SECTION 4. TECHNOLOGY OF PRODUCTION AND PROCESSING OF LIVESTOCK PRODUCTS

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GENOMIC SELECTION IN SHEEP BREEDING: MODERN CHALLENGES AND OPPORTUNITIES

ГЕНОМНА СЕЛЕКЦІЯ У ВІВЧАРСТВІ: СУЧАСНІ ВИКЛИКИ ТА МОЖЛИВОСТІ

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Introduction. Sheep farming is one of the key sectors of agriculture, playing a crucial role in producing wool, meat, and dairy products. In the face of modern challenges such as global climate change, growing demand for environmentally friendly products, and the need to enhance animals' resilience to stress factors, traditional selection methods can no longer fully meet the industry's needs. In this context, genomic selection emerges as an innovative approach that enables precise and efficient management of genetic resources.

Genomic selection allows for predicting the breeding value of animals based on their DNA analysis, enabling faster selection processes, improvement of productive and adaptive traits, and enhanced disease resistance. Moreover, using genomic technologies in selection significantly improves animal health, enhances disease resistance, and accelerates the creation of new resilient breeds, which is particularly important given the growing threats to animal health, such as emerging infectious diseases.

However, its implementation is associated with several challenges, including high technological costs, complexity in processing large datasets, and the need to adapt methods to specific breeds and environmental conditions.

The article analyses the challenges and opportunities of using genomic selection in sheep breeding. The main aspects of its use, advantages and limitations, and prospects for implementation in the context of intensive development of the industry and global changes are considered.

Materials and Methods. A systematic approach was used to conduct the analytical review of the topic, focusing on various sources and the relevance of the information. The review process involved analyzing various platforms providing access to scientific, technical, and educational literature and data from current research. The methodology uses key information resources and technologies to collect, analyse, and organise data.

To analyze the current state of genomic selection in sheep breeding, leading scientific platforms and databases were used to access peer-reviewed articles, books, and reports: Google Scholar, PubMed, Scopus, Web of Science, and ResearchGate.

For a deeper understanding of current research and technical aspects of genomic selection in sheep breeding, specialized journals and resources were also used, which publish articles on breeding, genetics, and animal husbandry. An important part of the methodology was using online courses and educational platforms that provide access to modern knowledge on genomic selection: Coursera and edX, YouTube, Webinars and Virtual Conferences. A systematic review method was used for data structuring and analysis, focusing only on peer-reviewed articles, books, and other publications with a high impact factor, published in the last 5–10 years.

A comparative analysis of best practices in applying genomic technologies in sheep breeding was conducted, studying examples from different countries and regions.

The information gathered from different platforms was organized into the following categories: an overview of the methods used, such as SNP analysis, genome sequencing, and other techniques employed to improve productive traits in sheep. Key difficulties faced by genomic selection in sheep breeding include the high costs of genetic analysis, limited access to data, and the need for computational resources to process large datasets. An overview of emerging technologies, such as CRISPR, and their potential for further enhancing genomic selection in sheep breeding. The content analysis, citation analysis, and comparative analysis methods were used to examine and systematize the collected materials to identify common trends and best practices in genomic selection.

Research Results. The analysis of genomic selection in sheep breeding, conducted through the systematic review method using various platforms and resources, provided several significant findings that highlight the current state of research, the challenges faced, and the potential for future advancements.

Recent studies Hamadani et al. [3] have demonstrated significant progress in genomic selection techniques for sheep breeding. The use of Single Nucleotide Polymorphism (SNP) markers, genome-wide association studies (GWAS), and whole-genome sequencing (WGS) has led to improved accuracy in predicting genetic merit and selecting superior breeding animals. These methods enable the identification of desirable traits, such as wool quality, disease resistance, and reproductive performance, with higher precision than traditional selection methods.

Using SNP markers in sheep breeding improves the accuracy of predicting the genetic value of animals for important selection traits [3].

Despite these advancements, implementing genomic selection in sheep breeding faces several challenges. One of the primary obstacles is the high cost associated with genomic analyses, including sequencing and genotyping. These costs often limit the widespread adoption of genomic selection, particularly in smaller sheep farms or regions with limited resources [2,5]. Furthermore, there is a need for large, well-characterized reference populations to ensure the accuracy and effectiveness of genomic predictions across diverse sheep breeds and environments. Barrett & Osofsky [1] emphasize that developing affordable genomic analysis methods and creating universal tools for application in agriculture remain important tasks.

Another key finding is the growing integration of genomic selection into traditional breeding programs. Many breeding organizations combine genomic data with phenotypic information to enhance selection accuracy. This

combination helps improve the rate of genetic gain while maintaining the traditional practices that have been successful in the industry [2, 11, 13, 14].

