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Review article

Horse breeding and horse meat production in Kazakhstan: current status, safety challenges and future development prospects

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Abstract

Background and Aim. The global agri-food system is facing systemic challenges driven by climate change, depletion of land and water resources and increasing demand for animal protein. Productive horse breeding represents a strategically important, environmentally sustainable pathway for diversifying the meat market. The aim of this study is to provide a comprehensive analysis of the current state of horse breeding and horse meat production in the Republic of Kazakhstan, including an assessment of the veterinary and sanitary, environmental, and biological factors affecting the quality, nutritional value and safety of horse meat products.

Materials and Methods. The study was based on statistical data, analytical reports and published scientific literature addressing various aspects of horse breeding and horse meat production.

Results. The conducted analysis demonstrates that global productive horse breeding is on the threshold of a conceptual shift. The present review advances a fundamentally new position: horse meat should be considered not merely as an ethnocultural niche or a marginal regional specialty, but as a strategically important, environmentally sustainable protein system of global significance.

Conclusion. From the perspective of the One Health systems concept, horse breeding and horse meat production are regarded as an interconnected system linking animal health, human health and environmental health. Contemporary approaches to the sustainable development of the industry require the consideration of environmental, veterinary and sanitary, and biological factors that affect the safety and quality of the products. The study identified key methodological and infrastructural limitations that impede the development of the sector and highlighted the role of horse meat as a strategic source of protein in addressing global food security challenges.

Keywords: animal protein; food security; horse meat; One Health; productive horse breeding; review.

Introduction

The modern structure of global food security system is undergoing fundamental transformations. According to long-term macroeconomic forecasts, aggregate global demand for animal-origin products continues to demonstrate a steady upward trend through 2034 (Food and Agriculture Organization, 2025). In this multifactorial context, the horse meat markets represents a unique segment, evolving from a local traditional product of nomadic cultures to the status of a functional superfood [1].

Historically, horse meat played a central role in the diets of the Eurasian steppe populations. Archaeological and genetic evidence indicates that the early domestication of horses in the settlements of the Botai culture on the territory of modern Kazakhstan (around 3500 BC) was accompanied by the active use of their meat and milk [2]. Today, this product attracts close attention from the global scientific community. Studies published in leading journals such as *Meat Science, Animals,* and *Toxins* have demonstrated that the meat of equids possesses exceptional nutritional properties: a high concentration of heme iron, an optimal ratio of polyunsaturated fatty acids and high dietary value [3, 4, 5, 6].

The significance of this study lies in the need for a comprehensive assessment of the current state of horse breeding, the factors influencing the quality and safety of horse meat products, and the development of evidence-based approaches to improving the competitiveness of the domestic horse meat industry.

Today, the Republic of Kazakhstan is at the forefront of the development of this sector. The domestic market is demonstrating historic records of horse meat consumption [7].

Current literature sources indicate a growing interest in horse meat as a high-protein and dietary product with high nutritional and biological value. Moreover, the ambitious Comprehensive Livestock Development Plan for 2026–2030 approved by the Government of the Republic of Kazakhstan provides an institutional basis for doubling exports of domestic meat [8].The aim of this study is to conduct a comprehensive analysis of the current state of horse breeding and horse meat production in the Republic of Kazakhstan, including an assessment of the veterinary and sanitary, environmental, and biological factors affecting the quality, nutritional value, and safety of horse meat products.The research novelty of the study lies in its comprehensive examination of the sector from veterinary and sanitary, environmental, and biological perspectives, as well as in the integration of contemporary approaches to ensuring food security and promoting the sustainable development of horse breeding within the context of the modernization of the country's agro-industrial sector.

At the same time, the current state of horse meat production requires further improvement of veterinary and sanitary control, food safety monitoring systems, and the implementation of international quality standards and product traceability systems.

Materials and Methods

This review article was prepared based on a bibliographic search of scientific publications retrieved from electronic databases such as Google Scholar, PubMed, Web of Science and Scopus, as well as reports and statistical data from international sources such as FAOSTAT and the analytical platform ReportLinker.

