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NEXT-GENERATION ROBOTICS AND ARTIFICIAL INTELLIGENCE IN PRECISION LIVESTOCK FARMING AND ANIMAL-SOURCE FOOD PROCESSING

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Abstract: *Robotics and artificial intelligence offer opportunities to enhance the precision, repeatability, and control of operations within livestock farming and the processing of animal based products. However, technological novelty does not, in itself, constitute the proof of biological, technological, or economic efficiency. This summary examines individual animal feeding, robotic milking, animal monitoring via sensors and data analysis, separate urine collection using the "Cow Toilet" system, hyperspectral meat inspection, and the use of robots in dairy processing. The analysis distinguishes between findings from experimental studies and the functions or performance metrics claimed in commercial documentation, incorporating technological developments presented between 2024 and 2026. Under the investigated conditions, the evidences support a reduction in nutrient intake by adapting feeding to individual animal needs, as well as a decrease in ammonia emissions by separate collection of urine. These results must be interpreted in the context of the technology used, animal population, and operational conditions evaluated. The transferability of algorithmic and industrial performances requires external validation—using animals, farms, product batches, and technological configurations that are independent compared to those employed during development and initial testing. This paper proposes an insightful framework for the evaluation and transfer of these technologies to Romania, integrating animal welfare, food safety, resources consumption, and the total cost of implementation and operation. The adoption of technologies must be grounded in measurable and reproducible benefits compared to the reference practice; awards received at exhibitions and commercial specifications are no substitute for independent validation of effectiveness.*

Keywords: robotics; precision livestock farming; artificial intelligence; Cow Toilet; hyperspectral imaging.

Introduction

Precision livestock farming enables individual animal monitoring and the adaptation of care, feeding, and housing conditions to each animal's needs. Robotics supports these activities by automating feed distribution, teat cup attachment, and alley cleaning, as well as product handling in processing facilities. Artificial intelligence (AI) analyses the collected data, helps anticipate problems, and identifies situations requiring intervention. The value of these technologies is demonstrated when their use leads to measurable improvements in animal health and welfare, production, or the efficiency of technological processes.

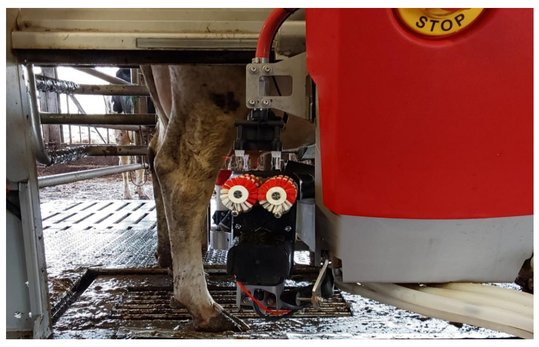
Review Approach

This paper was prepared as a narrative review, drawing on available full-text articles, publicly accessible abstracts, university reports, patents, and official information published by manufacturers and exhibition organizers. Each source was examined in terms of the technological application, study type, animals or products investigated, findings, and limitations to their applicability. Experimental studies, scientific reviews, institutional reports, commercial announcements, and the authors' proposals were assessed with consideration of the level of scientific evidence supporting them. Commercial sources were used to describe equipment functions and market introduction dates.

Robotics and AI in precision livestock farming

Andretta et al. (2016) evaluated precision feeding in 70 growing–finishing pigs over 84 days using five Automatic and Intelligent Precision Feeders (AIPF; University of Lleida, Spain). These systems electronically identified individual animals and automatically blended two feeds of differing nutrient densities according to their estimated daily lysine requirements. Compared with conventional three-phase group feeding, individualised feeding supplying 100% of estimated lysine requirements reduced digestible lysine intake by 26%, estimated nitrogen excretion by 30%, and feeding costs by 10% (US$7.60/pig), without compromising growth performance.





Introduced on 18 March 2025, the Lely Vector MFR Next is an electrically powered robotic system designed to automate feed mixing and distribution in dairy farming. With a maximum loading capacity of 800 kg, representing a 35% increase over its predecessor, the robot delivers freshly mixed rations throughout the day and night according to the nutritional requirements of different animal groups. An updated mobile application enables remote monitoring of operational data and robot status, while the redesigned feed centre allows two robots to be loaded simultaneously, supporting larger dairy operations. According to the manufacturer, these innovations aim to reduce manual labour, minimise feed wastage and improve feeding efficiency.



Introduced on 24 June 2025, the Lely Astronaut A5 Next incorporates an advanced teat detection system combining laser and camera technology, an upgraded operating system enabling remote support and software updates, and optional automatic milk filtration. For larger dairy farms, the Astronaut Max centralises essential milking services for up to 18 robots. Integration with herd management software and compatible sensors enables the monitoring of milk yield, milk characteristics, activity and rumination. Changes in these parameters can help identify animals requiring closer attention, supporting earlier assessment of potential health problems.