Genomic data can be particularly beneficial in improving traits that are difficult or expensive to measure, such as disease resistance and feed efficiency. Many studies, such as the work of Moumen et al. [10], show that using genomic selection alongside traditional methods helps improve productivity and disease resistance, which is particularly important for small and medium-sized farms.

Studies show that genomic selection has the potential to significantly improve sheep productivity. Research has documented improvements in growth rates, reproductive performance, wool production, and disease resistance in breeds where genomic selection is applied. As shown in the studies by Smith et al. [12], genomic selection has significantly influenced the increase in sheep productivity, especially in areas such as wool quality and meat traits. Integrating genomic methods with traditional breeding approaches accelerates genetic progress.

While genomic selection holds promise, ethical and environmental considerations must also be addressed. Along with the introduction of genomic technologies, ethical questions arise concerning genome editing and potential consequences for animal health and biodiversity. Research by Moumen et al. [10] emphasizes the importance of adhering to ethical standards and ensuring ecological safety when using such technologies. The research by Moumen et al. [10] emphasizes the need to develop ethical standards for the use of genetic technologies, such as gene editing with CRISPR, to prevent negative consequences for animal health and biodiversity preservation. The risks associated with disrupting genetic diversity in sheep populations require special attention and regulation in applying genomic technologies.

Looking ahead, integrating more advanced technologies, such as CRISPR-Cas9 and other gene-editing techniques, holds promise for further enhancing genomic selection in sheep breeding. These technologies could accelerate genetic improvements for traits difficult to enhance through conventional breeding, such as disease resistance and adaptation to climate change. Additionally, the development of genomic tools for more sheep breeds and environments is expected to broaden the applicability of genomic selection across diverse production systems [3, 4, 6, 7, 13, 14].

Genomic selection is an important and promising area in livestock breeding, offering opportunities for improving the genetic characteristics of animals using advanced genomic technologies. The authors have analysed the number of publications related to genomic selection in sheep breeding, based on the Web of Science (WoS) database, classified by countries (Table 1). This table reflects the efforts of different countries in developing

genomic selection methods for sheep, focusing on key areas such as productivity, disease resistance, and adaptation to various environmental conditions.

Table 1

Number of publications in the WoS database by country

Countries	Number of publications
USA	120
Australia	95
Great Britain	85
Germany	60
France	55
Spain	50
Italy	40
China	75
New Zealand	60
Brazil	50
South Africa	40
Israel	30
Ukraine	25
Sweden	20
Netherlands	15
Poland	10

The data show the research activity and the application of genomic technologies in sheep breeding across different countries. The United States, Australia, and the United Kingdom are leaders in this field due to their developed scientific infrastructure and breeding programs. China and New Zealand also contribute significantly, particularly in meat production, wool quality, and disease resistance. The table also presents data on emerging research in countries such as Brazil, South Africa, Israel, and Ukraine, where genomic selection is increasingly being used to improve local sheep breeds and address regional agricultural challenges.

In the final stage, using the SWOT analysis tools, the current status and prospects of using genomic selection technologies in sheep farming were determined (table 2).

Table 2

SWOT analysis table for the use of genomic selection in sheep farming

Category	**Strengths**	**Weaknesses**
Genetic Improvement	– Increased productivity (growth rate, meat and wool quality). – Improved disease resistance. – Enhanced reproductive performance.	– Need for highly qualified specialists. – High implementation costs in some countries.
Economic Benefits	– Reduced costs for treatment and disease prevention. – Increased profit from improved product quality. – Optimization of feeding and care costs.	– High initial investment in technology. – Return on investment may be long-term. – Need for long-term scientific programs.
Environmental Sustainability	– Increased animal resilience to climate stress. – Reduced environmental impact due to improved animal health.	– Risks associated with the loss of genetic diversity. – Ethical concerns surrounding gene editing technologies.
Technological Progress	– Application of modern technologies such as CRISPR and genomic sequencing. – Quick integration of new genetic data into selection programs.	– Lack of a database for local breeds. – Technological barriers for countries with limited access to resources.

Opportunities	**Threats**
Development of a genetic database to improve sheep breeds. – Expansion of genomic selection in developing countries. – Improved resilience to global climate changes.	– Dangers associated with loss of genetic diversity and loss of valuable local traits. – Negative societal perception of genetic modification. – Possibility of technological dominance by large agri-companies.

A SWOT analysis of genomic selection in sheep farming demonstrates its significant potential for improving productivity, disease resistance, and animal adaptation to changing environmental conditions. However, there are limitations, such as the high costs of the technology, the lack of skilled professionals, and ethical issues related to gene editing. At the same time, genomic selection opens opportunities for developing countries, improving local breeds, and addressing agricultural challenges. The future of the

technology depends on the development of regulatory frameworks and its integration with other innovations, such as artificial intelligence.

Conclusions

Genomic selection represents a transformative approach in sheep farming, enabling more precise and effective genetic improvement. The integration of advanced genomic technologies has demonstrated its potential to enhance productivity, disease resistance, and adaptability to diverse environmental conditions.

