DRIVING INNOVATION AND COMPETITIVENESS IN THE U.S. DAIRY SECTOR THROUGH STRATEGIC RESEARCH

Dairy Management Inc. (DMI)
Product Research-Ongoing Projects

DMI DAIRY MANAGEMENT INC.™

DMI

Dairy Management Inc.™ (DMI) is funded by America's dairy farmers, as well as dairy importers. Created to help increase sales and demand for dairy products, DMI and its related organizations work to increase demand for dairy through research, education and innovation, and to build trust in dairy foods, farms and businesses.

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https://www.usdairy.com/about-us/dmi/product-research-team/product-research-staff

DMI DAIRY PRODUCTS RESEARCH ANNUAL FUNDING:

Each year, DMI Dairy Products Research organizes a public call for proposals through National Dairy Council which is the science arm of DMI:

http://researchsubmission.nationaldairycouncil.org/Pages/Home.aspx

The goal of this program is to fund research projects at various dairy research centers and other universities and research centers to create scientific knowledge that results in the development of innovative dairy products and ingredients.

OUR RESEARCH FUNDING IS TARGETED TO ADDRESS THE FOLLOWING FOCUS AREAS:

CHEESE AND CULTURED DAIRY:
Enhance cheese and cultured dairy opportunities in domestic and export markets.

MILK POWDERS:
Enable the U.S. to be a preferred supplier of milk powders (SMP/NDM/WMP) by developing the knowledge to consistently produce powders that exceed customer specifications.

MILK AND WHEY INGREDIENTS AND FRACTIONS:
Increase utilization of milk/whey proteins and other fractions and ensure that dairy proteins remain the protein ingredient of choice for food formulators.

CO-PRODUCTS:
Improve quality, performance, and increase utilization of co-products.

FLUID MILK AND BEVERAGES:
Drive incremental growth in dairy beverages.

DISCOVERY:
Cutting edge research that leverages a new or emerging technology to keep the U.S. dairy industry at the forefront of innovation.

FOOD SAFETY:
Control of food safety risks in dairy foods and/or dairy processing environments.

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DAIRY MANAGEMENT INC.
Rosemont, IL

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A HIGH-PRESSURE PROCESSING MANUFACTURING STRATEGY TO PRODUCE LONG SHELF-LIFE YOGURT WITH ACTIVE PROBIOTICS AND ENHANCED IMMUNE ATTRIBUTES

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OBJECTIVE

This project aims to develop innovative solutions for producing yogurt with active probiotics and enhanced immune attributes, by using a High-Pressure Processing (HPP) strategy. High Pressure Processing (HPP) is a nonthermal food processing technology that subjects packaged foods to pressures typically between 300 - 600 MPa, for a few minutes, at temperatures between refrigeration to ambient. Yogurt characteristics and viability of the culture after HPP will be determined, and the HPP parameters that lead to the highest quality yogurt, and the lowest culture reduction will be determined. As a result of this project, a novel and viable strategy for delivering enhanced nutrition to the consumers using a novel dairy platform will be developed.

BENEFIT TO INDUSTRY/FARMER

This project is designed to advance the US dairy sector by developing a new generation of fermented products that directly address current consumer and industry demands, which will help solidify the U.S. dairy industry's position as a leader in global innovation. This new family of products could bring significant profits both to the dairy processors and to the dairy farmers who will supply the milk used for making the yogurt. The anticipated extended shelf life of HPP-treated yogurt will open opportunities for long-distance distribution across the United States. The data and knowledge generated in this work will be made available to both the scientific and dairy industry community in the US.

APPLICATION OF A PREDICTIVE TOOL ON MILK QUALITY AND RIPENING CONDITIONS TO REDUCE THE INCIDENCE OF BIOGENIC AMINES IN CHEESE

INVESTIGATORS

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OBJECTIVE

Biogenic amines (BA) are microbially produced nitrogenated organic compounds often found in ripened cheeses that are associated with flavor and gas defects, as well as potential toxicological reactions on consumers with high sensitivity. BA incidence in cheese is primarily produced by bacteria via amino acid decarboxylation during cheese ripening. In this work, an advanced molecular tool will be developed to predict the production potential of two BAs, histamine (His) and tyramine (Tyr). This research will quantify their levels in cheese milk, as well as in cheeses immediately after manufacture and during ripening. The prediction models will be then applied and validated in various scales of production (i.e., pilot plant scale, and a commercial facility). This tool can help cheesemakers reduce BA incidence in ripened cheese by adjusting ripening conditions.

BENEFIT TO INDUSTRY/FARMER

This project will have a direct impact on the quality of ripened cheeses and therefore a reduction in cheese being downgraded. We anticipate that targeted quantification of defect-causing bacteria in milk and cheeses after manufacture will have the potential to prevent a variety of cheese defects. We anticipate that this method can potentially be applied to prevent the incidence of other BA and help improve the quality and safety of cheese, therefore increasing trust in the dairy industry.

DEVELOPING A DAIRY-BASED ANTIFUNGAL INGREDIENT FOR USE IN THE CHEESE INDUSTRY

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OBJECTIVE

Food spoilage by fungal contamination is responsible for waste generation and great economic losses. Fungal contamination not only affects the appearance, texture, and flavor of food products, including cheese, but it can also generate certain compounds (mycotoxins) that can have serious and long-term health effects on consumers. Fungal contamination with cheese is commonly treated with a variety of methods such as modified packaging, preservatives, and bioprotective cultures, but recently, consumers are requiring natural and "clean label" ingredients in their foods. The objective of this project is to use components from whey proteins to create consumer-friendly and natural preservatives that meet consumer's needs.

BENEFIT TO INDUSTRY/FARMER

This project aims to reduce the incidence of cheese rejection from manufacturers, converters, retailers, and consumers. The proposed "clean label" dairy-based ingredient developed from this study will be enriched in bioactive peptides with antifungal properties that can be applied on the surface of cheeses to prevent and control most fungal contamination.

DEVELOPMENT OF PREDICTING MODELS FOR SHREDDABILITY OF CHEDDAR CHEESE USING WEAR BEHAVIOR AND MECHANICAL PROPERTIES

INVESTIGATOR

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OBJECTIVE

Cheddar cheese is commonly sliced or shredded for various applications in culinary dishes and restaurant services. During the process of slicing or shredding, problems such as wear phenomena often occur where cheese sticks to the moving parts of machinery or crumbles during high-speed operations. This type of wear accounts for significant material and economic loss to manufacturers. The objective of this project is to develop predictive models that provide an objective way to assess the machinability of Cheddar cheese based on controllable factors such as cheese age, composition, and temperature of operation.

BENEFIT TO INDUSTRY/FARMER

This project will provide manufacturers with empirical models to help predict the wear behaviors of cheese when sliced or shredded under high-speed conditions. These models can be used for a variety of operations such as judging the machinability of cheese, reworking the cheese into process cheese formulations, evaluating new cheese formulas, and changing processing conditions to reduce waste.

RELEVANT PUBLICATIONS

Sharma, Prateek. 2022. ADSA Foundation Scholar Award: Materials science approach to the study of mechanical and diffusion properties in cheese. J Dairy Sci. 105(6):4711-4721.

Pace, N., Verma, A., Mayank, Parhi, A., Sharma, P., 2024. The utility of a slice defect score method in understanding factors impacting the sliceability of commercial Cheddar cheese blocks. International Dairy Journal 151, 105865.

EFFECT OF SHRED DIMENSIONS ON FUNCTIONALITY AND CONSUMER ACCEPTANCE OF LOW MOISTURE MOZZARELLA CHEESE (LMPS)

INVESTIGATOR

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OBJECTIVE

Mozzarella cheese is widely used as a pizza topping because of its texture, melting, and stretching characteristics. The optimum shredding conditions of Mozzarella cheese depends on its manufacturing conditions, physicochemical properties, and its age, which can all affect its melt and stretch performance on pizza. The objective of this project is to conduct a survey of the existing quality of Mozzarella shreds available in the market, and study the different shred cuts, their properties under a controlled MAP environment, refrigeration, and freezing/thawing conditions, and examine the performance of each type on pizza.

BENEFIT TO INDUSTRY/FARMER

This project will help cheese manufacturers understand which properties of LMPS mozzarella they can control or manipulate to achieve the optimal machinability and performance of this ingredient for end users. This improved performance will help drive sales of LMPS.

RELEVANT PUBLICATIONS

Modi, Z and P. Salunke. 2024. Impact of maturity level and geometric cuts of natural cheese on processed cheese product functionality. International Dairy Journal 156: 105981.

HIGH-SOLIDS CHEESE MANUFACTURE IN ALPMA COAGULATOR

INVESTIGATOR

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OBJECTIVE

This project explores the use of ultrafiltration (UF) of whole milk to produce high-solids cheese milk (20–25% total solids) for cheese manufacturing, aiming to improve yield, productivity, and return on investment. While high-solids cheese milk presents challenges in texture, functionality, and flavor, these can be mitigated through strategic modifications in milk composition and curd handling. The study also integrates the ALPMA coagulator, a continuous, clean-in-place system widely used in Europe, to enhance process control, efficiency, and food safety. By combining UF whole milk with ALPMA technology and refining manufacturing steps, the project seeks to produce high-quality cheese with better economic outcomes, including valuable by-products like protein- and fat-rich whey and permeate. Ultimately, this initiative will expand industry knowledge and promote innovative, high-yield cheese production methods.

BENEFIT TO INDUSTRY/FARMER

The project addresses key inefficiencies in traditional cheese-making by introducing a process that uses whole milk ultrafiltration (UF) and ALPMA coagulator technology. This approach benefits small- and medium-scale manufacturers who typically face economic losses due to the need for milk separation and standardization. Additionally, this approach benefits large scale manufacturers who still use traditional cheese-making techniques, and face losses from productivity, food safety issues, manpower, and cheese/curd handling. By concentrating whole milk directly, the process improves membrane efficiency and cheese yield. The ALPMA system enables continuous, hygienic cheese production in small batches, allowing for quick adjustments and better product quality. Together, these innovations enhance productivity, food safety, and economic viability, helping U.S. dairy producers compete more effectively in the global market.

IMPROVED QUALITY OF BLOCK RINDLESS SWISS CHEESE

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OBJECTIVE

Due to its slightly lower fat, and its naturally low sodium content, Swiss cheese is attractive to the USDA's School Lunch Program. Converters have stated that there are significant issues with cheese flavor and texture, such as blind cheese (lacking eye development) or splits. The objective of this research is to investigate specific cheese making conditions needed to achieve the targeted pH and mineral balance for proper eye development. This research will also explore the properties of the experimental cheese and the impact of culture selection and ripening conditions on Swiss cheese quality.

BENEFIT TO INDUSTRY/FARMER

This research will improve the quality of Swiss cheese to allow the variety to continue to be offered by the USDA for its school lunch program. This research will explore if these cheesemaking approaches could help eliminate current Swiss cheese issues, including splits and cracks. Improved quality Swiss cheese will help increase its sales and distribution in retail and food service.

IMPROVEMENT OF CONSISTENT BLUE VEINING AND FLAVOR DEVELOPMENT IN BLUE CHEESE

INVESTIGATORS

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OBJECTIVE

The U.S. blue cheese market is expanding rapidly, but inconsistent veining and flavor are limiting growth. This project addresses key manufacturing challenges by exploring how curd moisture, pH, salt-in-moisture levels, and milk concentration affect mold development and texture openness—critical for Penicillium roqueforti growth. Recently, Blue cheese manufacturers have started using concentrated milk and more automated coagulators instead of traditional cheese vats. With manufacturers shifting to concentrated milk and automated systems, the research aims to optimize cheese body and structure to support consistent veining and flavor. Outcomes will guide industry practices to improve product quality, reduce spoilage, and boost consumer trust and sales.

