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Resource and production potential for deep processing of agricultural products in Kazakhstan

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Review Article

ABSTRACT

Deep processing of agricultural products is crucial for developing Kazakhstan's agro-industrial complex and boosting the value of its agricultural commodities. Based on official statistics from Kazakhstan's Bureau of Statistics and using comparative and structural analyses, this study reveals the country's substantial raw material potential, particularly in cereals, oilseeds, and livestock. However, processing depth remains inadequate for several key commodities. Promising areas for growth in the processing industry include starch products, vegetable oils, dairy products, and processed fruits and vegetables.

Keywords: Deep processing, Agro-industrial complex, Food industry, Agricultural raw materials, Export potential, Kazakhstan.

INTRODUCTION

Deep processing of agricultural products is crucial for modernizing the agro-industrial complex (AIC). It increases value-added, fosters sustainable supply chains, reduces reliance on food imports, and boosts national economic competitiveness. Shifting from raw material production to advanced processing requires technological modernization, expanded processing capabilities, and stronger integration between producers, processors, and logistics, ultimately driving exports of high value-added products and improving foreign trade structures (Iashina *et al.* 2023; Pal *et al.* 2024).

Kazakhstan possesses substantial resource potential for the development of agriculture and the food processing industry. According to the Food and Agriculture Organization of the United Nations, the total area of agricultural land in the country, including pastures, amounts to approximately 222 million hectares, reflecting an extensive raw-material base and considerable potential for the development of both crop production and livestock farming (Fao 2012). Pastures occupy a dominant position in the structure of agricultural land, creating favorable conditions for the development of the livestock sector and feed production (Fao 2022). The availability of significant natural resources forms the basis for expanding the processing of cereals, oilseed crops, and livestock products for both domestic consumption and export markets across Eurasia.

While a strong resource base is important, it doesn't guarantee a thriving processing industry. Kazakhstan's agriculture faces growing climatic and environmental challenges common in arid regions. Land degradation and desertification, affecting a large part of the country, pose further risks to agricultural output (Bissenbayeva *et al.*

2025). Therefore, efficient resource use, loss reduction, and resource-saving technologies are crucial for the agri-food sector's sustainable development.

Developed agricultural countries often face a "value-added gap," exporting raw materials while importing processed goods. A balance-based assessment, comparing production, consumption, and trade, is widely used to analyze these imbalances. This approach is relevant for Eurasian agri-food systems, considering production resources, domestic markets, export opportunities, and intersectoral linkages (Vinokurov 2023). In Kazakhstan, processing sector competitiveness depends on raw material availability, enterprise technology, infrastructure, and investment.

Deep processing involves producing goods where value is added through advanced technologies and functional ingredients. In the food industry, this includes fractionation, extraction, membrane technologies, fermentation, and extrusion. For example, whey processing in the dairy industry can yield protein concentrates and functional ingredients (Pires 2021; Buchanan 2023). Similarly, meat industry by-products are increasingly used as a source of bioactive compounds and food ingredients, improving resource efficiency and reducing waste (Gagaoua 2024).

Plant-based raw material processing follows similar trends. In the oil and fat industry, deeper processing involves refining oils and utilizing protein components from oilseed meals and cakes for functional ingredients (Hadidi 2024). Fruit and vegetable processing increasingly valorizes by-products, extracting dietary fibers, pectins, and other bioactive compounds, aligning with circular economy principles and reduced food waste (Khalid 2025; Newson 2025). Grain processing utilizes extrusion and biotechnological processes to produce value-added products like starch derivatives and bioethanol (Offiah 2019; Li 2022; Chen 2025).

Deep processing is now considered in terms of both economics and environmental sustainability. Transforming food industry by-products into new products reduces waste and improves resource efficiency. Food waste valorization stimulates innovation and lessens environmental impact (Caponio 2022). For Kazakhstan, efficient utilization of agricultural raw materials is particularly important due to its arid climate.

Despite Kazakhstan's significant resource potential and growing food industry, a comprehensive assessment of deep agricultural processing opportunities remains underexplored. Specifically, the relationship between resource base, processing capacities, and food market structure requires evaluation. This study analyzes Kazakhstan's resource and production potential in the food and processing industries to identify promising avenues for deep agricultural processing, considering economic and environmental factors. Statistical and analytical methods were used to assess agricultural resources and the development level of Kazakhstan's processing industry.

2. MATERIALS AND METHODS

This study analyzes official statistical data on agriculture and the food industry in Kazakhstan, sourced from the Bureau of National Statistics, FAO, and Eurasian Development Bank reports. National strategic policy documents were also consulted. The potential for deep processing of agricultural products was assessed by comparing production, domestic consumption, and foreign trade volumes using the Self-Sufficiency Ratio (SSR), Import Dependency Ratio (IDR), and Production Utilization Ratio (PUR). Comparative and structural analysis methods were applied to the statistical data.

