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CIRCULAR INNOVATION MANAGEMENT IN MILK AND DAIRY PROCESSING ENTERPRISES: STRATEGIC APPROACHES TO RESOURCE EFFICIENCY AND SUSTAINABLE DEVELOPMENT

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ABSTRACT

The transition towards a circular economy is becoming an important strategic priority for the food processing industry. Milk and dairy processing enterprises generate considerable quantities of secondary resources, including whey, organic residues, wastewater and packaging materials, which can create environmental challenges if they are not properly managed. At the same time, these materials represent opportunities for developing new products, reducing production costs and generating additional economic value. The purpose of this study is to develop strategic approaches to managing circular innovations in dairy processing enterprises. The research applies systematic analysis, comparative assessment, process-oriented analysis and conceptual modelling. Particular attention is given to the transformation of production by-products into economically valuable resources, the development of circular business models and the integration of environmental and economic objectives into managerial decision-making. The study proposes an organizational and managerial model for implementing circular innovations based on resource identification, technological selection, economic justification, partnership development and performance monitoring. The results demonstrate that circular innovation management should be considered not merely as an environmental activity but as an integrated strategic management approach capable of strengthening enterprise competitiveness and supporting sustainable industrial development.

INTRODUCTION

The modern food industry is experiencing significant changes associated with environmental challenges, resource limitations, increasing production costs and growing expectations regarding sustainable business practices. Traditional industrial production models are largely based on the linear principle of “take, produce and dispose”, which often results in inefficient resource utilization and increased environmental pressure.

In contrast, the circular economy promotes a different approach based on resource recovery, waste prevention, reuse, recycling and the creation of additional economic value throughout the production cycle.

Milk and dairy processing enterprises represent an important area for implementing circular economy principles. Their production activities generate different types of secondary resources, particularly whey, milk residues, organic sludge, wastewater and packaging materials. These resources should not automatically be con-

sidered useless waste because some of them contain valuable components that can be recovered and transformed into commercially relevant products.

One of the most significant examples is whey, which is generated during cheese and casein production. Research indicates that whey retains substantial nutritional components of milk, including proteins, lactose and minerals. Its uncontrolled discharge may also cause serious environmental problems due to its high organic load. Recent studies demonstrate that whey can be converted into protein concentrates, lactose-containing ingredients, fermented products and bioenergy. Innovative processing technologies therefore create opportunities for combining environmental protection with economic value creation.

However, the introduction of circular technologies requires more than technological modernization. It involves managerial decisions concerning investment allocation, production organization, business model transformation, cooperation with external partners and the establishment of appropriate performance indicators.

For developing economies, including Uzbekistan, this issue is particularly relevant. The modernization of the dairy processing industry requires approaches that enable enterprises to improve resource utilization while maintaining economic efficiency and product quality.

The purpose of this research is to develop strategic and organizational approaches to managing circular innovations in dairy processing enterprises. The research objectives are to examine the managerial significance of circular innovations; identify opportunities for converting secondary resources into value-added products; develop a strategic management model; determine performance indicators; and formulate practical recommendations for circular business models.

METHODS

The methodological framework of the research is based on systematic, comparative, analytical and process-oriented approaches. The study uses a conceptual analysis of scientific publications on dairy by-product valorization, circular business models, sustainable production and resource recovery.

The research methodology consists of four interconnected analytical directions. First, secondary resources are identified by examining production processes and classifying materials that can be reused, recycled or transformed into economically valuable products. Second, technological and economic alternatives are assessed according to technical suitability, investment requirements, operating costs and expected benefits. Third, circular business models are developed by considering internal recycling, product diversification and cooperation with external organizations. Fourth, managerial performance is evaluated through economic, environmental and organizational indicators.

The following indicators are recommended for practical assessment:

Assessment area	Indicators	Purpose
Resource efficiency	Share of secondary resources utilized; production losses	Measure material recovery
Economic efficiency	Additional revenue; avoided disposal costs; operating cost reduction	Assess financial value
Environmental performance	Wastewater pollution load; waste diverted from disposal	Monitor environmental outcomes
Technological performance	Processing capacity; equipment utilization; recovery efficiency	Assess process performance
Business development	New products; partnerships; additional revenue streams	Evaluate strategic development

RESULTS AND DISCUSSION

The analysis demonstrates that dairy processing enterprises have several opportunities to implement circular economy principles. The most important direction is the transformation of secondary resources into products with additional economic value.