BENEFIT TO INDUSTRY/FARMER

The U.S. blue cheese market is growing at nearly 6% annually, with global sales projected to reach $2B within six years. However, inconsistent veining and flavor are limiting consumer trust and product expansion. This project aims to solve these issues by identifying how manufacturing steps affect mold growth and cheese quality. By developing reliable techniques to promote consistent veining and flavor, the research will help reduce spoilage from external molds, improve product consistency, and support broader distribution.

INVESTIGATING THE CAUSES OF ASTRINGENCY AND CHALKINESS IN CONCENTRATED NONFAT YOGURTS

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OBJECTIVE

High protein, nonfat yogurt often has undesirable astringency and chalkiness, with no known mechanism. This study aims to investigate the cause of these defects by evaluating concentration methods, calcium content and post-fermentation mechanical force. The project will develop improved processing techniques to reduce the sensory defects, providing best practice and optimized processes for the dairy industry.

BENEFIT TO INDUSTRY/FARMER

The research will identify and mitigate major sensory defects in high protein, nonfat yogurt. It ensures a consistent product quality that improve consumer satisfaction and build trust in dairy brands. Additionally, the findings will help the dairy producers to optimize their processes, enhancing product competitiveness.

MANUFACTURE OF FUNCTIONAL MICROFILTERED MILK TO UTILIZE IN CLEAN-LABEL PIZZA CHEESE PRODUCTION

INVESTIGATOR

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OBJECTIVE

This project aims to develop a novel process for manufacturing clean-label pizza/low moisture part skim mozzarella (LMPS) type-cheese using functional microfiltered (MF) milk. The approach combines advanced membrane filtration (microfiltration and ultrafiltration) with clean acidification methods—like CO^2 injection and starter cultures—to eliminate emulsifying salts and imported rennet casein. The result will be LMPS type with improved stretchability, meltability, and increased usability. The process emphasizes scalability and consistent functionality over shelf life.

BENEFIT TO INDUSTRY/FARMER

By producing a clean-label pizza cheese using only dairy-derived ingredients and eliminating additives like emulsifying salts and imported rennet casein, this research aligns with consumer demand for simple, natural, and traceable food labels. It enhances trust in dairy as a wholesome, transparent ingredient source. Additionally, reducing reliance on imports and enabling domestic production supports supply chain resilience. The resulting product offers superior functionality and quality for both retail and foodservice sectors, ultimately promoting broader adoption of dairy products and increasing overall dairy consumption.

MANUFACTURE OF LOW MOISTURE PART-SKIM MOZZARELLA CHEESE USING MILKS HIGH IN CASEIN AND NOVEL CHEESEMAKING APPROACH

INVESTIGATORS

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OBJECTIVE

Modern cheese plants are becoming more focused on improving the consistency of their production processes and increasing cheese yields. Many large manufacturers have installed continuous coagulators to optimize plant efficiencies, and some are using concentrated milks to increase the throughput in their existing plants to avoid expanding their space. The objective of this study is to generate a novel cheesemaking approach using filtration operations and Alpma vats to produce low moisture part skim (LMPS) Mozzarella cheese from highly concentrated milk containing very high (5-10%) casein levels, reduced lactose, and desirable functionality.

BENEFIT TO INDUSTRY/FARMER

This research seeks to improve the efficiency of cheese production operations and to help US manufacturers be more competitive when exporting Mozzarella cheese. The results of this study will determine if continuous coagulators can handle highly concentrated milk to manufacture Mozzarella cheese. If successful, these operations will produce cheese with high yield efficiency, optimum functionality, and desirable bake performance.

RAPID CHARACTERIZATION OF EXOPOLYSACCHARIDES (EPS) PRODUCED BY LACTIC ACID BACTERIA AND CORRELATION TO EPS FUNCTIONALITY

INVESTIGATORS

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OBJECTIVE

Exopolysaccharide (EPS) produced from lactic acid bacteria play a critical role in the texture and stability of fermented dairy products. Thus, there is a need to characterize and quantify EPS to better control the product quality. However, there are no rapid methods that can quantify EPS accurately in dairy products. Furthermore, the existing EPS quantification methods require complicated isolation and purification which impart changes in the initial EPS structure. To overcome these challenges, the proposed study is anticipated to develop a rapid and facile Raman spectroscopy-based method for the structure characterization and *in situ* quantification of EPS in fermented milk.

BENEFIT TO INDUSTRY/FARMER

Developing a rapid and facile method for EPS analysis will significantly enhance the dairy industry's ability to innovate and maintain high product standards. By enabling precise and efficient screening of EPS-producing cultures, dairy producers can better select strains that contribute to improved texture, stability, and shelf-life of fermented products. These improvements collectively contribute to increased consumer satisfaction, and higher sales volumes across both traditional and emerging dairy product formats.

REDUCING BUTTER HARDNESS THROUGH BUTTER MAKING PROCESS MODIFICATIONS

INVESTIGATORS

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OBJECTIVE

Increased butter hardness leads to consumer dissatisfaction due to the poor spreading of butter at room temperature. This research seeks to address the issue by identifying the optimal combination of milk fatty acid composition and butter making conditions, specifically temperature cycling. It provides a practical solution to improve texture and produce a softer, more spreadable butter.

BENEFIT TO INDUSTRY/FARMER

This study offers a valuable approach to produce more spreadable butter, improving product quality and consumer satisfaction. The optimized processing practice can help dairy industry enhance operational efficiency and product consistency, contributing to reliable butter products in a competitive market.

REDUCTION OF BROWNING IN DIRECT-SALTED PARMESAN CHEESE

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OBJECTIVE

Undesirable low temperature browning (LTB) defects via Maillard reactions can occur during ripening (often 4-6 months) of Parmesan. Methylglyoxal (MG), a metabolite of sugar metabolism, is a likely precursor of LTB in Parmesan and has been implicated in the formation of Maillard reaction products. MG is very reactive and can interact with amines and amino acids to form brown pigments. The possible role of MG as a contributor to LTB has only been studied in model systems and has not been verified in Parmesan cheese. Currently, no solutions to prevent LTB exist and are urgently needed by industry.

BENEFIT TO INDUSTRY/FARMER

Development of brown colors in direct salted block Parmesan is a significant issue causing economic concerns to the industry. It is a key defect limiting its usage in food service and retail channels. Use of cheesemaking approaches and selection of starter or adjunct strains capable of affecting MG metabolism to mitigate LTB would provide a very useful advancement for the dairy industry. Improved quality of Parmesan cheese will help increase its sales, distribution, and also increase export market opportunities in Asia-Pacific region.

STRATEGIES TO CONTROL BROWNING/ BLISTERING IN LOW-MOISTURE PART-SKIM MOZZARELLA CHEESE

INVESTIGATORS

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OBJECTIVE

Mozzarella cheese is the most popular cheese in the U.S. and is widely used for pizza applications around the world. The degree of blistering and browning are its key attributes for pizza baking. Common consumer complaints are excessive blistering or browning when baked on pizza. The objective of this study is to develop alternative approaches for cheesemakers to successfully manufacture low moisture, part skim (LMPS) Mozzarella cheese from concentrated milks with reduced blistering in both young and aged cheeses.

BENEFIT TO INDUSTRY/FARMER

This project will help improve the performance of LMPS mozzarella cheese on pizza. The strategies developed from this study will help eliminate the browning/blistering issues and improve cheesemaking efficiency by using highly concentrated cheese milks without negatively impacting quality parameters.

STUDYING THE IMPACT OF DIAFILTRATION IN FRESH CHEESE (PANELA)

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OBJECTIVE

Fresh cheeses have more lactose concentration than aged cheeses, approximately 3.4% in panela cheese. Ultrafiltration (UF) and Diafiltration (DF) are the most common physical methods to reduce milk lactose. These processes can impact the characteristics of aged cheese, but little is known about the impact on fresh cheeses. This project investigates the use of ultrafiltration/diafiltration and enzymatic hydrolysis to produce lactose-reduced and lactose-free fresh cheese. The study will assess how varying lactose concentrations (0%, 2%, 4%) affect the cheese's protein content, shelf-life, sensory attributes, and physical and chemical properties. The goal is to develop optimized protocols for low-lactose fresh cheesemaking and analyze impacts on composition, flavor, and texture.

BENEFIT TO INDUSTRY/FARMER

With rising demand for "free-from" foods, this research responds to consumer interest in lactose-free dairy while maintaining traditional quality and taste. It supports dairy innovation by offering viable production strategies for high-protein, lactose-reduced fresh cheeses, meeting dietary needs of lactose-intolerant and health-conscious consumers. Ultimately, it strengthens consumer trust and incremental demand by delivering high-quality dairy products.

UNDERSTANDING IMPACT OF CONCENTRATED PLASMIN SYSTEM DUE TO ULTRAFILTRATION AND MICROFILTRATION PROCESS ON THE QUALITY OF CHEDDAR CHEESE PRODUCED FROM HIGH PROTEIN INGREDIENTS

INVESTIGATOR

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OBJECTIVE

The presence of excessive plasmin activity in cheese making can cause downgrades in the quality of cheese, causing extensive proteolysis and sometimes bitterness. With the increase in use of filtered milk in cheese making, understanding the concentration of the plasmin system becomes imperative so that strategies to mitigate defects may be devised. The objective of this project to understand the effect of filtration techniques on the concentration of the plasmin system in milk and its impact on the quality of cheddar cheese manufactured from this high-protein milk.

BENEFIT TO INDUSTRY/FARMER

This project will help the dairy industry understand the impact of the plasmin concentration in filtered milk used in cheese making. This includes a fundamental understanding of the impact of the concentrated plasmin system on milk proteins during ripening. Findings from the study will provide strategies to mitigate any quality concerns that may arise from using membrane-filtered milk in the cheese-making process.

UTILIZATION OF DAIRY PROTEIN-BASED PEPTIDES AND THEIR DERIVATIVES TO IMPROVE THE QUALITY OF HIGH MOISTURE CHEESES

INVESTIGATOR

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OBJECTIVE

The availability of U.S. manufactured soft cheese for export markets is limited by the short shelf-life of the product. Freezing is a convenient preservation method that extends the shelf-life of foods and retains their nutritional value, but it can also impair the functional and sensory quality of high moisture cheeses such as cream cheese. Dairy proteins have a great potential to be modified and used as anti-freezing agents. The purpose of this study is to create a dairy protein-based ingredient that will inhibit ice crystal growth and prevent or delay the structure and flavor degradation in cream cheese after frozen storage.

BENEFIT TO INDUSTRY/FARMER

This project will create a dairy-based ingredient that reduces the formation of large ice crystals during freezing of high moisture cheeses. This ingredient would have both antioxidant activity that prevent the oxidation of fats and off-flavor generation during refrigerated storage, and anti-freezing properties that preserve the structure of the product during and after frozen storage, consequently making the soft cheese dairy processors more competitive in export markets and more resilient through supply chain complications.

RELEVANT PUBLICATIONS

Wan Z, Fei T, & Wang T. 2022. Inhibition of ice crystal growth by protein hydrolysates from different plant-and animal-based proteins. Food Materials Research, 2(1), 1-9.

A MEMBRANE-BASED PURIFICATION METHOD FOR LACTIC ACID PRODUCED FROM THE FERMENTATION OF DAIRY COPRODUCTS

INVESTIGATORS

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OBJECTIVE

The objective of this research is to utilize acid whey as a model system to develop a membrane-based purification approach for lactic acid. Microfiltration or ultrafiltration will be used to separate the microorganisms, simulating continuous bioreactor conditions. Nanofiltration will be used to separate lactic acid, and some demineralization will be performed. The overarching goal is to make high purity lactic acid needed for polylactic acid (bioplastics) production. This process may further require electrodeionization.

