2015 to 7.98 mn heads in 2024) and horses (more than doubling), milk and egg production figures have been declining – especially in 2022, when milk production almost halved. This reflects inefficient storage and post-production processing, especially against the backdrop of seasonal temperature variations and limited access to modern infrastructure in rural areas.

Modern technologies allow agricultural enterprises to improve efficiency and reduce losses of livestock products substantially. In Kazakhstan, such measures are particularly relevant due to the extreme climate. The use of ERP systems (e.g., SAP S/4HANA in Eurasia Group), digital platforms, and advanced processing (kraft cheeses, dried meat) increases profitability and sustainability of farms. Vertical integration (Zhaiyk Et, Aknar PF) ensures control at all stages of production. Development of the cold chain and ecologisation of the agro-sector allow improving product quality, reducing losses by up to 10% and increasing competitiveness in foreign markets. Overall, the development of deep processing of raw materials, digitalisation of logistics processes, modernisation of refrigeration infrastructure, and development of agro-cooperatives are promising areas for improving preservation efficiency. In the future, it would be advisable to conduct farm-level studies to identify concrete loss factors and assess the effectiveness of implemented storage technologies.

ACKNOWLEDGEMENTS

None.

FUNDING

None.

CONFLICT OF INTEREST

None.

REFERENCES

[1] 42 farms of Zhambyl region teamed up into a dairy cluster. (n.d.). Retrieved from http://kazakhstan.dairycongress.org/news/2016/eng/article_7.
[2] Aknar PF. (n.d.). Retrieved from https://www.aknar-pf.kz/?mode=viewcat&id=19&lang=ru.
[3] Alhassan, A.-R., & Akudugu, M.A. (2020). Commodity clusters, arenas, linkages and business models. In *Supply chain management in African agriculture: Innovative approaches to commodity value chains* (pp. 37-71). Cham: Palgrave Macmillan. doi: 10.1007/978-3-030-54209-2_3.
[4] Alibekov, R.S., Alibekova, Z.I., Bakhtybekova, A.R., Taip, F.S., Urazbayeva, K.A., & Kobzhasarova, Z.I. (2024). Review of the slaughter wastes and the meat by-products recycling opportunities. *Frontiers in Sustainable Food Systems*, 8, article number 1410640. doi: 10.3389/fsufs.2024.1410640.
[5] Bhatti, U.A., Bhatti, M.A., Tang, H., Syam, M.S., Awwad, E.M., Sharaf, M., & Ghadi, Y.Y. (2024). Global production patterns: Understanding the relationship between greenhouse gas emissions, agriculture greening and climate variability. *Environmental Research*, 245, article number 118049. doi: 10.1016/j.envres.2023.118049.
[6] BIO Intelligence Service for the Global Food Cold. (2015). *Assessing the potential of the cold chain sector to reduce GHG emissions through food loss and waste reduction*. Retrieved from https://www.corporate.carrier.com/Images/Global-Food-Cold-Chain-GHG-Emissions-Study_v2_tcm558-77711.pdf?utm.
[7] Bogoyavlenskiy, A., Alexyuk, M., Alexyuk, P., Amanbayeva, M., Anarkulova, E., Imangazy, A., Bektuganova, A., & Berezin, V. (2022). Metagenomic exploration of koumiss from Kazakhstan. *Microbiology Resource Announcements*, 11(1), article number e01082-21. doi: 10.1128/mra.01082-21.
[8] Bureau of National Statistics. (n.d.). *Statistics of industrial production*. Retrieved from https://stat.gov.kz/en/industries/business-statistics/stat-industrial-production/.
[9] Casino, F., Kanakaris, V., Dasaklis, T.K., Moschuris, S., Stachtiaris, S., Pagoni, M., & Rachaniotis, N.P. (2021). Blockchain-based food supply chain traceability: A case study in the dairy sector. *International Journal of Production Research*, 59(19), 5758-5770. doi: 10.1080/00207543.2020.1789238.
[10] Chukwu, O.A., & Adibe, M. (2022). Quality assessment of cold chain storage facilities for regulatory and quality management compliance in a developing country context. *The International Journal of Health Planning and Management,* 37(2), 930-943. doi: 10.1002/hpm.3385.
[11] Construction of a deep meat processing complex worth 7.7 billion tenge has begun in eastern Kazakhstan. (2025). Retrieved from https://apk-news.kz/news/item-5372?utm.
[12] Danchuk, V., Comi, A., Weiß, C., & Svatko, V. (2023). The optimization of cargo delivery processes with dynamic route updates in smart logistics. *Eastern-European Journal of Enterprise Technologies*, 2(3(122)), 64-73. doi: 10.15587/1729-4061.2023.277583.
[13] Dayıoğlu, M.A., & Turker, U. (2021). Digital transformation for sustainable future-agriculture 4.0: A review. *Journal of Agricultural Sciences*, 27(4), 373-399. doi: 10.15832/ankutbd.986431.
[14] Espolov, T., Espolov, A., Tireuov, K., Zharylkassyn, Z., Keneyev, M., & Suleimenov, Z. (2020). Supply chain logistics in agricultural sector-assessing opportunities for competitiveness increase. *International Journal of Supply Chain Management*, 9(2), 745-752.
[15] Fadzli, M.A.F.M., & Nawawi, S.W.B. (2024). Automated storage and retrieval system for warehouse. *ELEKTRIKA-Journal of Electrical Engineering*, 23(1), 88-95. doi: 10.11113/elektrika.v23n1.471.
[16] Focker, M., & van der Fels-Klerx, H.J. (2020). Economics applied to food safety. *Current Opinion in Food Science,* 36, 18-23. doi: 10.1016/j.cofs.2020.10.018.
[17] Gabdualiyeva, R., Melekova, A., Jakupova, A., & Bazarova, B. (2024). Digitalization of the agricultural sector in Kazakhstan. *BIO Web of Conferences*, 82, article number 05038. doi: 10.1051/bioconf/20248205038.
[18] García-Díez, J., Saraiva, S., Moura, D., Grispoldi, L., Cenci-Goga, B.T., & Saraiva, C. (2023). The importance of the slaughterhouse in surveilling animal and public health: A systematic review. *Veterinary Sciences*, 10(2), article number 167. doi: 10.3390/vetsci10020167.
[19] George, A.S., & George, A.S.H. (2023). Optimizing poultry production through advanced monitoring and control systems. *Partners Universal International Innovation Journal*, 1(5), 77-97. doi: 10.5281/zenodo.10050352.
[20] How can sustainable food cold chains help feed developing countries? (2022). Retrieved from https://www.weforum.org/stories/2022/11/sustainable-food-cold-chains-feed-developing-countries/?utm.
[21] Improving the quality of life in rural areas: The project "Aul – El besigi" will cover 80% of all rural residents by 2025. (2019). Retrieved from https://primeminister.kz/ru/povishenie-kachestva-zhizni-na-sele-proektom-auil-el-besigi-do-2025-goda-budut-ohvacheni-80-vseh-selskih-zhitelei.

