WHO WE ARE

CONTACT US
Denise Mullinax,
Executive Director
mullinax@cdrf.org

Kevin Comerford, Ph.D.,
Chief Science Officer
kbcomerford@cdrf.org

Kimberly Yarris,
Executive Administrator
yarris@cdrf.org

BOARD OF DIRECTORS
Josh Zonneveld, Chairman
Jared Fernandes, Vice Chairman
Dante Migliazzo, Treasurer
Chuck Ahlem, Secretary
Greg Miller, Ph.D.
John Talbot
Darrin Monteiro
Sietse ‘Sean’ Tollenaar

Our Focus Areas

ENVIRONMENTAL MANAGEMENT

SOCIAL RESPONSIBILITY

HUMAN HEALTH AND NUTRITION

CAPABILITY BUILDING

PRODUCT INNOVATION

Our Focus Areas

Our Focus Areas
As CDRF completes its 35th year of supporting California dairy producers and the greater California dairy community, we take pride in the projects we manage and the impacts our research has had on the industry and in our communities at large.

This past year was an exciting one, opening us up to in-person meetings, conferences, and on-farm field days. Our research was published and distributed to key stakeholders and policy makers through newsletters, white papers, reports and peer-reviewed publications on varied subjects such as, “Evaluation of California’s Timeline to Climate Neutrality,” “Discovering the Bioactivity of Milk Fat Globules,” and, “Economic Opportunities and Risks of Automatic Milking Systems.” Much of our research produced outcomes that translated into field day presentations and lay articles through the California Milk Advisory Board across industry and other media outlets. We even added podcasting to the mix to promote current and upcoming programs designed to support California dairy producers.

In September 2022, we were thrilled to learn that CDRF and our collaborative partnership with CDFA, UC Davis and the California dairy industry resulted in us receiving a USDA Climate Smart Commodities grant in the amount of $85 million. The project will provide incentives to producers to adopt advanced manure management practices, verify GHG reductions and nitrogen surplus improvements and advance markets for climate-smart dairy products. The five-year project has now officially started this spring and we are excited to get to work. A more detailed description of the entire project can be found on page 29.

In 2023 we are working with a local consulting firm that specializes in the California agriculture sector to update and refine our new 5-year Strategic Business and Research Plan. The firm has conducted in-depth interviews with a variety of stakeholders and is working closely with CDRF staff and Board to ensure that we are on a path to continue to meet the needs of California dairy.

And, in April, the CDRF Board of Directors voted in a new Director, adding Sietse ‘Sean’ Tollenaar to the Board. We are excited to have his experience and enthusiasm on the CDRF team of industry leaders.

We greatly appreciate the opportunity to continue supporting our industry with a robust scientific education and research portfolio. We are proud to present this Annual Report on our 2022-2023 scope of work, which highlights our recently completed projects and provides an overview of the many projects currently in progress.

If you haven't done so yet, I encourage you to connect with our communications through cdrf.org, cdqap.org, dairycares.com, and SPLASH! at milkgenomics.org.

Sincerely,

DENISE MULLINAX
EXECUTIVE DIRECTOR
CONTENTS

SUMMARIES OF COMPLETED PROJECTS

ENVIRONMENTAL MANAGEMENT

• Optimum Dairy Methane Reduction Pathways (2021), Pg. 6
• Dairy Cares Communications and CDQAP Support (2022), Pg. 6
• Evaluation of California’s Timeline for Reaching Climate Neutrality (2021), Pg. 8
• Byproduct Trends and Opportunities for the California Dairy Industry (2022), Pg. 9
• Dairy Manure and Almond Wood Compost for Healthy Soils (2020), Pg. 10
• Growing and Storing Sugar Beets as Silage for Dairy Cows in California (2022), Pg. 11
• Growing and Ensiling Safflower for Dairy Cows in California (2022), Pg. 12
• Feed Additive Protocol and Stakeholder Engagement (2022), Pg. 13

SOCIAL RESPONSIBILITY

• The Effects of Antibiotic Use at Dry-Off on Milk Quality (2019), Pg. 15
• Economic Opportunities and Risks of Implementing Automatic Milking Systems (2020), Pg. 16
• Protection, Restoration, and Enhancement of Tricolored Blackbird Habitat (2022), Pg. 18

HUMAN HEALTH AND NUTRITION

• SPLASH! Milk Science Update and the International Milk Genomics Consortium (IMGC), (2022), Pg. 19
• Bioactivity of Milk Fat Globules (2021), Pg. 20
• Procream as a Source of Bioactive Compounds that Improve Human Health (2019), Pg. 21