BENEFIT TO INDUSTRY/FARMER

This research will focus on the development of novel filtration-based methods to purify lactic acid from real industrially produced dairy coproducts under various realistic conditions. The dairy industry already uses various filtration technologies to fractionate whey. The current world market for lactic acid is around $3 Billion and growing rapidly, and dairy companies could add the production of green chemicals as another profitable business to the cheesemaking activities.

BIOCONVERSION OF LOW-VALUE DAIRY SUGARS TO HIGH-VALUE PREBIOTICS

INVESTIGATOR

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OBJECTIVE

Human Milk Oligosaccharides (HMOs) promote the growth of beneficial gut bacteria and reduce incidences of other gut infections, which are in high demand for use in infant formula, probiotics, anti-adhesives, vaccine and tumor research. The project explores to establish a bench-scale proof of concept in using engineered enzymes to convert lactose and lactose-rich dairy co-products into prebiotic HMOs. The main objectives include validating enzyme capability and activity, enhancing its efficiency, scaling up the process and assessing in-vitro prebiotic potential.

BENEFIT TO INDUSTRY/FARMER

The project establishes a solid platform for the industry to product high-value bioactive component through precision fermentation. This innovative ingredient solution promotes the upcycling of low-value lactose-rich dairy co-product. It also opens new opportunities in functional dairy ingredients, supporting the growing health and wellness market.

WHEY PROTEIN PHOSPHOLIPID CONCENTRATE AS AN EFFECTIVE DIETARY SOURCE OF CHOLINE IN POST-MENOPAUSAL WOMEN

INVESTIGATOR

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OBJECTIVE

Whey protein phospholipid concentrate (WPPC), an underutilized dairy stream, is a rich source of choline. Post-menopausal women are at increased risk of choline deficiency due to lower estrogen levels, linking to cognitive decline and organ dysfunction. The project aims to investigate the efficacy of WPPC as a dietary source of choline for postmenopausal women by evaluating its choline content, bioavailability and potential as a cost-effective and easily formulated option to enhance choline intake.

BENEFIT TO INDUSTRY/FARMER

This project highlights the potential of repositioning WPPC, a low-value dairy coproduct, as a nutritional supplement to improve human health, particularly for post-menopausal women. The findings will boost consumer trust in dairy products and their health benefits, support dairy product innovation for new markets with enhanced economic viability.

CO-PRODUCT VALORIZATION: INNOVATIVE PRODUCTION OF RARE SUGARS FROM WHEY PERMEATE USING IMMOBILIZED ENZYME TECHNOLOGY

INVESTIGATOR

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OBJECTIVE

This research develops technology to convert lactose into two natural, healthier sugars: tagatose and allulose. These "rare sugars" taste like regular sugar but have fewer calories and minimal impact on blood sugar. The project will complete a four-step enzymatic pathway to convert lactose into tagatose and allulose via an immobilized enzyme bioreactor. Previous work has established how to break lactose into glucose and galactose using β-galactosidase, and how to convert glucose into fructose using glucose isomerase. This project will complete the pathway by identifying optimal methods to convert galactose into tagatose, and fructose into allulose. The enzymes will be immobilized on silica solid supports, which allows for reuse and better control in bioreactors. The final sweetener blend will be analyzed for purity and process efficiency.

BENEFIT TO INDUSTRY/FARMER

This research targets a major opportunity for the dairy industry: converting lactose—a caloric, minimally sweet sugar in whey permeate that can cause digestive discomfort—into high-value rare sugars, tagatose and allulose. These sugars are gaining attention for their low glycemic impact, reduced calories, and clean, sugar-like taste. Unlike artificial sweeteners or sugar alcohols, they do not cause off-flavors or gastrointestinal side effects. By transforming a low-value co-product into a premium ingredient, this project supports a circular economy model, adds value to dairy streams, and promotes sustainability. Producing rare sugars directly from dairy inputs also opens new markets in functional foods, beverages, and medical nutrition. This approach benefits dairy farmers, processors, and health-conscious consumers alike.

DESIGN OF A SIMPLE PROCESS TO OBTAIN AN INGREDIENT RICH IN MILK FAT GLOBULE MEMBRANE AND MILK PHOSPHOLIPIDS

INVESTIGATOR

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OBJECTIVE

There is growing demand of milk fat globule membrane (MFGM) due to its health benefits and emulsifying properties. The underutilized buttermilk creates an opportunity for valorization as a source of MFGM. To address the challenge of increasing the value of buttermilk, this project explores the development of an efficient and simple procedure to isolate MFGM from buttermilk. The research focuses on optimizing pre-treatment conditions, refining centrifugal fractionation and improving processes to achieve the desired functionality and bioactivity.

BENEFIT TO INDUSTRY/FARMER

The project provides a simple and scalable technique to produce a functional ingredient rich in MFGM from buttermilk. This approach delivers MFGM at desired concentrations for nutritional dairy foods while maintaining the overall quality of buttermilk. This work will enable the dairy industry to develop innovative high-value dairy products through cost-effective production without requiring major equipment investments.

ENGINEERING HMO BIOSYNTHESIS IN *L. ACIDOPHILUS* FOR PEDIATRIC GASTROINTESTINAL HEALTH

INVESTIGATOR

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OBJECTIVE

The cost of purified or synthetic human milk oligosaccharides (HMOs) limits their use for food applications, despite their potential to support the development and intestinal microbiome of the infants. Microbial biosynthesis of HMOs via fermentation offers a cost-effective solution. The project aims to engineer *Lactobacillus acidophilus* for the biosynthesis of HMO 2′-fucosyllactose (2′-FL) through the addition of new metabolic genes that can carry out the necessary steps to build 2′FL from lactose. This work will establish a new platform to synthesize HMOs with increased efficiency and calability for potential commercialization in the dairy industry.

BENEFIT TO INDUSTRY/FARMER

The engineered *Lactobacillus acidophilus* provides a scalable and sustainable platform for biosynthesis of HMOs. This innovation supports the dairy industry to access the nutritional benefits of human breast milk to improve pediatric health. The research outcome enables dairy product innovation with improved functionality and nutrition, positioning the dairy industry as a provider of advanced, healthpromoting food products.

EXPLORING HEAT-INDUCED ALTERATIONS IN MILK PROTEINS: A CASE STUDY ON WHEY PROTEIN PHOSPHOLIPID CONCENTRATE

INVESTIGATOR

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OBJECTIVE

WPPC is a low value co-product from WPI manufacture. However, it is a rich source of various milk based bioactives such as phospholipids and glycoproteins that have substantiated health and wellness benefits. The objective of this project is to understand the various heat induced interactions among milk proteins (predominantly whey proteins) and milk fat globule membrane (MFGM) components that hinder effective partitioning, and consequently recovery of MFGM and whey proteins from whey protein phospholipid (WPPC) stream.

BENEFIT TO INDUSTRY/FARMER

This work will focus on the development of strategies to effectively concentrate and extract such bioactives from WPPC that will valorize a low value stream of dairy processing. This research will enable the delivery of unique high value bioactives to the dairy and food industry to enable innovation novel foods for health and wellness.

RELEVANT PUBLICATIONS

Rugji J., Ozturk, G. 2024. "Concentrated Forms of Nutrition for Next-Generation Dairy Foods," INFORM.

FERMENTATION 2.0 EXPANDING DAIRY MARKET

INVESTIGATOR

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OBJECTIVE

This research will use Fermentation 2.0 platforms to enable the expression of calf, goat, and sheep lipases in yeast, thus creating enzymes that would be Kosher and Halal compliant. Once successful enzyme expression has been achieved, each lipase will be purified and characterized. Then, there will be a comparison of the fatty acid production profile of bovine milk fat treated with each individual lipase, as well as combinations, to that of commercially available animalderived lipases. This research would thus develop novel tools that could then be leveraged by US cheese manufacturers to expand their markets and increase the demand for US Dairy.

BENEFIT TO INDUSTRY/FARMER

A large portion of the world's population eat Kosher and Halal foods. These populations represent important markets for US dairy export, particularly for cheese and dairy snacks. Because many lipases used in the dairy industry for cheese flavor are not derived in Kosher or Halal compliant manners, many US cheeses and other foods that use cheese flavors cannot be sold to these markets. This project would develop and demonstrate that yeast produced animal lipase platforms can deliver Kosher/Halal compliant tools that deliver the equivalent functionality to animal-sourced lipases, thus empowering US dairy foods processors to compete in these critical markets and increase the demand for US dairy.

IMPROVED RECOVERY OF SUCCINIC ACID AND LACTIC ACID AS MICROBIALLY-PRODUCED VALUE-ADDED CHEMICALS FROM LACTOSE-RICH COPRODUCTS

INVESTIGATOR

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OBJECTIVE

The dairy industry produces large amounts of lactose-rich co-products such as ultrafiltered milk permeate and acid whey that have limited commercial value. Treating and disposing of these organic residues brings significant cost to industrial operations and reduces profitability of commercial products. The objective of this project is to evaluate the technical and economic feasibility of using fermentation bioreactors to convert these co-products into lactic acid or succinic acid for use in food ingredients, pharmaceuticals, cosmetics, and biodegradable polymer industries.

BENEFIT TO INDUSTRY/FARMER

This research will provide proof-of-concept work that dairy co-products can be valorized to lactic or succinic acid by microbial fermentation. This technoeconomic analysis will help the dairy industry assess how to best market these products as green or organic chemicals with a low-carbon footprint that supports a circular economy.

RELEVANT PUBLICATIONS

Walters, K. A., Mohan, G., Myers, K. S., Ingle, A. T., Donohue, T. J., & Noguera, D. R. 2023. A metagenome-level analysis of a microbial community fermenting ultra-filtered milk permeate. Frontiers in Bioengineering and Biotechnology, 11. Walters, K. A., Myers, K. S., Donohue, T.J., Noguera, D. R. 2024. Metagenome-Assembled Genomes from Microbiomes Fermenting Dairy Coproducts. Microbiology Resource Announcements. 0:e00173-24.

IMPROVING THE QUALITY OF PERMEATE POWDERS BY INHIBITING COLOR FORMATION

INVESTIGATOR

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OBJECTIVE

Browing during transportation and storage of whey permeate powders remains a critical challenge for the industry. The project focuses on improving the quality of whey permeate powders by mitigating color formation during storage. Permeate powders, a co-product of whey protein processing, are highly susceptible to the Maillard reaction, leading to browning and quality degradation. The study aims to systematically investigate the kinetics of browning in commercially produced permeate powders under various storage conditions and identify which constituents correlate with browning. Researchers will develop model systems to analyze the physical and chemical processes involved in browning and test formulation and processing techniques to minimize these effects. The study is designed to provide a scientific basis for stabilizing permeate powders for broader applications.

BENEFIT TO INDUSTRY/FARMER

By addressing the browning issue, this research will enhance the consistency and marketability of permeate powders, increasing consumer and industry trust in dairy ingredients. Higher-quality permeate powders will appeal to food manufacturers seeking reliable dairy-based ingredients, boosting sales in domestic and export markets. The project also supports the dairy industry's sustainability efforts by adding value to whey co-products. Through collaborations with key industry partners, the study will ensure practical applications that align with market needs, strengthening the global competitiveness of U.S. dairy products.

LEVERAGING THE US POTENTIAL TO DEVELOP AND MARKET PERMEATE POWDERS: PREDICTIVE APPROACHES BASED ON THE STATE DIAGRAM

INVESTIGATOR

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OBJECTIVE

The objective of this proposal is to utilize physical chemistry approaches to produce high quality whey and milk permeate powders that and make U.S. processors more competitive in local and global markets. This research will examine the variation in composition and physical properties of commercial permeates, and provide tailored drying standards for industrial permeate powders for optimized stability.