[22] Kandeepan, G., & Tahseen, A. (2022). Modified atmosphere packaging (map) of meat and meat products: A review. *Journal of Packaging Technology and Research*, 6(3), 137-148. doi: 10.1007/s41783-022-00139-2.
[23] Kazakhstan intensively introducing modern digital solutions in agricultural sector. (2025). Retrieved from https://primeminister.kz/en/news/kazakhstan-intensively-introducing-modern-digital-solutions-in-agricultural-sector-29669?utm.
[24] Kazakhstan: Sustainable livestock development program for results. (2021). Retrieved from https://www.worldbank.org/en/country/kazakhstan/brief/sustainable-livestock-development-program-for-results?utm.
[25] Kazhymurat, A., Uazhanova, R., Tlevlessova, D., Zhexenbay, N., Tungyshbayeva, U., & Mannino, S. (2021). Optimization of the HACCP safety control system for collagen hydrolysate production by implementing the FMEA model. *Eastern-European Journal of Enterprise Technologies*, 2(11(110)), 50-60. doi: 10.15587/1729-4061.2021.230318.
[26] Khanna, M. (2021). Digital transformation of the agricultural sector: Pathways, drivers and policy implications. *Applied Economic Perspectives and Policy*, 43(4), 1221-1242. doi: 10.1002/aepp.13103.
[27] Lainawa, J., Lumy, T.F.D., & Endoh, E.K.M. (2024). Strategic management of livestock-based integrated farming system with zero waste (LEISA) agriculture principle in North Minahasa regency. *IOP Conference Series: Earth and Environmental Science*, 1341, article number 012098. doi: 10.1088/1755-1315/1341/1/012098.
[28] Leah, D., Pașcalău, R., Șmuleac, L., Stanciu, S.M., Mergheș, P., Ahmadi-Khoie, M., Șmuleac, A., & Orghici, G. (2023). Challenges and new trends in rural modern cattle farms. *Research Journal of Agricultural Science,* 55(2), 114-120.
[29] Mamenko, O., Portiannyk, S., & Prusova, G. (2024). Prerequisites for innovative development of livestock and agriculture through the integration of agricultural production and environmental safety. *Ukrainian Black Sea Region Agrarian Science*, 28(3), 19-31. doi: 10.56407/bs.agrarian/3.2024.19.
[30] Ministry of Agriculture of the Republic of Kazakhstan. (n.d.). *Documents*. Retrieved from https://www.gov.kz/memleket/entities/moa/documents/1?lang=ru.
[31] Munro, W., & Schurman, R. (2022). Building an ideational and institutional architecture for Africa's agricultural transformation. *African Studies Review,* 65(1), 16-40. doi: 10.1017/asr.2021.82.
[32] Nayak, A., & Bagchi, K.K. (2022). Agricultural marketing infrastructure in West Bengal with special reference to cold storage facility. *Indian Journal of Agricultural Marketing*, 36(1), 181-196. doi: 10.5958/2456-8716.2022.00013.6.
[33] Neethirajan, S. (2020). The role of sensors, big data and machine learning in modern animal farming. *Sensing and Bio-Sensing Research*, 29, article number 100367. doi: 10.1016/j.sbsr.2020.100367.
[34] Order of the Minister of Agriculture of the Republic of Kazakhstan No. 3-4/617 "On Approval of Standards for Natural Loss, Shrinkage, Shaking, Spoilage of Agricultural Products and Products of Their Processing". (2014, November). Retrieved from https://adilet.zan.kz/rus/docs/V14F0010017?utm.
[35] Perdana, T., Tjahjono, B., Kusnandar, K., Sanjaya, S., Wardhana, D., & Hermiatin, F.R. (2023). Fresh agricultural product logistics network governance: Insights from small-holder farms in a developing country. *International Journal of Logistics Research and Applications,* 26(12), 1761-1784. doi: 10.1080/13675567.2022.2107625.
[36] Perkumienė, D., Ratautaitė, K., & Pranskūnienė, R. (2022). Innovative solutions and challenges for the improvement of storage processes. *Sustainability*, 14(17), article number 10616. doi: 10.3390/su141710616.
[37] Qian, J., Wu, Z., Zhu, Y., & Liu, C. (2022). One Health: A holistic approach for food safety in livestock. *Science in One Health,* 1, article number 100015. doi: 10.1016/j.soh.2023.100015.
[38] SAP S/4HANA migration for Eurasia Group Kazakhstan. (n.d.). Retrieved from https://leverx.com/case-studies/eurasia-group?utm.
[39] Sattarov, K., Eshmurodov, D., Mamatkulova, M., Julbekov, I., & Kharsika, I. (2025). The impact of active packaging and nanocoatings on the safety and shelf life of dairy products. *Animal Science and Food Technology*, 16(2), 110-128. doi: 10.31548/animal.2.2025.110.
[40] Sekaran, U., Lai, L., Ussiri, D.A.N., Kumar, S., & Clay, S. (2021). Role of integrated crop-livestock systems in improving agriculture production and addressing food security – a review. *Journal of Agriculture and Food Research*, 5, article number 100190. doi: 10.1016/j.jafr.2021.100190.
[41] Shepherd, M., Turner, J.A., Small, B., & Wheeler, D. (2018). Priorities for science to overcome hurdles thwarting the full promise of the "digital agriculture" revolution. *Journal of the Science of Food and Agriculture,* 100(14), 5083-5092. doi: 10.1002/jsfa.9346.
[42] Syzdykova, M. (2024). *Climate change and its impact on agriculture in Kazakhstan*. Retrieved from https://www.inform.kz/ru/klimaticheskie-izmeneniya-i-ih-vozdeystvie-na-selskoe-hozyaystvo-kazahstana-304236?utm.
[43] Taifouris, M., & Martín, M. (2022). Integrating intensive livestock and cropping systems: Sustainable design and location. *Agricultural Systems,* 203, article number 103517. doi: 10.1016/j.agsy.2022.103517.
[44] Twilley, N. (2022). *Africa's cold rush and the promise of refrigeration*. Retrieved from https://www.newyorker.com/magazine/2022/08/22/africas-cold-rush-and-the-promise-of-refrigeration?utm.