3. RESULTS

3.1 Resource potential of agricultural production

Statistical data reveal Kazakhstan's strong potential for advanced processing of agricultural goods. In 2024, agricultural output surpassed 3.3 trillion tenge, demonstrating sector growth and a larger raw material base for processing. The food and processing industry, encompassing over 800 product categories, is a key manufacturing sector, primarily driven by cereal, oilseed, and livestock production. Grain production reached approximately 26.7 million tons in 2024, including 19.8 million tons of wheat, solidifying Kazakhstan's position as a major cereal producer in Eurasia.

Table 1. Main indicators of agricultural production in Kazakhstan (2023-2024).

Product category	2023	2024	Change (%)
Cereals, million tons	25.2	26.7	+6
Oilseed crops, million tons	3.0	3.2	+6.7
Milk, million tons	3.42	3.63	+4.5
Meat (live weight), million tons	1.92	2.0	+4

Note*:* Data are based on official statistics from the Bureau of National Statistics of the Republic of Kazakhstan. The “Change” indicator reflects the relative increase in production in 2024 compared with 2023.

3.2 Production potential of the processing industry

An analysis of the structure of Kazakhstan's food and processing industry reveals significant differentiation between the number of enterprises and the actual production volumes across various subsectors (Fig. 1).

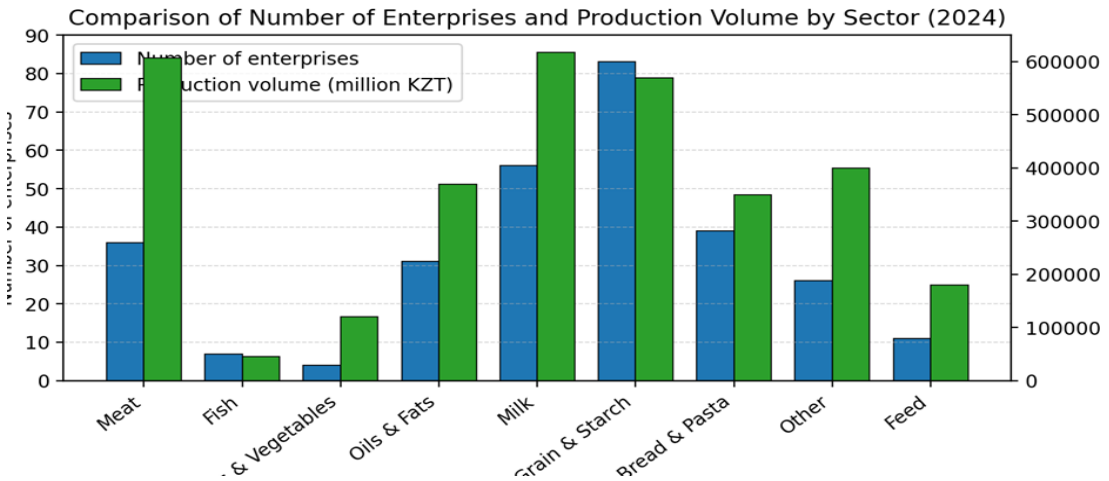

Fig. 1. Number of operating enterprises and total production output (million tenge) across major subsectors of the food and processing industry in Kazakhstan.

Grain processing has the most enterprises (83), reflecting specialization in flour milling, but its production volume (570 billion tenge) is lower than dairy and meat processing, indicating a fragmented structure of mostly small to medium enterprises. The dairy industry shows high production (618 billion tenge) with fewer enterprises (56), suggesting greater concentration and capacity utilization. Meat processing has a similar production volume (607 billion tenge) with even fewer enterprises (36), reflecting higher capital intensity. The oil and fat and bakery sectors show balanced enterprise numbers and production (350-370 billion tenge). Fruit, vegetable, and fish processing have few enterprises, indicating underdeveloped subsectors with potential for expansion.

3.3 Self-sufficiency level and import dependency

Priority directions for deep processing of agricultural products should be selected based on agricultural production scale, domestic food supply, import dependency, export potential, processing capacity, and logistics chain stability.

To assess food supply and identify promising processing industries, the Self-Sufficiency Ratio (SSR), Import Dependency Ratio (IDR), and Production Utilization Rate (PUR) were calculated using statistical data from the Bureau of National Statistics of the Republic of Kazakhstan.

Analysis reveals significant differentiation across commodity groups. Production of cereals, oilseed crops, and vegetables exceeds domestic demand, enabling export-oriented deep processing. Conversely, high import dependency persists for fruits, fish, and sugar, necessitating expanded processing capacities and modernized infrastructure.