BENEFIT TO INDUSTRY/FARMER

Significant quantities of whey and milk permeate are produced as a co-product of whey and milk protein manufacture in the U.S. Due to its high lactose content, permeate faces various challenges such as browning and caking over its shelf life that limit its use in applications especially in export markets. The anticipated outcome of this project is to help solve this quality challenge, thereby helping increase the sale of U.S. permeates locally and in export markets such as China and southeast Asia.

MAPPING AND IMPROVING EMULSIFICATION PROPERTIES OF PROCREAM FOR CLEAN-LABEL APPLICATIONS

INVESTIGATOR

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OBJECTIVE

Procream, commonly known as whey protein phospholipid concentrate (WPPC), is an undervalued dairy co-product. Its functionalities are not fully understood due to limited research. This project aims to investigate the functional properties of WPPC comprehensively, creating detailed functionality maps across various conditions to provide essential industry guidelines. The research seeks to enhance WPPC functionality for broader application in dairy products.

BENEFIT TO INDUSTRY/FARMER

Improving the functional properties of WPPC will broaden its application in clean-label food products, aligning with the growing consumer demand for simple natural ingredients. It will increase the value and utilization of WPPC, driving trust in dairy industry and boosting sales of dairy products.

METABOLIC ENGINEERING OF *CLOSTRIDIUM BEIJERINCKII* FOR BIOCONVERSION OF WHEY PERMEATE TO 3-HYDROXYBUTYRIC ACID

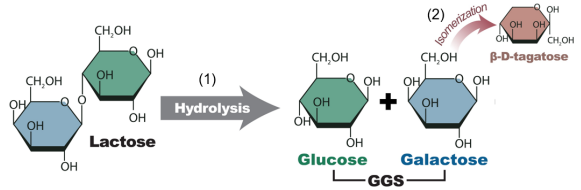

Fig. 1. Sugar conversions: (1) hydrolysis of lactose to glucose and galactose, and (2) isomerization of galactose to tagatose

INVESTIGATOR

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OBJECTIVE

The dairy industry continues to face pressure from shrinking profit margins and rising competition from plant-based alternatives. On top of that, managing whey permeate—a byproduct of cheese production—adds significant cost and environmental challenges. This project proposes a solution: converting whey permeate into a valuable chemical called 3-hydroxybutyric acid (3HBA), which has strong commercial potential.

Researchers will use *Clostridium beijerinckii,* a microorganism that naturally grows in whey permeate and produces key precursors to 3HBA. By enhancing this organism's ability to convert those precursors—3-hydroxybutyryl-CoA and acetoacetate—into 3HBA through targeted genetic engineering, the team aims to create a more efficient production process. The approach focuses on simplifying the conversion steps and reducing competition from other native metabolic pathways to maximize 3HBA output.

BENEFIT TO INDUSTRY/FARMER

This project aims to unlock the economic potential of whey permeate (WP), a common dairy byproduct, by converting it into 3-hydroxybutyric acid (3HBA)—a high-value chemical with strong market potential. By developing efficient methods to produce 3HBA from WP, the research lays the groundwork for future optimization and scale-up. If successful, this innovation could transform WP from a costly waste stream into a valuable feedstock, significantly improving profitability for dairy producers and processors. The long-term vision is to create a sustainable, revenue-generating solution that enhances the competitiveness of the dairy industry.

PERFUSION TO INCREASE CONVERSION EFFICIENCY OF GALACTO-OLIGOSACCHARIDES FROM LACTOSE-RICH DAIRY SIDE STREAMS

INVESTIGATOR

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OBJECTIVE

Galacto-oligosaccharides (GOS) is a niche product from the U.S. dairy industry and has been experiencing a rapidly rising market globally. Its commercial manufacturing platform involves purchasing lactose ingredients, single use of expensive enzyme and batch reactors, where the conversion efficiency is constrained by the reaction equilibrium. This research will develop an innovative perfusion system to produce GOS from lactose-rich dairy side streams that will be superior to conventional approaches. The technology is expected to provide higher productivity and conversion efficiency. Perfusion provides the continuous production of GOS and maintains a high activity of free-form enzyme through circulation. Continuously removing the generated GOS from the reactor also facilitates the forward shift of the reaction equilibrium that favors GOS production, thus enhancing yield. Additionally, the use of dairy side streams and enzyme circulation will reduce the costs.

BENEFIT TO INDUSTRY/FARMER

This project supports the U.S. dairy industry by improving how GOS, a valuable prebiotic, is produced from dairy side streams. The new perfusion technology can enable higher yields and better efficiency than current methods, helping manufacturers lower costs and improve product quality. By using dairy by-products as feedstock, the process also reduces waste and boosts resource efficiency. These improvements can make U.S. dairy products more competitive in both domestic and global markets. The technology may also be adapted to produce other specialty dairy ingredients, expanding opportunities for processors and farmers.

PRODUCTION OF BIODEGRADABLE, NON-TOXIC, AND BIO-BASED SURFACTANT AND SUSTAINABLE BIODIESEL FROM LACTOSE

INVESTIGATOR

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OBJECTIVE

The main objective of this project is to find novel uses for lactose rich dairy co-products by synthesis and characterization of a lactose fatty acid esters and biodiesel from lactose using green chemistry. In a previous DMI funded project related to this, the researcher showed successful development of lactose based biosurfactants and biodiesel from lactose using reaction chemistry. This project will involve scale-up and techno economic analyses work of the end products produced to realize commercial viability of the developed technology. If successful, this project will deliver novel value-added uses for dairy co-products into growing markets such as personal care, cosmetics, biofuels, and pharmaceuticals including food.

BENEFIT TO INDUSTRY/FARMER

This work will advance the value-added uses of dairy co-products into markets beyond human and animal food therefore adding to incremental sale of dairy based ingredients. At the same time, this research will advance the sustainability of the dairy industry by transforming co-products into valuable ingredients

SEPARATION AND REFINEMENT OF LACTOSE-DERIVED TAGATOSE USING SIMULATED MOVING BED CHROMATOGRAPHY

INVESTIGATORS

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OBJECTIVE

This research focuses on the separation and refinement of lactose-derived tagatose using Simulated Moving Bed (SMB) chromatography. The project aims to convert lactose-rich streams, such as whey and acid whey, into tagatose, a low-calorie sweetener. The study will develop an efficient chemical isomerization process to enhance tagatose yields and use SMB chromatography to achieve high purity levels. The project will conduct pilot-scale runs and deliver samples of purified tagatose to industry partners for commercial evaluation.

BENEFIT TO INDUSTRY/FARMER

This project upcycles dairy co-products into a valuable product - tagatose. By demonstrating a commercially viable method for tagatose production, the research provides dairy processors with an opportunity to create new revenue streams. Additionally, partnerships with major food companies increase consumer trust in dairy-based ingredients as sources of innovative, health-conscious products. By offering a low-calorie, prebiotic sugar alternative, the project aligns with growing market demand for food solutions for health and wellness, strengthening the dairy industry's competitive position.

SUSTAINABLE BIOSYNTHESIS OF BACTERIAL CELLULOSE FROM PERMEATE – PROCESS OPTIMIZATION, FOOD APPLICATIONS, AND RESIDUE VALORIZATION

INVESTIGATOR

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OBJECTIVE

This project aims to develop a cost-effective and scalable process for producing bacterial cellulose (BC) from whey permeate—a lactose-rich dairy co-product. It will compare microbial systems (SCOBY and *Komagataeibacter xylinus*), optimize fermentation parameters, and characterize BC for food applications such as thickeners and stabilizers. Additionally, it will analyze fermentation residues for use as biofertilizer or animal feed, promoting circular economy practices. The research integrates microbiology, food science, and waste valorization to upcycle dairy co-products into high-value functional ingredients, potentially replacing synthetic additives while creating new market uses for dairy co-products.

BENEFIT TO INDUSTRY/FARMER

By transforming whey permeate from a low-value co-product into a high-demand, clean-label food ingredient, this work showcases dairy's role in sustainable innovation. It addresses consumer interest in eco-conscious products and functional foods, reinforcing dairy as a source of health-promoting, environmentally responsible solutions. Demonstrating dairy co-product upcycling into natural stabilizers for popular foods can strengthen consumer trust and increase demand.

NOTES

APPLICATION OF REVERSE OSMOSIS TO IMPROVE THE FLAVOR WHILE MAINTAINING HEAT STABILITY OF MILK PROTEIN BEVERAGES

INVESTIGATORS

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OBJECTIVE

This project investigates the use of reverse osmosis (RO) prior to ultrafiltration (UF) to improve the flavor of high-protein milk beverages while maintaining heat stability. By concentrating milk solids through modest water removal with RO before UF, researchers aim to enhance the flavor profile without compromising heat treatment performance. The study involves varying RO levels, followed by sensory analysis and heat stability testing of beverages with 5.5–6.5% protein. The anticipated outcome of this project is to determine how applying reverse osmosis (RO) prior to ultrafiltration (UF) impacts the flavor and heat stability of milk protein beverages. Researchers expect that modest RO treatment will retain desirable milk flavors typically lost during UF, while preserving or improving heat stability—crucial for shelf-stable processing. The results aim to guide formulation strategies that minimize the need for stabilizers and additives, aligning with clean-label consumer preferences.

BENEFIT TO INDUSTRY/FARMER

This work will strengthen consumer trust and drive sales in dairy by addressing two major challenges in high-protein dairy beverages: off-flavors and poor heat stability. By optimizing the use of RO before UF, the project aims to produce milk protein beverages with improved flavor and clean labels—free of undesirable stabilizers. Delivering a product that tastes better and aligns with consumer demand for natural, nutritious options will enhance the appeal of dairy. These advancements will position dairy proteins as superior functional ingredients, supporting innovation in ready-to-drink beverages and reinforcing dairy's role in health-focused, high-protein markets—ultimately increasing consumption and category loyalty.

CONSUMER ACCEPTANCE OF LIQUID MF RETENTATES

INVESTIGATORS

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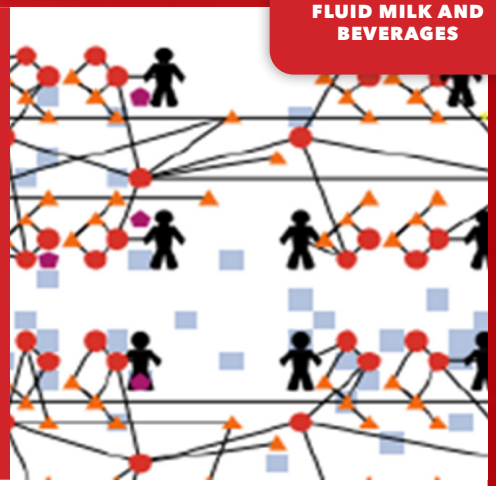
OBJECTIVE

Understanding consumer preference for protein beverages is essential for successful product development. This research focuses on evaluating flavored and unflavored protein beverages with minimal added sugar. These beverages will be made with liquid micellar casein concentrate (MCC) and milk protein concentrate (MPC) at varying protein concentrations. The insights from sensory profile and consumer acceptance evaluation will guide improvements in taste of protein beverages for expanded application.

BENEFIT TO INDUSTRY/FARMER

The project aligns protein beverage development with consumer preference through sensory and consumer insights. Consumer-focused innovation optimizes product taste and quality, fostering brand loyalty and reliability. It expands the application of dairy protein beverages to strengthen market differentiation and meet the evolving consumer expectations.

DEVELOPMENT OF A DIGITAL DAIRY PLATFORM TO DRIVE DAIRY INNOVATION



INVESTIGATOR

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OBJECTIVE

Digital tools are increasingly used in the food industry to drive innovation and to improve product development, process optimization, food safety, and sustainability. A digital twin is a virtual model (or twin) of an actual dairy system or processing line that can be used to understand a root cause of a problem or predict future changes in product quality before adjustments are implemented. The US dairy industry currently lacks a digital platform for developing and implementing digital twins as well as other digital tools. This objective of this project is to pilot digital tools that predict the impact of different changes and interventions on dairy product quality and to develop these tools so that they can be used as decision support tools by the industry.