[45] Uazhanova, R., Moldakhmetova, Z., Tungyshbayeva, U., Izteliyeva, R., Amanova, S., Baimakhanov, G., Seksenbay, S., & Sabraly, S. (2024). Ensuring quality and safety in the production and storage of poultry meat. *Caspian Journal of Environmental Sciences*, 22(5), 1271-1277. doi: 10.22124/cjes.2024.8342.
[46] Ufua, D.E., Salau, O.P., Saleem, O., Ogbari, M.E., Osibanjo, A.O., Osabuohien, E., & Adeniji, A.A. (2022). Systems approach to address human resource issues: A case in a commercial livestock farm in Southern Nigeria. *SAGE Open*, 12(2). doi: 10.1177/21582440221093370.
[47] Vovkotrub, V., Kołacz, R., Iakubchak, O., Vovkotrub, N., & Shevchenko, L. (2024). Effect of lactic acid bacteria ferment cultures on pork freshness. *Ukrainian Journal of Veterinary Sciences*, 15(1), 48-65. doi: 10.31548/veterinary1.2024.48.
[48] Wang, D., Li, R., Gao, G., Jiakula, N., Toktarbek, S., Li, S., Ma, P., & Feng, Y. (2022). Impact of climate change on food security in Kazakhstan. *Agriculture*, 12(8), article number 1087. doi: 10.3390/agriculture12081087.
[49] Wróbel-Jędrzejewska, M., & Polak, E. (2021). The operation analysis of the innovative mainbox food storage device. *Applied Sciences*, 11(16), article number 7682. doi: 10.3390/app11167682.
[50] Zhaiyk Et. (n.d.). *About the company*. Retrieved from https://al-aziza.kz/about.
[51] Zhang, L., Zhang, M., & Mujumdar, A.S. (2021). Technological innovations or advancement in detecting frozen and thawed meat quality: A review. *Critical Reviews in Food Science and Nutrition,* 63(11), 1483-1499. doi: 10.1080/10408398.2021.1964434.