Taking into account various aspects of the study, the results were divided into categories in accordance with the following approaches: the global meat market and the positioning of horse meat, macroeconomic patterns of international trade, assessment of the current state and development prospects of horse breeding, shifts in consumer behavior and nutraceutical characteristics of horse meat, including its dietary profile, which has a beneficial effect on human health.

The analysis also covered regional studies in the field of veterinary and sanitary control, characterizing the influence of environmental and biological factors on the quality, nutritional value and safety of horse meat.

Particular attention was paid to the limitations of molecular genetic research, the potential of genomic selection (GBLUP), as well as the transition from descriptive toxicology to a conceptual assessment of risks associated with exposure to xenobiotics.

Results

1. The global meat market and the positioning of horse meat: A macroeconomic analysis

1.1. Leading producing countries and production dynamics

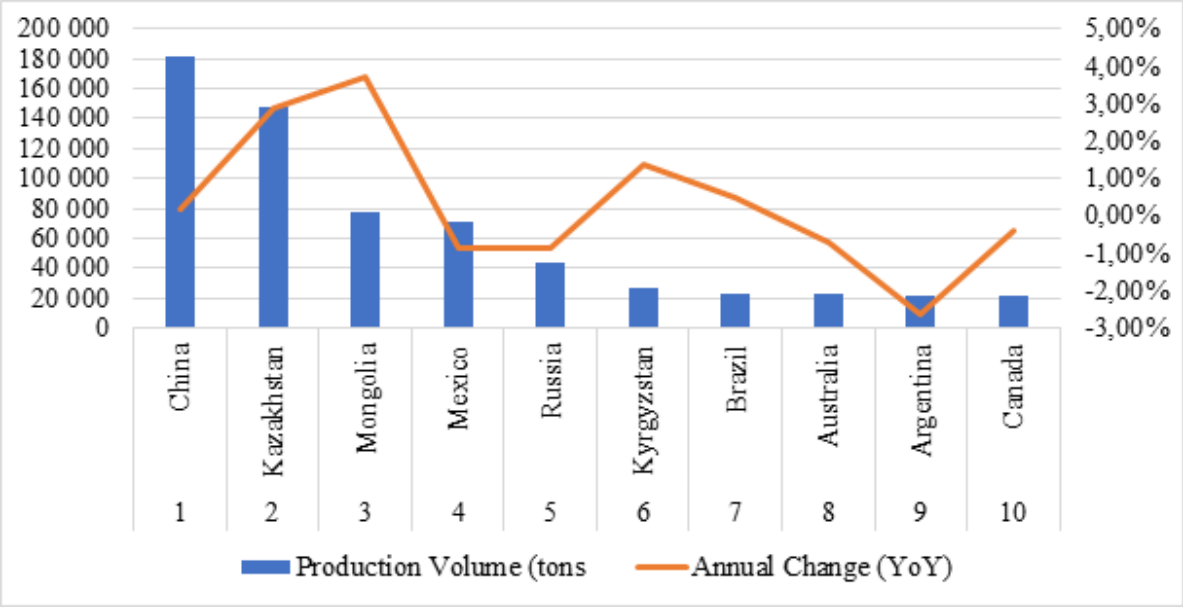
Global horse meat production demonstrates a high degree of concentration in the countries of the Asian region and Latin America. An analysis of aggregated data from FAOSTAT and the analytical platform ReportLinker makes it possible to identify the states that determine the architecture of global supply [11, 12].

Although poultry and pork account for the largest share of consumed animal protein, horse meat occupies a niche but important position. Its production is considered a more environmentally sustainable

alternative to beef due to lower methane emissions per unit of output [1]. The world's modern horse meat market is characterized by structural and trade asymmetry, where the production center is shifted to the countries of Asia and South America, whereas mostadded value is generated in the importing countries of the European Union [9]. Global production is concentrated in several countries, among which China (generating 24.3% of the global volume) and Kazakhstan (19.8%) dominate. In contrast, the largest net importers, shaping pricing policy, are Italy and Belgium, with the latter serving as a key logistical hub for the distribution of imported Latin American raw materials throughout Europe (Figure) [10].

This imbalance means thatproducing countries (such as Mongolia, accounting for 10.4% of production) often remain at the lower end of the value-added curve, acting exclusively as suppliers of low-cost raw materials [9].