Based on agricultural resource potential and food self-sufficiency, priority directions for developing deep processing of agricultural products in Kazakhstan were identified (Table 2).

The most promising segments include the processing of cereals with the production of starch derivatives and bioethanol, the processing of oilseed crops for refined oils and protein products, the development of dairy processing (including cheese, butter, and UHT products), as well as the expansion of vegetable, fruit, and meat processing industries.

Table 2. Priority directions for deep processing of agricultural products in Kazakhstan.

Product group	Production potential	Self-sufficiency level	Import dependency	Priority directions for deep processing
Cereals	Very high	150%+	Low	Starch products, bioethanol, pasta, compound feed
Oilseed crops	High	200%+	Medium	Refined vegetable oils, mayonnaise, margarine, oilseed meal
Vegetables	Very high	150–300%	Low	Purees, tomato paste, frozen and dried products
Fruits and berries	Medium	27–76%	High	Juices, jams, fruit pastilles, freeze-dried products
Dairy products	Medium	≈100%	Medium	Cheese, cottage cheese, butter, UHT milk
Meat products	Medium	90–130%	Medium	Sausages, canned meat, semi-processed products
Fish and aquaculture	Low	18%	Very high	Fish fillets, smoked products, canned fish, fish meal
Sugar products	Medium	≈51%	Very high	White sugar, molasses, starch derivatives

Note: the table was compiled by the authors based on data from the Bureau of National Statistics of the Republic of Kazakhstan and an analysis of food supply indicators.

3.4 Priority directions and regional specialization of deep processing of agricultural products

Comparing agricultural resources and processing industry structure in Kazakhstan reveals promising avenues for advanced agricultural processing. These include grain processing for starch derivatives and bioethanol, oilseed processing for vegetable oils and protein concentrates, and dairy processing for cheeses, milk powder, and whey-based ingredients. Fruit and vegetable processing for juices, canned goods, and dried foods also presents opportunities. Regionally, Northern Kazakhstan is well-suited for grain, milk, and meat processing, while the South and Southeast specialize in fruits and vegetables. The Caspian region shows potential for fish and camel-based product processing. A "product – region – market" matrix, based on agricultural specialization and sales markets, identifies optimal locations for processing facilities (Table 3).

Table 3. Matrix of regional directions for deep processing development in Kazakhstan.

Deep processing product	**Main production regions**	**Potential markets**
Premium flour, pasta	Akmola, Kostanay	Central Asia, China
Hard cheeses	North Kazakhstan	Kazakhstan, Russia
Yogurt, pasteurized milk	Pavlodar, East Kazakhstan	Domestic market, Uzbekistan
Potato products	Karaganda, Pavlodar	Kazakhstan, Russia
Fruit juices, fruit pastilles	Almaty, Zhetysu	Kazakhstan, China
Organic honey	Almaty, Zhetysu	EU, China, UAE
Rice products	Kyzylorda	Central Asia
Canned fish	Atyrau, Mangystau	Caspian region, EU
Canned meat, sausages	East Kazakhstan, West Kazakhstan	Russia, domestic market
Camel milk products	Mangystau	Middle East

Note*:* compiled by the authors based on the analysis of regional agricultural specialization in Kazakhstan.

Agri-food clusters, integrating raw-material production, processing, storage, and logistics, are internationally recognized as the most effective model for developing deep processing in agri-food systems. Table 4 presents a comparative analysis of processing sector development strategies across several countries.

Table 4. International models for the development of deep processing of agricultural products.

Country	**Key policy instruments**	**Main processing sectors**
Netherlands	Agri-food clusters, integration of science and business	Vegetables, dairy products
Germany	Farmer cooperatives, quality standards	Meat and dairy products
Brazil	Industrial zones, tax incentives	Sugar, juices, meat
Turkey	Cold-chain logistics, SME support	Fruits, nuts, oilseed crops

Note*:* compiled by the authors based on international analytical sources and FAO publications.

3.5 SWOT analysis of the development of deep processing of agricultural products in Kazakhstan

A SWOT analysis evaluated internal and external factors influencing the development of deep processing of agricultural products in Kazakhstan, systematizing key conditions affecting the sector (Table 5).

