Awards issued prior to January 20, 2025, were funded under previous Administrations and may not reflect the priorities and policies of the current Administration.

United States Department of Agriculture
Project Initiation

Project Data for Accession Number 1032139

Project Title

PARTNERSHIP:Optimizing Individualized Feeding to Increase Production And Profit, And Minimize Environmental Impacts Of Dairy Farms

Project Details

Sponsoring Institution National Institute of Food and Agriculture	**Project Status** ACTIVE
Funding Source NIFA Non Formula	**Grant Year** 2024
Grant No. 2024-68016-42391	**Cumulative Award Amt.** $1,150,000.00
Proposal No. 2023-10997	**Multistate No.** (N/A)
Project Start Date Sep 01, 2024	**Project End Date** Aug 31, 2028
Program Code [A1261] Inter-Disciplinary Engagement in Animal Systems	

Project Director

Hanigan, M.

Recipient Organization

VIRGINIA POLYTECHNIC INSTITUTE & STATE UNIVERSITY

300 TURNER ST NW

BLACKSBURG, VIRGINIA 240603359

Performing Department

(N/A)

Non Technical Summary

Energy and protein feeding represent 65% of milk production costs. Underfeeding nutrients results in lost revenue, and overfeeding causes increased costs and environmental impact. Current systems do not accommodate genetic diversity in nutrient requirements. Discovering true amino acid requirements, and feeding individuals to meet those requirements should result in $0.22 to $0.44/cow/day additional profit and 46 to 92 g/cow/day reduction in nitrogen excretion.We have developed a data collection and feeding control system that uses real-time data to monitor animal performance, discover individual animal amino acid requirements, and formulate individul animal diets fed through on-farm automated feeders. We propose to complete development of the anomaly detection system, assess economic gains and environmental impact redutions when using the system on 4 farms, develop extension programming based on project results, and conduct extension programming on nutrient efficiency, dairy profit, and enviornmental impacts.

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The test data will be mined in real-time to improve our understanding of thermal stress and nutrition, environment, and management factors contributing to health disorders. Extension programming flowing from the project will be used to improve producer and nutritionist understanding and competency in feeding and animal management.Overall, we expect the long-term outcomes of this work to be better management practices including more efficient feed use, a growing acceptance of use of technology to account for on-farm variation, the emergence of on-farm application of machine learning, and greater economic and management incentives for dairy producers. Ultimately, these changes will not only improve the bottom line for dairies but will also improve the sustainability of US agriculture by allocating fewer land resources for milk production. As data accumulates over time, we will be able to develop breeding values for efficiencies of DM digestibility and use of individual metabolized amino acids for milk and body tissue. The data will also support maintenance of the energy efficiency predictions. This will be critical to the development of a feed efficiency selection index that incorporates traits indicative of rumen function and efficiency beyond current growth measures.

Animal Health Component

Animal Health Component: 5%

Research Effort Categories

Basic	30%
Applied	50%
Developmental	20%

Classification

Knowledge Area (KA)	Subject of Investigation (SOI)	Field of Science (FOS)	Percent
307	3410	1010	60%
601	3410	3010	10%
315	3410	2080	10%
404	3410	2080	20%

Knowledge Area

[307] Animal Management Systems

[601] Economics of Agricultural Production and Farm Management

[315] Animal Welfare/Well-Being and Protection

[404] Instrumentation and Control Systems

Subject Of Investigation

[3410] Dairy cattle, live animal

Field Of Science

[1010] Nutrition and metabolism

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[3010] Economics

[2080] Mathematics and computer sciences

Keywords

dairy, management, precision, machine-learning

Goals / Objectives

The goals of this project are:to apply a mix of supervised heuristics and unsupervised machine-learning performance diagnostics to real-time, individual animal data to derive actionable management information and to control automated animal feeders;to influence dairy nutritionists and producers to use these tools to improve management decisionsThe specific objectives of the proposed work are:1: Predict individual animal performance and identify deviations from expected production, normal health, income minus feed costs, and expected nutrient excretion.2: Economically optimize diets for individual cows based on their discovered requirements for total metabolized essential amino acids, and use it to derive feeding solutions to control auto feeders.3: Evaluate system operation on commercial dairy farms and refine based on observations and stakeholder feedback.4: Develop and deliver a translational extension program integrating on-farm existing technologies and system attributes.