CAPABILITY BUILDING

• CDQAP: California Dairy Quality Assurance Program (2022), Pg. 22
• Feed Industry Fellowship with a Focus on Dairy Feeding Systems (2021), Pg. 24

PRODUCT INNOVATION

• Milk Protein Concentrates as Emulsifiers in Clean Label Ice Cream (2021), Pg. 25
• Innovative Dairy-Based Emulsions Systems for Controlled Nutrient Delivery (2021), Pg. 26
CONTENTS

CURRENT PROJECTS PORTFOLIO

ENVIRONMENTAL MANAGEMENT

• Partnership for Climate-Smart Commodities Grant and Dairy PLUS Program, Pg. 29
• The Effects of Grape Marc on Reducing Enteric Methane Emissions, Pg. 29
• Production of Pathogen-Free Pelletized and Granulated Products from Dairy Manure Solids, Pg. 30
• Dairy Cares Communications & CDQAP Support, Pg. 30
• Benchmarking and Describing California Dairy Sustainability Metrics, Pg. 30
• The Effects of Dry Co-Extruded Flaxseed on Reducing Enteric Methane Emissions, Pg. 31

SOCIAL RESPONSIBILITY

• Composting as an Economical and Sustainable Emergency Animal Mortality Management Option, Pg. 31
• Protection, Restoration, and Enhancement of Tricolored Blackbird Habitat, Pg. 32
• Impacts of Milk Microbiota Composition on Whey Quality in California, Pg. 32
• Optimized Controls for Cooling California Dairy Cows, Pg. 32

HUMAN HEALTH AND NUTRITION

• The Yogurt Matrix During Digestion: Benefits of Milk Composition and Structure, Pg. 33
• Microbial Taxa and Function in Lactase Non-Persisters, Pg. 33
• Bovine Milk and Non-Dairy Alternatives: Characterization of Oligosaccharides Structures, Abundance and Functions, Pg. 33
• The Effect of Yogurt on Mucosal Immunity in the Gastrointestinal Tract, Pg. 33
• SPLASH! Milk Science Update and Support of the International Milk Genomics Consortium (IMGC), Pg. 34

CAPABILITY BUILDING

• CDQAP: Environment, Animal Care & Food Safety Outreach, Pg. 34
• Feed Industry Fellowship with a Focus on Dairy Feeding Systems, Pg. 35

PRODUCT INNOVATION

• Increasing the Economic Value of Permeate Streams from Cheese, Pg. 35
Researchers: Dr. Ermias Kebreab, Dr. Frank Mitloehner, and Dr. Daniel Sumner, UC Davis

KEY TAKE-A-WAYS

- California Senate Bill 1383 requires a 40% reduction in methane emissions from the livestock sector below 2013 levels by 2030. Analysis shows continued implementation of California’s incentive-based dairy methane reduction efforts should achieve the full 40% reduction goal set by the state by 2030.

- The resulting report outlines the need for continued implementation of California’s four-part strategy for dairy methane reduction: farm efficiency and herd attrition, methane avoidance (alternative manure management), methane capture and utilization (anaerobic digesters), and enteric methane reduction.

- Continued alignment of state and federal climate-smart agricultural approaches and incentives will be critical to maintaining progress.

BACKGROUND AND OBJECTIVES

California has set aggressive targets for reducing methane 40% below 2013 levels by 2030, including from the dairy and other livestock sectors (see SB 1383). This research focused on California’s world-leading efforts to reduce dairy sector methane in the five-plus years since the enactment of SB 1383, with the objective to document technologies and management practices that have been successful.

METHODS, FINDINGS AND OUTCOMES

Analysis by UC Davis researchers shows continued implementation of California’s incentive-based dairy methane reduction efforts should, by 2030, achieve the full 40% reduction goal.

The report, “Meeting the Call: How California is Pioneering a Pathway to Significant Dairy Sector Methane Reduction,” written by distinguished professors of livestock emissions and agricultural economics, takes a comprehensive look at progress and projections, expanding upon the analysis previously conducted by the California Air Resources Board. By documenting achievements-to-date, additional reduction efforts already funded, historic and current economic trends, and the projected availability of new solutions, the analysis lays out a workable path toward meeting California’s targets in methane reduction.

The analysis recognizes that enteric methane from the dairy and other livestock sectors is a significant source of greenhouse gas emissions in the U.S. and California. Several feed additives are expected to become commercially available in the next several years, which could be used to reduce enteric methane emissions from California’s dairy herd.

The report finds that methane reductions from California’s programs and projects in place today, coupled with the implementation of a moderate feed additive strategy to reduce enteric emissions, is on track to reduce between 7.61 to 10.59 million metric tons of methane (CO₂e) by 2030, all from the dairy sector alone.