Table 5. SWOT analysis of the development of deep processing of agricultural products in Kazakhstan

Strengths	**Weaknesses**
Significant raw material base of grains, oilseeds, and livestock products; advantageous geographical location between the markets of the European Union, China, and Central Asia; government support for the development of the processing industry; growing domestic demand for locally produced food products.	Obsolescence of technological equipment at a number of processing enterprises; insufficient coordination between agricultural producers and processing companies; limited development of logistics infrastructure and cold-chain systems; low innovation activity in certain regions.
Opportunities	**Threats**
Growth in global demand for processed and functional agri-food products; development of agri-food clusters and export hubs; implementation of digital technologies for production and logistics management; expansion of export markets in Asia and the Middle East.	Increasing competition from imported products; climate risks affecting the stability of agricultural production; seasonality of raw material supply; limited access of small and medium-sized enterprises to long-term financing.

Note: compiled by the authors based on statistical data from the Bureau of National Statistics of the Republic of Kazakhstan and industry analytical sources.

The processing industry's strengths lie in its diverse raw material base, favorable location between major markets, and government support. Weaknesses include outdated equipment, limited coordination between producers and processors, and underdeveloped logistics. Opportunities arise from growing global demand for processed agri-food products and the development of agri-food clusters and digital technologies. Threats include competition from imports, climate risks, and limited access to financing for SMEs. This SWOT analysis highlights the need for technological modernization, improved cooperation, and better logistics to enhance efficiency and expand high-value food production.

4. DISCUSSION

Kazakhstan's agri-food sector exhibits a structural imbalance, with agricultural production outpacing technological processing of raw materials. This model, common in export-oriented agricultural economies, results in value added being generated primarily outside the country through raw commodity exports and processed food imports. International experience, particularly within the European Union's agri-food clusters, demonstrates that increasing raw material processing is crucial for agri-food system sustainability. These clusters integrate production, processing, and logistics, enhancing resource utilization, product competitiveness, and high-value-added food exports. Furthermore, recent studies highlight the role of deep-processing technologies and valorization of agri-food by-products in fostering a circular bioeconomy, enabling the production of functional ingredients, bioactive compounds, and biomaterials while minimizing waste and improving resource efficiency (Ligarda-Samanez *et al.* 2025).

Integrating agricultural processing into a circular bioeconomy fosters sustainable agri-food systems and new technological value chains. Biotechnological and biorefinery processes transform agricultural materials into valuable products like protein ingredients, biochemicals, and bioenergy (Ezeorba *et al.* 2024). Agri-food processing enhances agricultural profitability and rural sustainability. Studies show farmer participation in value-added chains, including processing and branding, can increase income by 15-40%, reduce losses, and stabilize markets (Bhai *et al.* 2026). In Kazakhstan, these approaches can strengthen agri-food supply chains, expand value-added production, and improve resource utilization.

Grain and oilseed crops offer the greatest potential for processing capacity expansion. International studies confirm that deep processing of these crops into products like starch derivatives, bioethanol, and protein ingredients is crucial for developing bioeconomies and circular production systems (Hadidi 2024; Pal *et al.* 2024). This development can improve agricultural raw material utilization and reduce reliance on primary product exports.

High import dependence on fruits, fish, and sugar necessitates expanding processing capacities and modernizing infrastructure. International experience demonstrates that developing fruit and vegetable processing and aquaculture diversifies the agri-food sector and strengthens food security (Newson 2025).

The spatial organization of processing is also critical. Processing facilities should be located considering regional agricultural specialization, a common practice in countries with advanced agri-food industries, to minimize logistics costs and improve agri-food supply chain efficiency.

Therefore, increasing deep processing of agricultural products demands a comprehensive strategy that includes modernizing processing technologies, developing agri-food clusters, and expanding export-oriented production of high-value-added foods.

Research limitations

This study's limitations include its reliance on aggregated statistical data, which precludes assessment of individual processing enterprises' technological efficiency, and the lack of detailed investment efficiency indicators for specific deep-processing projects. The spatial analysis, conducted at the regional specialization level, also overlooks micro-level logistical and infrastructural factors. Future research should incorporate economic-mathematical modeling of processing facility allocation and assess the investment attractiveness of specific deep agricultural processing technologies.

Policy implications

These results inform policies aimed at strengthening Kazakhstan's agro-industrial complex. Priorities include technological modernization of processing enterprises, development of agri-food clusters in regions with concentrated agricultural production, and improved logistics infrastructure, particularly cold-chain systems. Implementing these measures can increase agri-food product value and strengthen export potential.

CONCLUSION

Kazakhstan has substantial resources and production capacity for advanced agricultural processing, supported by a strong raw material base of grains, oilseeds, and livestock. However, a structural imbalance exists between raw material production and technological processing, especially for fruits, vegetables, fish, and sugar. Promising areas for development include starch derivatives and bioethanol from grain, refined vegetable oils, expanded dairy processing, and fruit and vegetable processing. A cluster-based approach, infrastructure modernization, and export-oriented production can enhance the value and competitiveness of Kazakhstan's agri-food sector.

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