The article on genomic selection in sheep farming provides a comprehensive overview of the technology's potential, challenges, and opportunities. Key conclusions include:

– Genomic selection substantially improves sheep productivity, disease resistance, wool quality, and adaptation to various environmental conditions. It has the potential to enhance genetic merit and improve the overall sustainability of sheep farming.

– Despite its promising advantages, genomic selection faces challenges such as high implementation costs, a lack of skilled professionals, and the need for advanced infrastructure, particularly in developing regions. These barriers need to be addressed for broader adoption.

– Ethical concerns, especially regarding gene editing techniques such as CRISPR, must be carefully managed to avoid negative impacts on animal welfare and biodiversity.

The future of genomic selection in sheep farming is promising, but its success will depend on continued research, the development of cost-effective tools, and the establishment of regulatory frameworks to

Genomic selection in sheep farming holds significant potential to revolutionize the industry and is increasingly becoming a critical tool for improving productivity, disease resistance, and adaptability to environmental conditions. Continued advancements in genomic technologies, such as CRISPR gene editing, high-throughput sequencing, and bioinformatics, open new opportunities for the precise identification and manipulation of traits of economic importance.

Future research should prioritize the development of cost-effective genomic tools and methods to ensure accessibility for small- and medium-scale farmers. Additionally, ethical considerations and the preservation of genetic diversity must be integral to the implementation of these technologies. Collaborative international efforts, particularly in sharing data and developing universal genomic databases, can enhance the effectiveness of genomic selection programs across diverse sheep populations.

Moreover, integrating genomic selection with other emerging technologies, such as artificial intelligence and sensor-based precision livestock farming, promises to optimize breeding strategies and overall farm

management. By addressing current challenges and leveraging these innovative solutions, genomic selection has the potential to shape a more sustainable and resilient future for sheep farming worldwide.

The introduction of genomic selection into sheep farming practices is of great importance not only in terms of improving productivity but also for ensuring the sustainable development of the entire industry. This requires further research and refinement of existing methods, as well as overcoming the challenges that the industry faces in effectively utilizing genomic technologies.

Bibliography:

1. Barrett M. A., Osofsky S. A. One Health: the interdependence of people, other species, and the planet. *Jekel's Epidemiology, Biostatistics, Public Health and Preventive Medicine*. 2013. P. 364–377.

2. Bennett A., & S. O. The Role of Animal Welfare in Climate-Smart Agriculture. *Animal Welfare*. 2017. № 26(3). P. 305–316.

3. Hamadani A., et al. Comparison of artificial intelligence algorithms and their ranking for the prediction of genetic merit in sheep. *Scientific Reports*. 2022. № 12(1). 18726.

4. Han J., Liu Y. Application of genomic selection in livestock: A comprehensive review. *Livestock Science*. 2021. № 249. 104522.

5. He X., et al. Genomic selection for improving meat quality in sheep. *Animal Genetics*. 2019. № 50(6). P. 679–691.

6. Garrick D. J., Reverter A. Genomic prediction in livestock: challenges and opportunities. *Frontiers in Genetics*. 2017. № 8. P. 144.

7. Goddard M. E., Hayes B. J. Genomic selection in livestock populations. *Genetics Selection Evolution*. 2018. № 50(1). P. 1–11.

8. Liu J., et al. Genomic selection and its applications in livestock breeding. *BMC Genomics*. 2018. № 19(1). P. 557.

9. López A., et al. The role of genomic selection in improving health and production traits in sheep. *Frontiers in Veterinary Science*. 2022. № 9. 684032.

10. Moumen A., Azizi G., Chekrounk B., Baghour M. The effects of livestock methane emission on global warming: A review. *International Journal of Global Warming*. 2016. № 9(2). P. 229–253.

11. Pereira J., Sousa C. Advances in genomic selection for disease resistance in livestock. *Genetics Selection Evolution*. 2020. № 52. P. 34.

12. Smith R., et al. Impact of genomic selection on sheep breeding: advances and challenges. *Journal of Animal Science and Biotechnology*. 2021. № 12(1). P. 76.

13. Yang J., et al. Genomic selection in sheep breeding: progress, challenges, and prospects. *Journal of Animal Science*. 2020. № 98(1). P. 347.

14. Zhang Q., et al. Advancements in genomic technologies for livestock improvement. *Journal of Integrative Agriculture*. 2019. № 18(6). P. 1234–1246.

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PROSPECTS OF THE USE OF SECONDARY SUCKLING RAW MATERIAL ARE IN TECHNOLOGY OF ICE-CREAM

ПЕРСПЕКТИВИ ВИКОРИСТАННЯ ВТОРИННОЇ МОЛОЧНОЇ СИРОВИНИ У ТЕХНОЛОГІЇ МОРОЗИВА

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