Економічна ефективність збереження та використання тваринницької продукції в аграрному секторі економіки

Ельміра Кузенбаєва

Докторант
Жетисуйський університет імені Ільяса Жансугурова
040009, вул. Жансугурова, 187А, м. Талдикорган, Республіка Казахстан
https://orcid.org/0000-0002-8696-5027

Гульнара Тулешова

Кандидат економічних наук, завідувач кафедри
Жетисуйський університет імені Ільяса Жансугурова
040009, вул. Жансугурова, 187А, м. Талдикорган, Республіка Казахстан
https://orcid.org/0000-0002-4567-4418

Анотація. Робота була спрямована на вивчення шляхів підвищення економічної ефективності аграрного виробництва за рахунок вдосконалення систем безпеки та раціонального використання продукції тваринництва. Методологічною основою дослідження виступав комплексний підхід, що включає аналіз статистичних даних, структурно-динамічний та порівняльний аналіз, а також елементи системного та факторного аналізу. Валовий випуск продукції тваринництва у Казахстані збільшився з 2066,4 млрд тенге у 2015 році до 3012,5 млрд тенге у 2023 році. При цьому чисельність великої рогатої худоби зросла з 6,18 млн. голів у 2015 році до 7,98 млн. у 2024 році, а кількість коней більш ніж подвоїлася – з 2,07 до 4,35 млн. голів за той же період. Результати аналізу показали, що незважаючи на стійке зростання поголів'я та валової продукції, ефективність безпеки залишається на середньому рівні. Це зі зносом холодильної інфраструктури, слабким розвитком "холодової ланцюга", дефіцитом кваліфікованих кадрів, недостатньою цифровізацією логістичних процесів і кліматичними особливостями регіонів. Обсяги виробництва молока знизилися майже вдвічі. Втрати на етапах зберігання та транспортування також відображені у зниженні виробництва яєць з 5,59 млрд штук у 2018 році до 4,48 млрд у 2024 році. У роботі обґрунтовано, що інвестиції у модернізацію інфраструктури зберігання, цифровізацію логістики та розвиток глибокої переробки є не надмірними витратами, а інструментом оптимізації виробничого процесу та підвищення стійкості агробізнесу. Також запропоновано напрями стратегічного розвитку: формування агропромислових кластерів, розвиток кооперації, підвищення кваліфікації кадрів, розширення державної підтримки та впровадження екологічно стійких технологій. Зроблено висновок, що підвищення рівня безпеки продукції тваринництва в Казахстані здатне не лише знизити втрати, а й підвищити рентабельність господарств, зміцнити продовольчу безпеку країни та її експортний потенціал

Ключові слова: інфраструктура схову; логістичні обмеження; цифровізація; кліматичні умови; контроль якості