Whey, for example, can be used as a raw material for producing whey protein concentrates, lactose-containing ingredients, fermented beverages and other functional food products. Depending on its composition and the enterprise's technological capabilities, it may also be directed towards biological processing and energy recovery.

Other production residues can also be considered within circular management strategies. Organic sludge may be suitable for appropriately controlled biological treatment or other recovery processes, subject to environmental and sanitary requirements.

Table 1. Opportunities for utilizing secondary resources in dairy processing enterprises

Secondary resource	Potential utilization direction	Expected economic benefit
Whey	Whey beverages, protein ingredients, lactose recovery	Additional revenue and reduced disposal costs
Organic production residues	Biological treatment and potential biogas production	Energy recovery and waste reduction
Wastewater	Treatment and technically appropriate water reuse	Lower freshwater consumption
Packaging materials	Collection, sorting and recycling	Reduced material losses
Milk processing residues	Recovery of suitable components and permitted feed applications	More efficient resource utilization

The selection of a particular utilization pathway should depend on the composition of the secondary resource, available technologies, production scale, market demand and investment capacity. Not every by-product can be economically recycled by every enterprise. In some cases, cooperation with specialized processing organizations may be more efficient than establishing an independent processing facility.

The implementation of circular innovations requires a transition from traditional waste management towards business models that incorporate resource recovery into the enterprise's value creation process. Four strategic business models can be distinguished.

1. Internal resource recovery model. The enterprise independently processes its secondary resources and integrates recovered materials into existing production processes. This model is relevant when the enterprise has sufficient production capacity and technological infrastructure.

2. Product diversification model. Secondary resources are transformed into new commercial products. For example, suitable whey streams may be used in the production of fermented beverages or specialized food ingredients.

3. Industrial partnership model. The enterprise cooperates with external organizations specializing in biotechnology, feed production, organic waste treatment or energy recovery. This approach can reduce the investment burden associated with independent technological development.

4. Integrated circular value chain model. Several organizations cooperate within a coordinated system of resource collection, processing, transportation and commercialization. This model makes it possible to distribute costs, technological responsibilities and economic benefits among participating organizations.

Recent research on decentralized by-product valorization and circular business models in the dairy sector highlights the importance of selecting solutions according to stakeholder priorities, value-chain characteristics and local operating conditions.

Table 2. Managerial priorities for implementing circular innovations

Management priority	Recommended managerial action	Expected result
Resource management	Conduct regular material-flow audits	Identification of unused resources
Investment management	Evaluate circular projects using economic criteria	More informed investment decisions
Innovation cooperation	Establish partnerships with research institutions	Access to new technologies
Production management	Integrate resource recovery into production planning	Reduced material losses
Strategic management	Include circular targets in enterprise strategies	Long-term sustainable development

The effectiveness of the proposed approach can be evaluated through a combination of economic, environmental and organizational indicators. Managers can monitor the share of generated whey that is commercially utilized, additional revenue obtained from secondary resources, reductions in disposal expenditure and the share of recycled water in technically suitable operations.

The use of such indicators allows managers to evaluate whether circular innovation projects generate measurable business value. Nevertheless, technological feasibility and environmental safety must remain essential selection criteria. The recovery of secondary resources should comply with food safety, sanitation and environmental regulations.

CONCLUSION

The research demonstrates that circular innovation management represents an important strategic direction for improving the economic and environmental performance of milk and dairy processing enterprises.

First, secondary resources generated during dairy processing should be considered not only as production residues but also as potential sources of additional economic value. Their effective utilization can contribute to reducing resource losses and diversifying enterprise revenue.

Second, the introduction of circular innovations requires an integrated managerial approach that combines resource identification, technological selection, investment planning, organizational cooperation and performance monitoring.

Third, the proposed strategic management model provides a systematic framework for incorporating circular innovation projects into enterprise development strategies. It enables managers to select appropriate utilization pathways according to technological capabilities, financial resources and market opportunities.

Fourth, circular business models, particularly industrial partnerships and integrated value chains, can create opportunities for enterprises that lack sufficient financial and technological resources to establish independent processing facilities.

Finally, the transition towards circular production should be considered an element of long-term enterprise competitiveness rather than merely a response to environmental requirements. For dairy processing enterprises in Uzbekistan, these approaches may create opportunities to improve resource efficiency, develop new products, reduce production losses and strengthen cooperation between industrial enterprises, agricultural producers and research institutions.

Further research should focus on the empirical assessment of circular business models using production, financial and environmental data from selected dairy processing enterprises in Uzbekistan.

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