BENEFIT TO INDUSTRY/FARMER

A key anticipated outcome of this project will be a digital dairy webpage that provides the industry with easy access to existing digital tools. Training will be provided for individuals affiliated with the dairy industry through office hours and workshops. This research will have a direct impact on dairy product quality and sustainability.

HIGH-PROTEIN LACTOSE-FREE DAIRY BEVERAGE: EFFECT OF ASEPTIC PROCESSING, PACKAGING AND STORAGE ON QUALITY CHARACTERISTICS

INVESTIGATOR

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OBJECTIVE

The project focuses on developing a high-protein, lactose-free dairy beverage using aseptic processing, packaging, and storage to ensure product quality and stability. The study aims to address challenges such as Maillard browning, protein stability, and shelf life while meeting consumer demand for functional dairy beverages. Researchers will investigate processing parameters, formulation strategies, and post-processing modifications to optimize beverage properties and enhance commercial viability. The project will contribute to the dairy industry by providing insights into product stability and shelf-life extension, leveraging ultra-accelerated shelf-life testing and aseptic processing advancements

BENEFIT TO INDUSTRY/FARMER

This project supports dairy industry growth by developing high-protein, lactose-free beverages that align with consumer demand for functional, nutritious products. By optimizing aseptic processing and formulation, the research ensures quality, stability, and extended shelf life, addressing key consumer concerns about taste, texture, and nutrition. Delivering science-backed solutions strengthens trust in dairy innovations, demonstrating commitment to health, convenience, and sustainability. With insights into Maillard browning, protein stability, and commercial scalability, the industry can launch premium, value-added dairy products, expanding market reach and driving sales growth in the competitive functional beverage segment.

INVESTIGATING DAIRY INGREDIENTS AS NATURAL CALCIUM CHELATORS TO IMPROVE THE STABILITY OF HIGH PROTEIN ASEPTIC BEVERAGES

INVESTIGATORS

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OBJECTIVE

This project explores the use of sodium caseinate and calcium-reduced dairy ingredients as natural calcium chelators to enhance the stability of high-protein UHT beverages. These beverages often suffer from sedimentation and age gelation, largely due to calcium-induced protein aggregation. By sequestering free calcium ions using clean-label dairy proteins, the project aims to reduce sedimentation while increasing protein content. The research includes evaluating chelation effectiveness, identifying mineral complexes, and modeling physical properties like viscosity and particle size. Outcomes will support formulation of shelf-stable, consumer-friendly beverages, advancing clean-label solutions and dairy ingredient innovation.

BENEFIT TO INDUSTRY/FARMER

This project explores the use of sodium caseinate and calcium-reduced dairy ingredients as natural calcium chelators to enhance the stability of high-protein UHT beverages. These beverages often suffer from sedimentation and age gelation, largely due to calcium-induced protein aggregation. By sequestering free calcium ions using clean-label dairy proteins, the project aims to reduce sedimentation while increasing protein content. The research includes evaluating chelation effectiveness, identifying mineral complexes, and modeling physical properties like viscosity and particle size. Outcomes will support formulation of shelf-stable, consumer-friendly beverages, advancing clean-label solutions and dairy ingredient innovation.

INVESTIGATION OF PLASMIN SYSTEM ACTIVITIES IN MILK PROTEIN FRACTIONS: TOWARDS APPLICATION OF HIGH PROTEIN BEVERAGES

INVESTIGATOR

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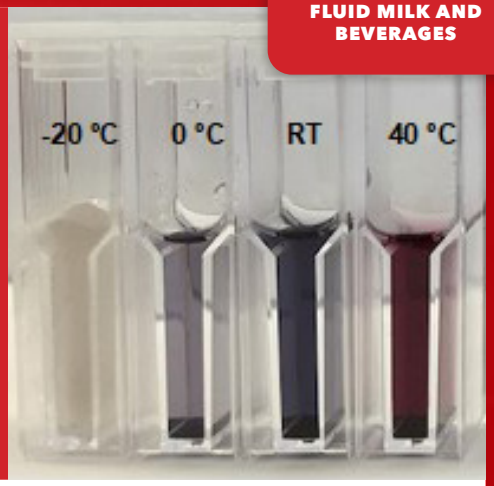
OBJECTIVE

A common industry problem with UHT milk and shelf-stable dairy protein beverages are undesirable quality defects such as sediments and gelation that develop during storage. Milk bovine enzymes (plasmin) are strongly associated with these defects. To ensure U.S. milk proteins are the preferred and reliable source of ingredients for use in ready-to-drink (RTD) protein beverages on a global scale, the knowledge about plasmin activity in MPC retentate and MPC powder is essential to MPC processors in the U.S. The objective of this project is to investigate the quality problems associated with (high-protein) shelf-stable dairy beverages with a focus on enzymatic activities.

BENEFIT TO INDUSTRY/FARMER

The anticipated outcome of this project is to provide baseline knowledge on behaviors of the plasmin system in MPC85 retentate and model high protein beverages. It will also provide data-based guidance to ingredient and food manufacturers regarding thermal inactivation of plasmin system in RTD protein beverages. This research will ensure U.S. milk proteins have a reputation of being high quality ingredients.

NANOMATERIALS-BASED TIME-TEMPERATURE INDICATORS FOR MONITORING THE QUALITY OF ASEPTIC MILK PRODUCTS



INVESTIGATOR

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OBJECTIVE

Consumers' decisions to consume or discard foods rely heavily on food-date labels such as "Best if used by". However, these conventional labels are not based on exact science and do not indicate if a product has been stored properly. Time-temperature indicators (TTIs), in contrast, can record the temperatures that the products have been exposed to, and for how long. So far, however, TTIs have been challenging for the food industry to adopt because they are costly and require extra work to tailor them to the complex differences among food products. Therefore, the goal of this project is to develop low-cost nanomaterials/biopolymer-based TTIs that provide consumers with non-reversible colorimetric information to help them monitor the quality of aseptic milk products.

BENEFIT TO INDUSTRY/FARMER

The main anticipated outcome of this project is a class of low-cost device suitable for monitoring the quality of aseptic milk products. Its success would give consumers a new way to assess the quality of their aseptic milk. Additionally, the project's results could potentially improve milk's long-term profitability by promoting consumers' trust in dairy products and the dairy industry.

PROCESSING AND INGREDIENT APPROACHES TO IMPROVE THE STABILITY OF HIGH PROTEIN UHT DAIRY BEVERAGES

INVESTIGATOR

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OBJECTIVE

High protein dairy beverages that are ultra-high-temperature (UHT) processed often experience instability issues, such as sedimentation during storage, raising consumer concerns. This project aims to identify effective processing and ingredient strategies to minimize sedimentation in high-protein UHT dairy beverages. The research investigates the effects of various preheat steps and explores using dairy calcium-binding ingredients as a natural solution to enhance product stability.

BENEFIT TO INDUSTRY/FARMER

The novel approaches improve the stability and shelf-life of high-protein UHT dairy beverages by addressing sedimentation using natural ingredients. The findings will enable dairy producers to offer products with consistent quality, fostering consumer trust to drive sales and strengthening international market position.

PROOF-OF-CONCEPT: A THERMOELECTRIC-BASED MULTI-PASS HEAT EXCHANGE TECHNOLOGY FOR DECARBONIZING AND ELECTRIFYING MILK PASTEURIZATION

INVESTIGATORS

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OBJECTIVE

The project aims to develop a ThermoElectric-based Multi-Pass (TEMP) heat exchange technology for decarbonizing and electrifying milk pasteurization. It will be achieved by creating a complete system that emulates commercial operation conditions and optimizes energy efficiency by incorporating power supplies, pumps, and system control. The TEMP technology actively transfers heat from pasteurized hot milk to raw cold milk, significantly minimizing the need for additional heating and cooling media, thereby reducing process complexity and cost.

BENEFIT TO INDUSTRY/FARMER

The project aims to deliver a fully operational TEMP heat exchange system evaluated against conventional High-Temperature-Short-Time (HTST) system in terms of processing efficacy, system reliability, and energy efficiency. This research will validate the proof of concept, demonstrating that the TEMP system is a more sustainable alternative method for dairy industry to save energy and water during operation with reduced complexity and costs. The technology is also suitable for on-farm milk pasteurization without using steam.

THE ROLE OF MILK PROTEIN FRACTION, BEVERAGE HEAT TREATMENT AND ADDED INGREDIENTS ON FLAVOR BINDING IN READY-TO-DRINK PROTEIN BEVERAGES

INVESTIGATORS

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[2]Cornell University, Ithaca, NY

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OBJECTIVE

The aim of this project is to determine the critical factors that influence interactions between dairy proteins and added flavors, particularly in ready-to-drink (RTD) protein beverages. The research will investigate the effects of protein concentration, types of milk protein, heat treatment and chelating salt on protein-flavor binding in RTD protein beverage systems. Unique approaches combining instrumental and sensory methods will be applied to effectively optimize flavor of high protein foods.

BENEFIT TO INDUSTRY/FARMER

The actionable insights enable the dairy industry to improve the flavor profiles of high-protein drinks, enhancing consumer satisfaction and product appeal. The project delivers practical strategies to support the development of more flavorful and stable dairy beverages, strengthening brand trust and driving market growth.

THE ROLE OF SOLUBLE MILK COMPONENTS ON HEAT STABILITY OF MILK PROTEIN BEVERAGES

INVESTIGATORS

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OBJECTIVE

With the rising demand of high protein dairy beverages, its heat stability remains a challenge. The project aims to identify specific milk components that contribute to thermal stability and determine critical points during filtration where heat stability declines. A novel approach will be developed using these components to refine filtrations process, improving shelf stability and quality of milk protein beverages without relying on additives.

BENEFIT TO INDUSTRY/FARMER

The research focuses on enhancing the heat stability of high-protein milk beverages. It enables innovation in dairy processing technology, ensuring consistent product quality and extended shelf life. The improved approach supports the development of additive-free options to enhance consumer trust in high-quality and safe dairy products.

UNDERSTANDING THE BASIC TASTES AND FLAVOR PROPERTIES OF LIQUID SKIM UF RETENTATES

INVESTIGATORS

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OBJECTIVE

The removal of lactose and soluble minerals during milk ultrafiltration (UF) causes a flavorless profile in the retentates, lacking characteristic milk flavor. The project aims to restore basic tastes and aromatic notes associated with skim milk by reintroducing permeates back to the retentates. To achieve this, liquid milk protein concentrate (MPC) at various concentrations will be formulated into milk beverages and assessed for sensory quality and consumer acceptance. The research will clarify the impact of lactose and minerals in flavor profile of UF retentates.

BENEFIT TO INDUSTRY/FARMER

Understanding the flavor contributions of lactose and minerals will improve the sensory quality of skim UF retentates. By enhancing the milk flavor in the retentates, the dairy industry can develop more flavorful and appealing protein beverages to build greater trust with consumers seeking both taste and nutrition.

ASSESSING AN ENVIRONMENTAL *LISTERIA* STRAIN FOR ITS ABILITY TO SURVIVE AND FORM BIOFILMS IN THE PRESENCE OF BACKGROUND MICROFLORA ISOLATED FROM DAIRY PROCESSING ENVIRONMENT

INVESTIGATOR

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OBJECTIVE

Listeria monocytogenes is a foodborne pathogen that can thrive and develop in a wide range of environments that provide adequate nutrients and water. They are also resilient to and protected from extreme environmental stresses such as sanitizers and disinfectants used in dairy processing plants because of their ability to form biofilms. The cross contamination of finished food products due to *L. mono* is a major concern. The objective of this study is to understand the persistent nature of *L. mono* and develop a biosurfactant of bacterial origin for preventing persistence of *Listeria* in dairy plants through limiting its biofilm forming ability.