However, the available data remain limited due to the opacity of transnational supply chains and insufficient statistical accounting in developing countries. The main limitation of current economic research is the lack of empirical models assessing the impact of non-tariff barriers on pricing. At the macroeconomic level, such asymmetry means that without the creation of strong domestic clusters of deep processing, producing countries will continue to lose economic rent in favor of European transit hubs.



Top 10 horse meat producing countries in the world

FAOSTAT statistics and the analytical platform ReportLinker indicate a decline in horse slaughter volumes in the countries of the Americas and Australia. At the same time, the countries of Central and East Asia demonstrate accelerated growth. Kazakhstan ranks second globally and demonstrates one of the highest CAGR rates (+3.17%), being surpassed in growth rate only by Mongolia (+6.26%) [11, 12].

1.2. The structure of international trade: Export-import flows

In 2024, the total volume of global horse meat trade experienced a correction due to logistical constraints in Europe. Nevertheless, the market maintains a clear division of roles between exporters and high-valueimporters.

Italy holds the leading position in imports (23,237,219 kg; 142,178,974 USD), significantly surpassing Belgium (11,935,024 kg; 60,285,965 USD) and Japan (4,677,055 kg; 35,395,333 USD). Switzerland is characterized by high unit prices despite relatively low volumes, which indicates a premium segment, while the Netherlands demonstrates moderate volumes at comparatively low unit values. The key exporters are Mongolia, Poland, Spain and Argentina [13].

1.3. Sociocultural determinants of consumption

The perception of horse meat varies from being a food taboo to being regarded as a delicacy. The studies conducted among chefs in France have identified several profiles: from "conservatives"

to “pragmatists,” who consider horse meat as a sustainable alternative to beef due to its low carbon footprint and high nutritional value [14, 15].

2. Integration into the global Halal market

For Kazakhstan, oriented toward exports to the countries of the Middle East and Southeast Asia, compliance with Halal standards is critically important. The Halal meat market is in a phase of accelerated expansion [16, 17]. In Islamic law (Fiqh), the majority of scientists recognize horse meat as fully permissible (halal). This is based on authentic hadiths. According to these reports, during the time of Prophet Muhammad, his companions consumed horse meat. This provides religious justification for the production and export of Kazakhstani horse meat to global Muslim markets [18].

3. Kazakhstan as a strategic production model

The Republic of Kazakhstan serves as an illustrative model for analyzing the potential and barriers of commercial horse breeding. The country possesses significant territorial resources and shows rapid growth in domestic consumption. However, its integration into the global export market is constrained by structural inefficiencies. The industry exhibits pronounced fragmentation of the value chain: large agricultural holdings, due to economies of scale, achieve profitability levelsof 18–22%, while numerous small producers demonstrate profitability not exceeding 5–8% [19].

This profitability gaplimits the scalability of production and reduces overall competitiveness. This divergence can be explained by dependence on imported feed additives, a shortage of modern processing infrastructure and the absence of consolidated cooperative linkages among farmers. The transition from an exclusive focus on domestic consumption to export expansion requires the implementation of integrated cluster models (such as the “Kaz Meat Cluster” project), that are capable of mitigating transaction costs. Strategically, this means that the success of the Kazakhstani model will depend not on a simple increase in livestock numbers, but on the technological modernization of the entire logistics chain “from farm to table” [20].

4. Nutritional value and functional properties

The biochemical profile of horse meat is characterized by a high content of easily digestible protein and micronutrients with a minimal level of lipids compared to beef and pork [21, 22]. The crude protein content is approximately21.1%, which is comparable to beef. However, intramuscular fat content ranges from only 2.0% to 6.0%. The baseline cholesterol index in horse meat is also at a nutritionally favorable level of 50–61 μg /100 g. Of particular value is the profile of micronutrients responsible for hematopoiesis: the concentration of heme iron in horse meat can reach 34.21 μg/100 g, which radically exceeds the indicators of beef (on average 2.50 μg/100 g) and pork (17.42 μg/100 g) [23, 24].