Conclusions: The responsible use of these technologies supports more efficient livestock production, animal welfare, and food quality.



Toilets for cows?

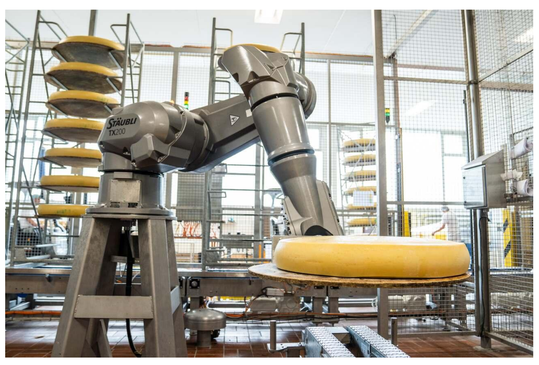


Developed by Hendrik Jan Hanskamp, the Cow Toilet is an automated urine-collection system integrated into a feeding station. Gentle mechanical stimulation induces urination, allowing urine to be collected separately from faeces and transferred to a dedicated storage tank. At Dairy Campus (Netherlands), a controlled comparison involving two groups of 16 dairy cows demonstrated a 35–47% reduction in ammonia emissions relative to conventional housing. Over a separate 52-week monitoring period, the system collected an average of 10.1 L of urine/cow/day, representing approximately 35% of estimated urine production. The collected urine contained 5.6 g nitrogen/kg and 10.9 g potassium/kg. These findings demonstrate the potential of automated urine separation to reduce ammonia emissions while retaining nutrients for subsequent agricultural use.

Robotics in carcass processing. Frontmatec's AiRA range automates carcass splitting, internal fat removal, and pH measurement, helping to reduce manual effort and standardise operations. The solutions presented for IFFA 2025, including the Leaf Lard Remover Robot and robots for primal cutting and pork belly trimming, expand the possibilities for automation in meat processing .

Hyperspectral imaging for quality control. By combining spatial and spectral information, this technology enables the estimation of meat composition, physicochemical and sensory properties, and indicators of spoilage. Ghimpeteanu et al. (2025) used the Specim FX17 camera (900–1700 nm) and a Vision Transformer model to identify foreign bodies on pork belly. Evaluation using 55 images with contaminants and 183 without contaminants demonstrated the feasibility of automated detection, while the complete processing pipeline eliminated false positives from the contaminant-free dataset. These findings support the technology's potential for automating inspection and assisting quality control.





Key Findings: Robotics and artificial intelligence can improve operational precision and resource use by linking monitoring to tailored interventions. The reviewed studies demonstrate measurable benefits of individualised feeding and separate urine collection for reducing ammonia emissions under the conditions evaluated. Hyperspectral imaging supports meat quality control, while robotics enables the automation of demanding operations in dairy processing. These technologies must be assessed in terms of efficiency, animal health, and welfare, distinguishing declared functions from demonstrated outcomes. Integrating data into farm management facilitates the identification of situations requiring intervention and the adaptation of care to animals' needs. Automating repetitive tasks allows staff to devote more time to livestock monitoring and process control.

RECENT INNOVATIONS	DOCUMENTED FUNCTION	BENEFITS
Oasis ONE — Grand Prix, Geneva 2026	Aquaculture platform combining genetics, biosecurity, and water recirculation.	Integrated production management, water reuse, and support for biological risk control.
Vaccybot — Agri Advanced Technologies; gold, EuroTier 2024	Visually identifies the injection site and robotically vaccinates pullets; bird shackling remains manual.	Automated vaccine administration and reduced repetitive manual operations.
RoBooVaxx — Óbuda University; silver, EuroTier 2026	Identifies cattle using RFID and performs needle-free administration using visual analysis and a robotic arm.	Automatic association of each animal with the intervention and administration without needles.
Glide Flo — Sveaverken/SVEA; silver, EuroTier 2026	Cleans slatted floors using LiDAR for mapping, navigation, and obstacle recognition.	Automated cleaning and reduced manual labour requirements for floor maintenance.
Barn Buggy — Wasserbauer; silver, EuroTier 2026	Plans alley cleaning using LiDAR and adapts its movement to obstacles and barn characteristics.	Automated alley cleaning and route adaptation to the barn layout.
Smart Farrowing Pen — WEDA/VetVise; gold, EuroTier 2026	Uses video analysis to monitor sow and piglet behaviour and adjusts creep-area temperature and the feeding curve.	Continuous monitoring and automatic adjustment of housing and feeding conditions.