BENEFIT TO INDUSTRY/FARMER

This project will aid in designing effective *Listeria* control strategies in the dairy industry, which would help to reduce the risk of environmental *Listeria* strains turning into persistent or resident strains and posing a risk of cross contaminating the processed products leading to potential outbreaks and expensive product recalls.

EFFECT OF BIOPROTECTIVE CULTURES ON *LISTERIA MONOCYTOGENES* IN MILK AND HIGH MOISTURE CHEESE

INVESTIGATOR

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OBJECTIVE

Listeria monocytogenes contamination continues to pose a threat to cheese safety, especially for high moisture cheeses. Due to restrictions on the use of most antimicrobial interventions imposed by the Standard of Identity for cheese, and the emerging consumer demand for safe, yet minimally processed cheese, the development and validation of more natural control measures are needed. The objective of this project is to determine the efficacy of commercially available protective bacterial cultures to control *Listeria monocytogenes* in milk and high moisture cheese. We hypothesize that this inhibitory effect will be greater than that of other protective cultures on the market.

BENEFIT TO INDUSTRY/FARMER

The US dairy industry has a long reputation of unsurpassed safety. However, occasional outbreaks still occur, particularly with high moisture cheese. Applications from this work can be utilized by high-risk cheese manufacturers to reduce risk in compliance with the Food Safety Modernization Act. The anticipated outcome of this research is to help ensure the safety of high moisture cheeses thereby upholding the reputation and consumer confidence in the dairy industry to provide safe, nutritional products resulting in sustained or increased consumption of dairy products.

IMPROVING OUTCOMES IN DOMESTIC AND EXPORT MARKETS BY PREPARING THE US DAIRY INDUSTRY TO ADDRESS *MICROBACTERIUM*, AN EMERGING BACTERIAL CONTAMINANT OF CONCERN

INVESTIGATOR

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OBJECTIVE

Microbacterium is a bacterial contaminant found throughout the dairy product continuum that represents an emerging concern for dairy product quality and conformance. *Microbacterium* exhibits characteristics that allow it to persist in milking and dairy processing equipment, survive extreme heat treatments, and impact dairy products. The objective of this research is to establish a single gene sequencing target for subtyping *Microbacterium*, evaluate the survival and spoilage potential of a standard set of *Microbacterium* that can be utilized for future research, and ultimately provide guidance for identifying, monitoring, and tracking *Microbacterium* to improve outcomes.

BENEFIT TO INDUSTRY/FARMER

Microbacterium represents an emerging microorganism that is a key risk to dairy product quality and conformance. In order to prepare the US dairy industry to combat this organism across the dairy continuum from the farm through processing, and in a variety of products including fluid milk, cheese, and powders, development of knowledge and tools is necessary. The anticipated outcome of this work is to provide the dairy industry with the tools needed to understand risks and outcomes associated with *Microbacterium*.

UNDERSTANDING *CRONOBACTER* DIVERSITY, DISTRIBUTION, AND ECOLOGY TO INFORM *CRONOBACTER* CONTROL STRATEGIES IN THE DAIRY INDUSTRY

INVESTIGATOR

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OBJECTIVE

This project is designed to help the dairy industry to more effectively control *Cronobacter*, by providing a better understanding of *Cronobacter* prevalence and diversity in natural, urban, and rural environments, which will provide improved information on sources and reservoirs of *Cronobacter*. This research will also provide a comprehensive WGS database for *Cronobacter* from non-food sources, which will be valuable for interpreting WGS findings and for defining *Cronobacter* species and subtypes that differ in their ability to cause infections in infants.

BENEFIT TO INDUSTRY/FARMER

While *Cronobacter* only causes a very small number of human infections, it represents a major concern for the dairy industry, including due to the severity of the disease it causes in infants. The key significance of this project is that it will provide the dairy industry with improved knowledge to facilitate risk-based approaches to control *Cronobacter*. This knowledge will not only be important to assure the public and regulators that the dairy industry is addressing *Cronobacter*, but also is essential to allow industry to effectively control *Cronobacter* in their facilities and products.

UTILIZATION OF THE NOVEL ATMOSPHERIC COLD PLASMA TECHNOLOGY FOR CONTROLLING *LISTERIA MONOCYTOGENES* IN BRINE SOLUTION AND PROCESSING EQUIPMENT

INVESTIGATORS

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OBJECTIVE

Listeria monocytogenes is one of the major foodborne pathogens in ready-to-eat foods, including dairy. Hence, it is important to control L. monocytogenes in the dairy industry. Currently, there is no effective method to eliminate post-pasteurization L. monocytogenes contamination during dairy processing. The objective of this research is to utilize novel nonthermal high voltage atmospheric cold plasma (HVACP) technology to eliminate L. monocytogenes contamination in brine solutions by producing high concentrations of reactive gas species (RGS) that are highly bactericidal. It is expected that HVACP-treated brine solution will inhibit the growth of L. monocytogenes and spoilage microorganisms in brined cheeses with minimal changes to the cheese quality.

BENEFIT TO INDUSTRY/FARMER

The completion of this project would allow the reduction of post-pasteurization L. monocytogenes contamination by cold plasma treatment, which can improve the safety and prolong the shelf-life of dairy products. It is expected that HVACP treatment will efficiently eliminate Listeria in brine solutions. Moreover, the HVACP-treated brine solutions could inhibit the growth of Listeria and spoilage microorganisms in brined cheese with minimal changes in cheese qualities. The successful delivery of a pathogen-free product with extended shelf-life would ensure the health of consumers, reduce the loss due to spoilage deterioration, and help build trust in dairy.

VALIDATING DRY FLUSHING AS A CONTROL MEASURE FOR *CRONOBACTER* SPP. IN MILK POWDER OPERATIONS

INVESTIGATOR

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OBJECTIVE

The dairy powder industry seeks water-free sanitation practices, and flushing (sometimes called purging or pushing) is a dry cleaning method for maintaining hygiene in milk powder production environments. Validated dry flushing methods would provide substantial value for milk powder producers to help reduce recalls. Flushing helps the industry avoid the introduction of water into the manufacturing environment and reduce the total downtime involved in sanitation. However, risk reduction associated with flushing is not well characterized and, consequently, operations often rely on intermittent wet sanitation methods which come with inherent tradeoffs due to moisture introduction. This project will generate and vet a set of tools that can be used by the dairy industry to develop and validate dry sanitation regimens for equipment cleaned by flushing.

BENEFIT TO INDUSTRY/FARMER

This research addresses a critical gap in dry dairy sanitation by strengthening the scientific foundation for dry cleaning methods like flushing. This helps the dairy industry better demonstrate pathogen control to buyers and auditors, enhancing product marketability. Quantifying sanitation effectiveness will also expand the utility of dry-cleaning procedures, which offer operational advantages. Generally speaking, this means more time in operation and less time spent cleaning. This work aims to reduce the scope and frequency of costly recalls through lot segregation via validated sanitation regimes.

AN ALTERNATIVE APPROACH TO PRODUCE SUGAR-FREE HIGH PROTEIN INGREDIENTS: CONVERTING RESIDUAL LACTOSE INTO LACTOBIONIC ACID

INVESTIGATOR

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OBJECTIVE

The project aims to develop a method to produce sugar-free, high-protein dairy ingredients by converting residual lactose in lactobionic acid (LBA) using lactose oxidase (LOX). Unlike the traditional lactase hydrolysis, the novel approach eliminates the galactose production and minimizes water use. The research focuses on optimizing the enzymatic conversion in high-protein systems and enhancing the understanding of the chemical and functional properties of the resulting milk protein concentrate (MPC).

BENEFIT TO INDUSTRY/FARMER

The anticipated outcome of this study is to produce commercially viable, lactose-free, high-protein dairy ingredients that can be used in various food products, particularly in high-protein beverages and cheese. Developing a cost-effective and sustainable production method for sugar-free dairy ingredients with improved sensory and storage stability will support the dairy industry with innovative products that address the demands for health-conscious consumers.

APPLICATION OF COLD PLASMA TECHNOLOGY IN MANUFACTURING MILK PROTEIN CONCENTRATE: AN INVESTIGATION OF CRITICAL CONTROL PARAMETERS AND INGREDIENT FUNCTIONALITIES.

INVESTIGATORS

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OBJECTIVE

Milk protein concentrates (MPC) are widely utilized for its functional benefits. Technological advancements are essential to further improve its functionality and stability for enhancing appeal across diverse food applications. The project explores to integrate atmospheric pressure cold plasma (ACP) and plasma-activated water (PAW) into MPC processing. The research focuses on establishing optimized protocol for using cold plasma technology in the production of MPC with improved functional properties.

BENEFIT TO INDUSTRY/FARMER

Advancing dairy processing with cold plasma technology enhances the quality and functionality of MPC, improving its solubility, stability, emulsifying/foaming properties and gelation performance. This innovation supports the development of scientifically enhanced dairy ingredients to boost consumer confidence and strengthen market competitiveness, meeting the growing demand for high quality and nutritious products with extended shelf life.

ß-CASEIN FRACTION AND ß-CASEIN-CALCIUM-DEPLETED MILK CASEIN CONCENTRATE AND THEIR APPLICATION IN CHEESE

INVESTIGATOR

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OBJECTIVE

This project investigates the fractionation and application of β-casein and β-casein-calcium-depleted milk casein concentrate derived through cold microfiltration using carbon dioxide as an acidulant. The research aims to develop novel dairy ingredients with enhanced functionality. These ingredients will be functionally validated in Mozzarella cheese applications, aiming to improve melt and stretch properties. The approach integrates solubilization kinetics studies, process optimization, and chemical and functional characterization of the isolated fractions. Using scalable membrane-based techniques at low temperatures, the project seeks to create ingredients with improved heat stability, solubility, and functionality, which are especially beneficial for dairy-based functional food applications.

BENEFIT TO INDUSTRY/FARMER

The new dairy ingredient(s) developed will play an important role in dairy product development. As a key protein in milk, beta-casein contributes to the texture, emulsification, and stability of various dairy products, such as cheese, yogurt, and dairy-based beverages and will help the US dairy industry especially high protein beverage and cheese manufacturers.

CO-DELIVERY OF IRON AND ZINC USING WHEY PROTEIN HYDROLYSATE TO PREVENT MINERAL DEFICIENCY AND PROMOTE GUT IMMUNITY

INVESTIGATOR

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OBJECTIVE

This project aims to develop a novel whey protein hydrolysate (WPH)-based system to co-deliver iron and zinc, addressing widespread micronutrient deficiencies. Through microencapsulation, WPH-Fe-Zn-hydrocolloid microparticles will be formulated for enhanced mineral stability, controlled release, and improved bioavailability. These particles are designed to overcome challenges like poor absorption, gastrointestinal side effects, and sensory issues commonly associated with mineral fortification. The research will also evaluate gut health benefits, supporting immune function through bioactive peptides. Outcomes will inform the creation of shelf-stable, fortified dairy products suitable for broad global applications.

BENEFIT TO INDUSTRY/FARMER

This work showcases dairy's potential as a trusted platform for delivering essential nutrients through scientifically validated innovation. By using whey protein hydrolysate—a dairy-derived ingredient—to co-deliver iron and zinc with enhanced bioavailability and stability, the project aligns dairy with health-forward consumer trends. It addresses public health needs while overcoming common drawbacks of mineral fortification, such as poor taste and absorption. The development of fortified, functional dairy products enhances consumer confidence in dairy's health benefits and supports product differentiation. This research will help drive demand, expand dairy's market reach, and reinforce its role as a credible source of nutrition and wellness.