Project Methods

Obj. 1: Real-time production, step and chewing activity, feed delivery, health event, and environmental temperature data will be collected electronically from each dairy and subjected to machine-learning based anomaly detection to identify unexpected deviations in observed performance, health, and activity relative to that expected, The anomalies will be summarized in management reports to aid in management decisions, and, where appropriate, used to manage nutrient supply delivered by teh automated feeders. Accumulated data will periodically be explored to disccover unknown relationships among nutrition, health, environmental stress, and management. The problem will be approached in a hierarchical manner starting with expected performance (mechanistically predicted where possible), followed by anomaly detection, and problem identification, and concluding with system improvements. The work will facilitate the development of translational extension programming with a focus on data mining and interpretation.Obj. 2: Ideal diets will be derived by optimization of available feed ingredient inputs to the NASEM (2021) model using dry matter intakes predicted from animal chewing activity and a one-time, marker-based assessment of intake; and ingredient and milk prices reported by the dairy. Intake predictions will be bias adjusted based on pen feed intakes (reported delivery and pickup or delivery and visual feed refusal scores). A second round of optimization will be conducted to derive grain and forage mixes used to construct the partial mixed ration fed in each pen and the mixes fed through the automated feeders.The efficiency of conversion of metabolized amino acids to milk protein production by individual cows will be assessed by systematic manipulation of the grain mixes offered at the automated feeders. The 2 grain mixes available at the feeders will be coerced to high and low metabolized protein content with equal energy contents using constraints during the 2nd round of diet optimization. Each cow will be subjected to 5 different metabolized protein feeding rates within a replicated Latin Square design. The observed changes in marginal efficiencies for each cow will be used to adjust the efficiency settins in the NASEM (2021) model for subsequent diet formulation work. Reductions in predicted nitrogen excretion and economic gains will be assessed.Obj. 3: The system containing the enhanced anomaly detection and diet optimization code and the protein efficiency assessment protocol will be evaluated under field conditions at 1 research and 3 commercial dairies. Farm staff and support professionals will be engaged to identify dairy characteristics, goals, and constraints. Based on these inputs and in collaboration with pertinent personnel, diets will be optimized and grain and forage mixes derived. Half the cows will be assessed for chewing, digestive (marker protocol), and metabolized protein (dose-response protocol) efficiencies, and their diets adjusted to reflect their unique characteristics. Reductions in nitrogen excretion and economic gains will be compared to animals not enrolled in the program. Upon completion of the test, the remaining animals in the herd will be tested and enrolled.Feeedback from the farm staff and support professionals will be solicted.Obj. 4: The 1st phase will

consist of the development of educational materials (i.e., video and audio contents, extension articles, and factsheets) that will start in year 1 to enhance knowledge of dairy producers and other stakeholders by translating technical information on general feeding management, robot feeding recommendations, environmental impacts, and financial returns. The data generated in the first 3 objectives will support the deployment of these materials. Additionally, a series of short-term technical videos in a webinar series format will be developed for professionals and producers. These rapid features will be up to five minutes in duration. Entitled "What if", this feature will be a series of mini case studies that present frequent challenges stakeholders face in their routine, followed by how the proposed system features can contribute to overcoming this challenge and foreseen potential upcoming problems. The "What if" web series will be available in multiple formats to allow stakeholders to decide what is the most convenient way for them to follow our updates at any time. The videos will be converted into audio content and transcribed into factsheets. "What if" developed materials will serve as crucial linking pieces of our extension program to rapidly equip investigators such as extension personnel to provide comprehensive and engaging information on applied use of system data, and will serve to demystify and simplify data mining, provide effective recommendations, and ultimately translate daily challenges into opportunities.Stakeholder input will also be captured and used to guide system refinements. Adjustments may be made to the interface, report layout, content, and user control to ensure a friendly and intuitive format. This will be achieved through video conference meetings with enrolled farms in years 1 and 2. The target size for the stakeholder group is a maximum of 12 representatives to ensure effective participation. Stakeholders will include participating dairy producers, dairy managers, and consulting nutritionists. These individuals will be recruited from different states to ensure national representation. Initial meetings will focus on the layout and content of input screens and reports. Later meetings will focus on user control of the system and system operation. The users will be provided access to the system throughout development and encouraged to provide feedback at any time.The 2nd phase will comprise a series of technical training workshops that will take place in years 3 to 4, and will be open to Extension personnel, nutritionists, and producers nationally. Workshop attendees will utilize the system to set up and control a simulated herd that will be based on information gleaned from cooperating farms. Workshops will also provide general knowledge and understanding of dairy production and management that will be transposable to other facets of the operation. Providing this hands-on atmosphere will allow participants to successfully master techniques and ask questions in a way which is familiar to them. These exercises are necessary for successful educational training and will allow the project team to refine the training materials and to develop reference estimates for methods to improve feeding efficiency. A pre- and post-workshop evaluation will assess attendee knowledge gain. Workshops and demonstrations will be recorded and posted on the SLdairy webpage. Voice-over will be conducted on each video explaining key points to remember and practice, how to use different metrics, and why recommended feeding testing is needed. Video learning modules will be made available online and allow dairy producers to achieve many of the same learning outcomes as those who attend workshops in person. Examples of a similar program (jointly produced by UNL and Iowa State) is currently listed on the UNL Dairy extension website: https://dairy.unl.edu/calf-care-and-handling-videos-now-available-online . The online resource will be publicized at dairy producer meetings, e-newsletters, and social media sites in addition to in-person presentations in conferences. Enhancement of participation is expected with industry collaboration and support. We anticipate information to also be shared in presentations around the country annually over the 4-year proposal length and for several years after the project ends.