However, published data on the precise nutritional value of horse meatoften vary. This inconsistency can be explained by the influence of heterogeneous factors, such as the age of the animal, breed, type of muscle tissue studied and feeding system. The main limitation of modern reviews is the extrapolation of data obtained from isolated regional populations to the entire species. The biochemical density of horse meat and its high iron content indicate its high potential not simply as a source of basic calories, but as a specialized functional product for the correction of iron-deficiency and metabolic conditions in high-risk populations.

5. Lipidomics and health implications

The lipid profile of horse meat is of significant scientific interest due to the specific features of equine digestion (a monogastric digestive system with hindgut fermentation in the cecum), which allow the absorption of polyunsaturated fatty acids (PUFAs) from pasture grasses without complete bacterial biohydrogenation, characteristic of ruminant animals [21]. Horse meat is distinguished by a high protein content and a low level of intramuscular fat. Meat from pasture-raised horses is characterized by an optimal ratio of Omega-6 to Omega-3 fatty acids, while the absolute content of cardioprotective alpha-linolenic acid (Omega-3) reaches 1.4%, which significantly exceeds the indicators of beef (0.1%) and pork (0.6%). At the same time, the concentration of linoleic acid is about 11.1%, forming a favorable PUFA: SFA index at the level of 0.29. From a physiological perspective, such a lipid profile may contribute to a reduced atherogenic risk, making horse meat an anti-inflammatory component of the diet [25, 26, 27, 28, 29].

Despite these biochemical advantages, the clinical evidence base remains fragmented. Most conclusions about the health benefits of horse meat are based on the extrapolation of in vitro properties

of individual identified fatty acids, rather than on long-term dietary interventions. A critical limitation is the lack of controlled randomized clinical trials in humans that could reliably confirm the epidemiological advantages of regular horse meat consumption compared to conventional types of red meat [5].

5.1. Micronutrients and vitamins

Horse meat has been reportedto contain a high level of retinol (30 vs. 12 or 5 μg/100 g) and a lower niacin content(1.6 vs. 5.9 or 5.7 mg/100 g) compared to beef and pork, respectively. The riboflavin content in horse meat was similar to that in beef and pork (0.21 vs. 0.19 or 0.16 μg/100 g), respectively. The thiamine content in horse meat was higher than in beef but lower than in pork (0.20 vs. 0.07 or 0.56 μg/100 g), respectively. The bright color of horse meat is due to the high concentration of myoglobin and heme iron, which has high bioavailability. In addition, by-products (bones) are a rich source of calcium and phosphorus, which creates prospects for the production of dietary supplements [3].

6. Toxicology, ecotoxicology and biological safety

Access to international markets is strictly regulated by biological and ecotoxicological standards regulating the levelsof heavy metals, radionuclides and pesticides.

6.1. Biological safety: The problem of sarcocystosis

A key threat to export (especially to Japan, where basashi, a dish made from raw horse meat, is popular) is infection with the parasite Sarcocystis fayeri. This intracellular parasite produces an actin-depolymerizing factor (ADF), which is a potent enterotoxin causing severe food poisoning [30, 31].

In addition to sarcocystosis, a serious threat to animal health and the quality of the obtained meat is posed by parascaridosis. According to recent studies by scientists of the NJSC “Shakarim University” conducted on indigenous horses of the Zhabe breed, this parasitic invasion has a pronounced negative impact on the physiological condition of animals. It has been established that infection significantly reduces key hematological indicators: the hemoglobin level decreases by 23.5–36% and a decrease in the number of erythrocytes, total protein and glucose is also recorded, which directly worsens the development and well-being of the animal [31].

6.2. Ecotoxicological assessment: heavy metals, pesticides, and radionuclides

In the context of environmental safety, the most important aspect is the ecotoxicological monitoring of horse meat produced in various regions of Kazakhstan. The studies show that the level of accumulation of xenobiotics in the muscle tissue of herd-raised horses directly depends on the industrial and historical specifics of the grazing region.