DETERMINATION OF MILK COAGULATION AND GELATION PROPERTIES BY HIGH FREQUENCY ULTRASOUND WAVE SPEED AND AMPLITUDE CHANGES

INVESTIGATORS

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OBJECTIVE

Gelation is essential for traditional dairy products like yogurt and cheese. However, unintended coagulation creates challenges in high protein beverages, affecting their stability during processing and storage. The project aims to develop a non-destructive method for the early detection of milk coagulation and gelation in milk protein beverages using high-frequency ultrasound transducers. The method will be tested for its effectiveness across different processes, including gelation induced by acid and enzymes, and thermal coagulation.

BENEFIT TO INDUSTRY/FARMER

The early detection method will help dairy producers improve shelf-life stability and product quality. It will enhance consumer satisfaction and confidence in the product safety and consistency, leading to increased consumption and stronger market presence for dairy products.

DEVELOPING TECHNICAL CAPABILITY FOR QUANTITATIVELY CHARACTERIZING MILK FOAMINESS, MILK FOAM STABILITY, AND MILK PROTEIN FRACTIONS

INVESTIGATOR

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OBJECTIVE

Foam is an essential structure to diversified processed foods and beverages, in which milk components are used as foaming agents. Although milk foaminess and foam stability have been extensively studied, however, the mechanism and factors that govern milk foams are yet fully understood. The objective of this project is to study the effect of protein and fat content on dairy beverages' foaming and foam stability. This technical development will be a valuable addition to the dairy ingredient manufacturers in the US.

BENEFIT TO INDUSTRY/FARMER

Milk/dairy beverages as an ingredient, especially in beverages at food service and retail, is a growing category. The study aims to understand the influence of milk composition on foaming, a functionality that is desired in some beverage applications. The anticipated outcome of this project is to help aid the industry designing foaming dairy products with specific functionalities and applications, thereby driving sales in dairy.

ENHANCING HEAT STABILITY OF WHEY PROTEINS VIA ENZYMATIC DEAMIDATION FOR BEVERAGE APPLICATION

INVESTIGATOR

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OBJECTIVE

Whey proteins in low acid protein beverage denature and aggregate during pasteurization. This leads to undesirable turbidity and sedimentation. The project explores enzymatic deamidation as a green, scalable method to increase the surface change and enhance thermal stability of why proteins. It allows the development of clear, low-acid protein beverages. This approach will also be applied to develop whey protein powders with improved heat stability for potential commercialization.

BENEFIT TO INDUSTRY/FARMER

This innovation eliminates the restrictions on applying why protein ingredients in low-acid protein beverages. It allows dairy producers to develop stable, clear protein beverages without the need for stabilizers. The research creates opportunities for new product segments, facilitating market growth and consumer trust in dairy protein-based products.

ENZYMATIC APPROACH TO TAILOR FUNCTIONAL PROPERTIES OF DAIRY INGREDIENTS

INVESTIGATORS

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OBJECTIVE

Poor solubility of milk protein concentrate is a big challenge for dairy ingredient manufacturers, as high protein formulations are rising in popularity. This poses a challenge for high protein dairy product viscosity, drinkability, and shelf-life. Enzymes have potential to hydrolyze milk proteins and alter their functionality. The objective of this project is to optimize enzymes, specifically chymosin and other commercially available proteases to selectively hydrolyze caseins in milk protein concentrates, Isolates, and Micellar Casein ingredients and study the effects on the final functionality of these modified ingredients.

BENEFIT TO INDUSTRY/FARMER

Although, dairy protein ingredients are one of the most functional ingredients available in the marketplace for development of high-quality foods, one of the key challenges with current dairy protein ingredients is their limited functionality when used at higher levels in dairy and food products to venture beyond traditional high protein foods. This project attempts to resolve that challenge using enzymes to modify dairy protein functionality, thereby helping increase the utilization of dairy protein ingredients.

EVALUATING PULSED ELECTRIC FIELD TECHNOLOGY TO IMPROVE THE EFFICIENCY OF WHEY PROTEIN POWDER PRODUCTION

INVESTIGATOR

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OBJECTIVE

The primary method for processing liquid whey to powder is spray drying. However, this method energy intensive, and suffers from challenges with viscosity and solubility as the product is concentrated. This objective of this project is to reduce drying energy and improve the physical properties of whey protein powders. Pulsed electric field (PEF) technology will be utilized prior to spray drying whey protein concentrates (WPC) and isolates (WPI) with the intent of introducing higher solid content streams into spray dryers at reduced solution viscosity.

BENEFIT TO INDUSTRY/FARMER

WPC and WPI are important products for the U.S. dairy industry. Technologies to enhance the efficiency and quality of processing of WPC and WPI will amplify competitiveness for U.S. dairy products in the global marketplace, leading to expanded dairy market share. This research project will generate data required to calculate the return on investment for the adoption of PEF equipment to sustainably generate whey powder products.

This project is co-funded Dairy West through the BUILD program.

FUNCTIONAL ENHANCEMENT OF MILK PROTEIN CONCENTRATES WITH AGGREGATED WHEY PROTEINS FOR CONTROLLING VISCOSITY IN HIGH PROTEIN FERMENTED PRODUCTS

INVESTIGATOR

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OBJECTIVE

This project aims to solve textural issues associated with higher protein fermented dairy products by developing a novel milk protein concentrate. In the proposed project, whey protein-whey protein interactions are encouraged leading to microparticulated whey proteins (Micro-WP). Developed Micro-WP will be added back to microfiltration retentate to create a novel milk protein concentrate containing Micro-WP. This would help reducing the viscosity of high protein fermented beverages.

BENEFIT TO INDUSTRY/FARMER

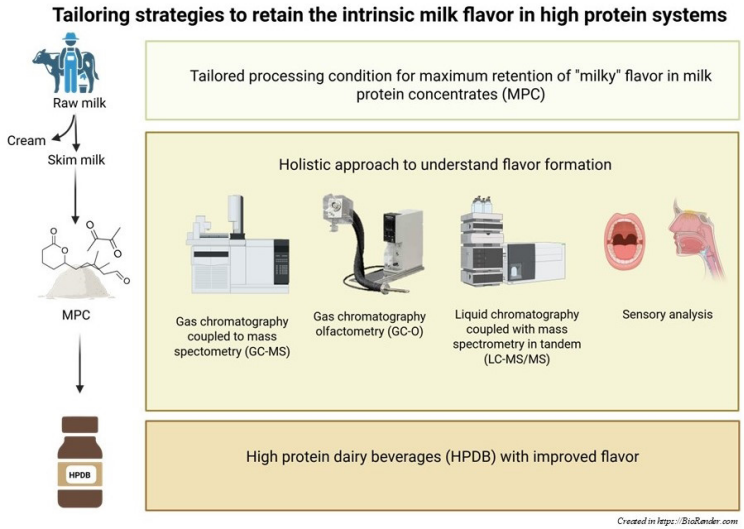
High protein is a growing trend in the dairy and food industry. Additionally, the "clean label" and natural food movements are driving consumer trends. This project will deliver "clean label" dairy ingredient solutions to help deliver higher protein yogurt and yogurt based products to meet consumer demands.

RELEVANT PUBLICATIONS

Rathod, G., Amamcharla, J., 2024. Milk Whey Protein Fibrils–Effect of Stirring and Heating Time. Foods 13, 466.

Rathod, G., Kapoor, R., Meletharayil, G.H., Amamcharla, J.K., 2023. Development of spray dried functional milk protein concentrate containing whey proteins as fibrils. International Dairy Journal 145, 105719.

TAILORING STRATEGIES TO RETAIN THE INTRINSIC MILK FLAVOR IN HIGH PROTEIN SYSTEMS



INVESTIGATOR

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OBJECTIVE

The increasing consumer demand for nutritious and healthier products is driving the growth of high-protein dairy beverages (HPDB). Delivering high-quality beverages with enhanced milk flavor profile is essential for successful product development and consumer acceptability. The challenge with increasing protein content is that it tends to reduce sweetness and affects the flavor profile. This project aims to enhance the milk flavor in HPDB. The research focuses on understanding the influence of processing parameters on the flavor of milk protein concentrates (MPC) to guide ingredient development with improved flavor profile in high-protein applications.

BENEFIT TO INDUSTRY/FARMER

The research aims to enhance understanding of key factors influencing MPC flavor and provide guidance on ingredient development to improve taste and acceptance of high-protein products. It will benefit consumers with nutritious and tasty options, help the industry foster dairy product innovation and support the broader application of dairy ingredients.

NOVEL APPROACH TO PRODUCE A HIGHLY FUNCTIONAL WHEY INGREDIENT

INVESTIGATORS

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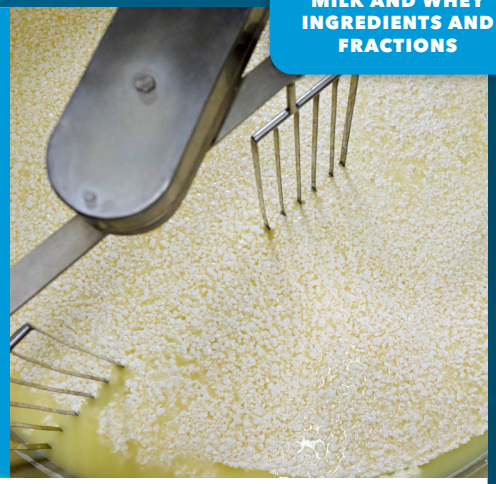
OBJECTIVE

Whey protein fibrils offer unique functionalities for food applications. However, their commercialization is constrained by the expensive and slow fibrilization process. This project aims to develop an efficient and cost-effective process to produce a novel dairy ingredient based on whey protein fibrils using archaea-derived proteases. The hydrolysis capability and efficiency of these enzymes will be explored. The research will assess the effects of enzymatic treatment on structural modification of whey proteins and the functional properties of resulting fibrils in food applications.

BENEFIT TO INDUSTRY/FARMER

By exploring a novel proteolysis approach to accelerate the fibrillation of whey proteins, this work offers an efficient and cost-effective process for the dairy industry to produce a highly functional whey ingredient. The novel ingredient is expected to deliver improved functionalities, such as enhanced viscosity, gelation and emulsification properties. It opens the opportunities to develop healthier, functional food products for health-conscious consumers.

TITANIUM DIOXIDE FOR RECOVERING PROTEINS AND PHOSPHOLIPIDS FROM CHEESE WHEY



INVESTIGATOR

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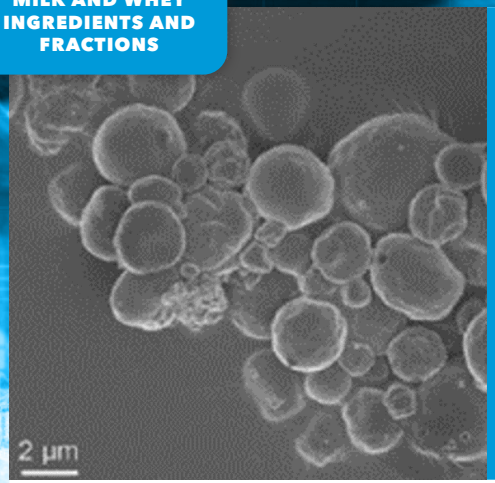
OBJECTIVE

Conventional purification technologies in the dairy industry are expensive and time-consuming in terms of sanitation and regeneration. The project aims to address these limitations using titanium dioxide (TiO2) for the efficient recovery of proteins and phospholipids from cheese whey. The research focuses on evaluating the adsorption/ desorption capability of TiO2 and establishing novel purification processes to improve both product yield and purity.

BENEFIT TO INDUSTRY/FARMER

The novel approach offers a more efficient and cost-effective method for purifying whey proteins and phospholipids, leading to significant benefits for the dairy industry. By providing higher-purity, value-added dairy ingredients, the project enhances the utilization of whey and broadens its application in diverse sectors.