To download “Meeting the Call: How California is Pioneering a Pathway to Significant Dairy Sector Methane Reduction,” visit cdrf.org, clear.ucdavis.edu, or dairycares.com

DAIRY CARES (2022) COMMUNICATIONS AND CDQAP SUPPORT

Project Lead: Michael Boccadoro, Dairy Cares

KEY TAKE-A-WAYS

- Dairy Cares continued its commitment to supporting science-backed communication about sustainability and showcasing the California dairy industry’s global leadership.

- Outreach activities included presentations to key influencers and stakeholders, co-hosting the third California Dairy Sustainability Summit, and sharing educational videos on social media platforms.

- Communication strategies ensured the dissemination of Dairy Cares’ key messages on California dairy sustainability efforts to target audiences by providing credible, accurate, and highly accessible information.
BACKGROUND AND OBJECTIVES
For over two decades, Dairy Cares has worked on behalf of California dairy farmers on issues related to sustainability, including animal well-being, environmental stewardship, and community involvement.

Dairy Cares has helped the industry address methane emission challenges, water regulations, and rising labor and energy costs, all while optimizing cow health and comfort.

The overarching objective of Dairy Cares remains to increase awareness and understanding of how California dairy farmers are leading the world in the development of planet-smart farming practices.

In 2022, this objective was accomplished with a clear communication strategy for gathering and disseminating the latest research and statistics, utilizing multimedia tools to engage target audiences with key messages, and providing ongoing communications support for the California Dairy Quality Assurance Program (CDQAP).

METHODS, FINDINGS AND OUTCOMES
In 2022, Dairy Cares coordinated and delivered multiple presentations for key stakeholders, both in-person and virtually. The third California Dairy Sustainability Summit was held in April as a virtual event and brought together over 460 registered attendees, including dairy farmers, government staff, researchers, and other industry stakeholders. During this three-day event, speakers from the U.S. and across the globe discussed the leadership of California’s dairy farms in adoption of sustainable practices and the impact of these efforts on a global scale. All summit sessions were recorded and published to YouTube.

The Planet-Smart Dairy message was further elevated in 2022 as Dairy Cares developed and published several new videos including the ‘Planet-Smart Dairy Showcase’ and the ‘Overview of Planet-Smart Dairy.’ A one-minute version of the ‘Planet-Smart Dairy Presentation’ video received more than 67,000 views on YouTube. In addition, Dairy Cares produced a one-month long video campaign on LinkedIn in September 2022 which generated more than 216,000 views from targeted audiences.

Dairy Cares also presented at the Annual Meeting of the Dairy Farmers of America (Western Area), the Annual Fall Meeting of the Dairy Institute of California, and the Spring Meeting of the Dairy Sustainability Alliance. This type of outreach ensured the communication of Dairy Cares’ key messages on California dairy sustainability efforts to target audiences in both outside and within industry.

Finally, Dairy Cares provided ongoing communication support to CDQAP. Dairy Cares staff assisted with creation of event flyers and publication of monthly newsletters and has been coordinating with CDQAP and other co-hosts in coordinating the next California Dairy Sustainability Summit, planned for spring 2024.

CONCLUSIONS
Dairy Cares’ communication efforts were amplified in 2022 and included several significant presentations to internal and external audiences at the local, state, national, and international level.

Dairy Cares continued to partner with leading researchers and key opinion leaders to strengthen the credibility and expand the reach of communication efforts. The third semi-annual California Sustainability Summit, planned in collaboration with CDQAP, CDRF, California Milk Advisory Board (CMAB), and Dairy Council of California (DCC), was well attended and session recordings continued to be shared on YouTube.

Videos shared on LinkedIn generated significant interest from targeted audiences.

For information about Dairy Cares communications, visit dairycares.com
EVALUATION OF CALIFORNIA’S TIMELINE FOR REACHING CLIMATE NEUTRALITY (2021)

Researcher: Dr. Frank Mitloehner, UC Davis

KEY TAKE-A-WAYS

- The California dairy industry’s greenhouse gas (GHG) footprint is mainly comprised of methane. California Senate Bill 1383 requires a 40% reduction in methane emissions from the livestock sector below 2013 levels by 2030.

- The two primary ways the dairy industry can significantly reduce methane emissions are from improving manure management (e.g., anaerobic digesters) and using feed additives that reduce methane emissions from enteric fermentation.

- Applying a modified method for estimating the global warming potential (GWP*), the study determined that the California dairy industry can achieve climate neutrality by the year 2027 by implementing aggressive, consistent methane reduction strategies.