A detailed regional analysis published in Veterinary World in 2026 showed that levels of anthropogenic contamination vary by region. Exceedance of maximum permissible concentrations (MPC) for cadmium (Cd) was recorded in horse meat samples at the level of 0.105 ± 0.015 μg/kg. The industrial Karaganda region proved to be the most susceptible to contamination with toxic elements, where exceedances of MPC for lead (Pb), cadmium (Cd), copper (Cu), and zinc (Zn) were recorded in almost all types of meat. In the Akmola region, exceedances for copper were noted in beef, lamb and horse meat, as well as locally for cadmium in horse meat (Shortandy district). At the same time, in the Abai region, exceedance of MPC in meat was detected exclusively for cadmium [33].

According to the conducted study, beef samples from various zones of the Semipalatinsk nuclear test site in most cases comply with organoleptic standards, however, the presence of small amounts of radioactive substances may lead to their accumulation in the body, thereby causing various pathological changes in organs and tissues. The conducted studies indicate the need to strengthen radiation monitoring and to prioritize radioisotope analysis in assessing the safety of meat products [34].

7. The domestic market of Kazakhstan: macrostatistics and breeding

In 2025, Kazakhstan updated historical records of horse meat consumption. In the fourth quarter, consumption reached 2.35 kg per capita and by the end of the year it was 7.63 kg. The share of horse meat in the meat consumption of the people of Kazakhstan increased to 9%, driven by faster growth in beef prices [7].

As of January 1, 2026, the highest annual growth is observed in poultry farming (+7.6%), as well as in horse breeding (+6.7%), which indicates the most dynamic development of these sectors. Moderate growth rates are recorded for cattle (+3.2%) and for sheep and goats (+2.2%), which indicates stable but less intensive development of these areas. The lowest growth is observed in pig farming (+1.0%), which indicates slower rates of expansion of this sector compared to other types of livestock [37].

7.1. Zootechnical, physicochemical and organoleptic indicators of horse meat of Kazakhstani breeds

According to the data of the Food and Agriculture Organization of the United Nations (FAO DAD-IS), 8 horse breeds are officially registered in Kazakhstan: Kushum, Mugalzhar, Kostanay, Akhal-Teke, Aday, Kazakh, Zhabe (an intra-breed type of the Kazakh breed) and Karabair [35]. Each of these breeds possesses its own unique zootechnical profile. Nevertheless, it is the indigenous breeds and their derivatives that form the basis of the country's meat balance due to year-round pasture-based management [36].

The meat-and-dairy direction of horse breeding in Kazakhstan is represented by the Mugalzhar and Kushum breeds, that characterized by high live weight (up to 656 kg) and a slaughter yield of up to 60%, as well as by the Kazakh breed (Zhabe type), that distinguished by high adaptability and the ability to obtain forage by digging through snow (tebenevka). The Aday and Karabair breeds possess combined productivity and satisfactory working qualities. The Kostanay and Akhal-Teke breeds are primarily oriented toward sporting use, and their meat productivity is of secondary importance [19, 35, 36, 38, 39, 40]. Scientific breeding makes it possible to significantly improve the physicochemical and organoleptic parameters of horse meat from indigenous horses while preserving its exceptional dietary value [41].

The horse meat is characterized by high nutritional value due to its significant protein content, favorable amino acid and fatty acid profile, as well as a reduced level of undesirable lipid fractions. Organoleptic indicators vary depending on the anatomical localization of muscles, but, in general, good characteristics of tenderness and color parameters are noted, which confirms its high quality as a food product (Table) [42].

Physicochemical and organoleptic indicators of horse meat (indigenous and improved breeds of the Republic of Kazakhstan)

№	Category	Indicator	Characteristics / Values	Research base
1	Physicochemical	Mass fraction of protein	20.0% - 24.0% (High protein density against the background of low intramuscular fat content)	General population of local breeds
		Trans fatty acids (TFA)	1.85% - 3.46% (under pasture-based management). This is significantly lower than in lamb (about 8%) and beef (up to 9.6%)	Pasture-raised
		Amino acid profile	20 amino acids identified (9 essential). L-lysine, L-glutamic acid, and L-aspartic acid predominate. High EAA/NEAA index	Kazakh horse (in various muscles)
		Fatty acid profile	19 acids identified (8 saturated, 7 monounsaturated, 4 polyunsaturated). Optimal n-6/n-3 PUFA ratio	Kazakh horse (Semitendinosus muscle)