PILOT SCALE PRODUCTION AND PRODUCT APPLICATION OF ENCAPSULATED LACTOFERRIN AND TRYPTOPHAN NANOPARTICLES

INVESTIGATOR

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OBJECTIVE

Milk contains bioactive compounds that offer significant health and wellness benefits, such as supporting sleep quality, mental health, and immune function. However, incorporating these components into heat-treated dairy products is challenging because they are sensitive to thermal processing, which can degrade their functionality and create undesirable sensory attributes. This project aims to develop and evaluate encapsulation technologies for two key milk-derived ingredients, tryptophan and lactoferrin, to enhance their stability and improve sensory attributes. By creating encapsulated complexes, the study will explore their behavior in relevant applications and assess feasibility for large-scale production.

BENEFIT TO INDUSTRY/FARMER

Encapsulation technologies for bioactive ingredients offer a transformative opportunity for the dairy industry. By stabilizing tryptophan-rich whey protein and lactoferrin during heat processing, manufacturers can create functional products that retain their nutritional and sensory qualities. This innovation enables large-scale production of health-promoting dairy products that support consumer wellness goals such as improved sleep, mental health, and immune function. Additionally, the scalable nature of these technologies provides economic advantages for processors and farmers by opening new markets for value-added dairy ingredients, driving growth in high-demand functional food categories.

RATIONAL DESIGN OF WHEY PROTEIN SELF-ASSEMBLIES FOR PICKERING STABILIZATION AT OIL-WATER INTERFACE

INVESTIGATORS

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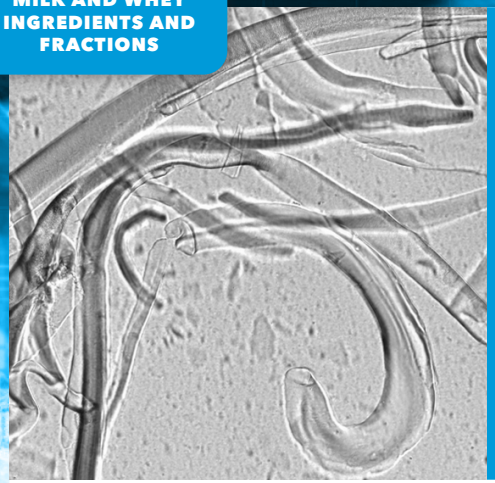
OBJECTIVE

Microparticulated whey protein has been available in the market; however, newly produced sub-micron whey protein particles display unique functionalities in gelation and interfacial stabilization. These recent discoveries shine a light on pathways to new application opportunities for whey protein. This project aims to build and elucidate functionalized whey protein particles using advanced techniques.

BENEFIT TO INDUSTRY/FARMER

The outcomes will provide dairy ingredient manufacturers with essential knowledge and technical capabilities for a rational design of functionalized whey protein ingredients for tailored Pickering stabilization. This work will help develop advanced capabilities for the U.S. dairy industry to deliver tailor made whey proteins to deliver innovative products for consumers in various growth spaces such as health and wellness, “clean label”, and high protein.



SCALABLE AND COST-EFFECTIVE LIQUID SHEAR-DRIVEN FABRICATION OF MESOSCOPIC WHEY PROTEIN ASSEMBLIES

INVESTIGATOR

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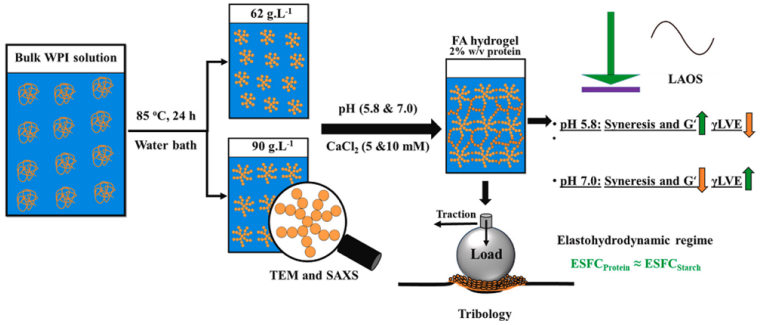
OBJECTIVE

Whey protein particles with fractal dimensions may be used for multiple purposes in various food matrices such as interface stabilization and improving heat stability, and to reduce the viscosity of high protein food products. The goal of the project is to develop scalable manufacturing technology for mesoscopic-scale whey protein assemblies (MWPA) with unique heat stability and emulsion stabilizing functionality to be used as an ingredient by food manufacturers.

BENEFIT TO INDUSTRY/FARMER

The anticipated outcome of this study is to produce a feasible technology for MWPA fabrication that can be used by ingredient manufacturers in the U.S. without major modifications of their plants. The resultant MWPA ingredients will have unique and enhanced functionalities over whey protein isolates (WPI) in terms of heat treatment related physicochemical stability and emulsion/foam stabilization capacities.

SOFT MATTER STRATEGY FOR CREATING NOVEL FOOD TEXTURIZER: REPLACEMENT OF STARCH USING WHEY PROTEIN AGGREGATES AND AGGREGATES STABILIZEDOIL/WATER PICKERING EMULSION DROPLETS



INVESTIGATOR

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OBJECTIVE

There is potential for whey protein to replace starch based thickeners in food applications, under the proper conditions. The objective of this project is to perform scalable interventions to whey proteins using pH, temperature, and salts to modify their structure and consequently functional properties so that whey proteins are effective in mimicking the functionality of food starches in various applications such as high protein yogurts.

BENEFIT TO INDUSTRY/FARMER

High protein and clean label continue to remain strong consumer trends. Whey is uniquely positioned to support these growing consumer trends. This project will help deliver novel whey protein-based ingredients that can play a larger role in the clean label space, and at the same time, providing protein levels required in high protein foods. This will help increase the demand for dairy products and ingredients.

RELEVANT PUBLICATIONS

Amin, U., Lin, Y., Zuo, X., Zheng, H., 2024. Soft matter approach for creating novel protein hydrogels using fractal whey protein assemblies as building blocks. Food Hydrocolloids 151, 109828.

SYNERGISTIC EFFECTS OF WHEY PROTEIN MICROGELS ON ENDOGENOUS GLP-1 SECRETION AND DPP-4 INHIBITION

INVESTIGATOR

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OBJECTIVE

This project investigates the potential of whey protein microgels (WPMs) to naturally modulate metabolic health by enhancing endogenous GLP-1 secretion and inhibiting DPP-4 activity. GLP-1 plays a key role in insulin regulation and appetite control, but is rapidly degraded in the body. WPMs—engineered dairy particles with controlled digestion properties—offer a promising delivery system for bioactive peptides. Through simulated digestion, peptide profiling, and cell-based assays, the study aims to identify WPM formulations that improve peptide stability, bioavailability, and metabolic function. Findings will support the development of dairy-based functional foods targeting type 2 diabetes and obesity through a safe, food-first strategy.

BENEFIT TO INDUSTRY/FARMER

This research reinforces dairy's role as a science-backed, functional food category by demonstrating how whey protein microgels (WPMs) from an ingredient developed by DMI can deliver measurable metabolic health benefits. By providing credible, data-driven evidence of GLP-1 stimulation and DPP-4 inhibition (in vitro), the work positions dairy as a proactive solution to growing health concerns like diabetes and obesity. Such innovation enhances consumer trust in dairy as a health-supportive, naturally functional ingredient. It also enables brands to differentiate products with validated health claims, supporting premium positioning and market expansion. Ultimately, this science empowers the dairy industry to meet evolving consumer demands while driving value-added sales growth.

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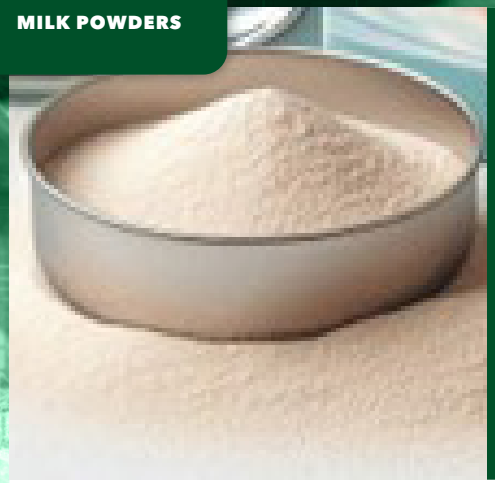

ESTABLISHING A DATABASE OF INTERFACIAL PROPERTIES FOR US MILK POWDERS: INTERFACIAL CHARACTERISTICS AS INDICATORS OF POWDER QUALITY AND FUNCTIONALITY

INVESTIGATOR

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OBJECTIVE

Dairy ingredients are used in various food applications for their superior functional properties. This project will provide an efficient analytical method for characterizing milk protein ingredient functionality (wettability, flowability, and emulsification properties). It will also include a database of interfacial properties for different dairy ingredients that may be used as a technical reference for quality control, ingredient innovation, and formulation development of new consumer foods.

BENEFIT TO INDUSTRY/FARMER

This project will deliver rapid interfacial characterization techniques for dairy protein powders which consequently will help processors to evaluate the quality and consistency of commercial powders in terms of application related functionalities.

PHYSICAL, CHEMICAL, AND FUNCTIONAL ASSESSMENT OF LOW-, MEDIUM-, AND HIGH-HEAT NONFAT DRY MILKS PRODUCED IN THE UNITED STATES

INVESTIGATOR

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OBJECTIVE

The overall objective of this project is to map the functional properties of Nonfat Dry Milk (NDM) and Skim Milk Powder (SMP) that have different heat classifications (low-heat, medium heat, and high heat). Low-, medium-, and high-heat nonfat dry milks produced in the United States will be assessed for their physical, chemical, and functional properties. Understanding the functional and physical properties using advanced techniques will help food formulators to select the appropriate NDM.

BENEFIT TO INDUSTRY/FARMER

U.S. Milk powders (NDM and SMP) have a significant local and global market and are used in various dairy and food applications across the globe. A major functional advantage in milk powders arises from the way they have been produced (specifically, the heat treatment they go through prior to concentration and drying). Research on specific functional difference and applications of these different milk powders is almost 25 years old. This research will provide the US milk powder processors concrete data on which powder will work best for their customers' end uses, thereby increasing the demand of the U.S. produced milk powders.

PRODUCTION OF LACTOSE FREE DRIED MILK USING NOVEL DRYING TECHNOLOGIES: FEASIBILITY STUDY OF PULSED VACUUM INFRARED DRYING

INVESTIGATOR

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OBJECTIVE

This project will develop an innovative pulsed vacuum infrared drying (PVID) process to produce lactose free dry milk (LFDM) of comparable or superior qualities to the conventional spray-dried ones. The LFDM produced from PVID is expected to have superior physical and chemical properties. This is because the moderate temperature, vacuum, and low oxygen conditions and drying time under PVID may help to control the crystallization of sugars in the dried milk and minimizing other quality decay of milk powders. Additionally, the processing yield and energy efficiency of the PVID process are expected to be higher than spray drying, since the periodic vacuum pulsation and infrared heating during PVID will selectively enhance the heat and mass transfer rates during the drying.

BENEFIT TO INDUSTRY/FARMER

The application of the PVID process to produce high-quality LFDM is expected to bring significant benefits to the U.S. dairy industry and its farmers. By delivering LFDM with quality attributes that are comparable or even superior to existing market products, this innovation enhances the industry's ability to meet consumer expectations. The improved capability to produce premium LFDM will strengthen the competitiveness of the U.S. dairy sector in both domestic and international markets. Furthermore, the novel drying method developed in this study has the potential to be adapted for other dehydrated dairy products, offering promising improvements in processing efficiency, throughput, and energy consumption.

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