Table continued

2	Organoleptic	Tenderness	The maximum degree of tenderness (reduction in shear force) is observed in the lumbar muscle Psoas major (PM)	Kazakh horse
			he lightness (L*) value is highest in the Longissimus dorsi; the redness (a*) value is maximal in the diaphragm	Kazakh horse

Discussion

8. Integration of the "One Health" concept

The "One Health" paradigm postulates an inseparable, mechanistic link between environmental conditions, animal health and human well-being. In the context of horse breeding, this concept describes strict cause-and-effect cascades: the state of the environment (soil degradation, industrial pollution) directly determines the toxicological safety of the feed base [33]. The quality of feed and climatic stressors modulate the immune status of the animal, which increases its susceptibility to zoonotic infections and accelerates the bioaccumulation of heavy metals.

The consumption of contaminated meat closes this chain, transmitting the accumulated toxicological and microbiological risks directly to the human population. This creates a negative feedback loop, where anthropogenic climate change depletes pasture resources, which steadily reduces animal resilience, and consequently, the quality of food products. This cascade pathway implies that ensuring food and epidemiological safety is impossible without the primary ecological remediation of agrobiocenoses. However, empirical data confirming these interconnections remain fragmented due to the fact that veterinary supervision, environmental monitoring, and healthcare services function in institutional isolation.

9. Research gaps and future directions

A critical analysis of the existing literature reveals several fundamental gaps that hinder the systemic transformation of the industry. First, there is a lack of international standardization in research methodologies, from muscle sampling protocols to analytical chemistry calibrations, which makes reliable meta-analyses difficult. Second, a critical shortage of genomic and transcriptomic data persists; the absence of dense reference SNP panels for meat-oriented horses completely blocks the application of marker-assisted selection. Third, the macroeconomic analytics of the global market suffers from weak granularity, failing to account for the impact of informal sectors of the economy on pricing. Finally, there is no harmonized international toxicological regulation that takes into account the specifics of the physiology and metabolism of heavy metals in the horse organism. Eliminating these institutional and methodological gaps should become the main priority for international research consortia in the coming decade.

Conclusion

This review demonstratesdemonstrates that global productive horse breeding is on the threshold of a conceptual shift. The present review advances a fundamentally new position: horse meat should be considered not merely as an ethnocultural niche or a marginal regional specialty, but as a strategically important, environmentally sustainable protein system of global significance.

Documented nutritional advantagessuch as record levels of heme iron, an ideal amino acid profile and enrichment with omega-3 polyunsaturated fatty acids make it a valuable dietary product.

The rational use of this resource offers a real mechanism for reducing the carbon intensity of the meat industry while simultaneously providing the population with high-quality micronutrients. Nevertheless,

the realization of this macroeconomic potential is impossible without critically overcoming current barriers. The industry requires the urgent integration of advanced genomic selection tools (GBLUP), the implementation of precision mathematical models for managing toxicological risks (EDI, THQ), and the restructuring of disproportionate trade chains. At all stages of the integration process, the implementation of the HACCP system is substantiated as an integral part of veterinary and sanitary examination, ensuring the identification and control of biological, chemical, and physical risk factors and guaranteeing the safety of products of animal origin.

Kazakhstan possesses significant potential for the further development of horse breeding. The sector is increasingly recognized not only as a traditional branch of animal husbandry but also as a promising source of environmentally sustainable and nutrient-rich meat products. In this context, government support, the modernization of livestock production systems and the growing focus on product quality and export potential create favorable conditions for the industry's long-term sustainable development.

Further development of the sector should be based exclusively on the strict interdisciplinary paradigm of “One Health,” which will ensure the necessary balance between the intensification of the agrarian economy, the preservation of fragile steppe ecosystems, and the long-term protection of human health.

Authors’ Contributions

ZhT: developed the study concept, conducted the literature review, and prepared the initial draft of the manuscript. KI: participated in data analysis and revised the manuscript. AS: supervised the study and assisted with the methodology. SD: carried out editing and final proofreading of the manuscript. All authors have read, reviewed, and approved the final version of the manuscript.

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Statement on Competing Interests

The authors declare that they have no conflicts of interest.

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