BACKGROUND AND OBJECTIVE

The California dairy industry’s GHG footprint is primarily composed of methane, which is a potent, but relatively short-lived climate pollutant. The two primary ways the dairy industry can achieve climate neutrality (achieved by an industry when it contributes no additional warming to the atmosphere) are by building anaerobic digesters to reduce methane emissions from manure and using feed additives to reduce methane emissions from enteric fermentation.

The objective of this study was to evaluate the California dairy industry’s warming contributions from present day to 2030 under multiple scenarios to determine how long it would take the industry to reach climate neutrality. The first scenario assumes that the dairy industry remains constant (“business as usual”). The second scenario represents a 40% manure methane reduction in line with California Senate Bill 1383’s state goals, and the third scenario represents a 40% methane reduction from manure plus an 11.3% methane reduction from enteric fermentation.

METHODS, FINDINGS AND OUTCOMES

It is critical to accurately assess the true climate impacts of California dairies to ensure that policies are well guided and mitigation techniques are effective. This study employed a modified method for estimating global warming potential (GWP) called GWP* (pronounced G-W-P-Star). GWP has been criticized for misrepresenting the warming dynamics of short-lived climate pollutants like methane.

In contrast, GWP* treats methane as a temporary pulse instead of a constant agent of warming.

“What’s most exciting about this study, is that it shows the aggressive methane reductions the dairy sector has pursued not only lead to a point in which they are no longer adding warming to the atmosphere, but can go further and chip away at historical emissions.

Agriculture is one of the few sectors that can do that”

— Dr. Frank Mitloehner, UC Davis Professor, Air Quality Specialist, Director of the CLEAR Center at UC Davis

Because dairy emissions are dominated by methane, an accurate understanding of warming effects under increased, stable, and decreased methane emissions scenarios is essential.

Using GWP* in their models, researchers found that the California dairy industry can achieve climate neutrality by the year 2027 by implementing both the second and third scenarios. Under the first scenario (business as usual), there was a general trend for a reduction in the GHG warming contributions of methane emissions from 2020 to 2030 due to consistent cattle herd numbers producing the same amount of methane year after year. However, the implementation of
either the second and third scenarios were shown to significantly offset the warming contributions of methane emissions in California.

CONCLUSIONS
GWP* more accurately accounts for the industry’s warming impact than does GWP because it treats methane as a temporary pulse instead of as a constant agent of warming. Applying GWP* and evaluating three different mitigation scenarios, this study found that continuing with business as usual does result in a small decline in methane over time but will not allow the industry to reach climate neutrality. However, implementing scenarios that lead to a 40% manure methane reduction or a 40% manure methane reduction plus an 11.3% methane reduction from enteric fermentation will allow the California dairy industry to reach climate neutrality by 2027. The correct utilization of technology, policies, and incentives will be necessary to help the California dairy industry meet these aggressive emissions reductions mandates and reduce its contributions to atmospheric warming.

BYPRODUCT TRENDS AND OPPORTUNITIES FOR THE CALIFORNIA DAIRY INDUSTRY (2022)

Project Lead: Jennifer Heguy, UC ANR

KEY TAKE-A-WAYS

- Utilizing agricultural byproducts in feeds is one potential approach to mitigate the high feed costs for dairy cattle while providing the fiber and nutrition necessary to maintain rumen function, gut health, and productivity.
- Twenty-six dairy nutritionists completed surveys about their use of byproduct feeds. Their responses suggest that over 40% of the California dairy ration is composed of byproducts.
- Survey results showed that 80% of responding nutritionists expect increased use of byproducts in the next five years.

BACKGROUND AND OBJECTIVE
Information on how byproducts are incorporated into dairy rations as substitutes for higher cost forages can save producers money on feed costs, reduce water use, and reduce agricultural waste in California. The objective of this study was to investigate opportunities for increasing byproduct inclusion rates in California dairy rations by surveying dairy cattle nutritionists and studying farms that utilize high levels of byproduct feeds, and to create sustainability stories for outreach.

METHODS, FINDINGS AND OUTCOMES
Twenty-six dairy cattle nutritionist surveys were assessed in this study. The responding nutritionists serviced 498 dairy farms, representing approximately 936,700 milking cows housed mostly in San Joaquin Valley herds. Across the surveys, byproduct inclusion rates ranged from 5 to 80% dry matter (DM), with a weighted average inclusion rate of a little over 40% DM in the diets of lactating cows in California.

Though the study has concluded, data collected from 2019 through 2022 on byproduct feeding and milk production will continue to be analyzed and result in four, stand-alone case studies that will be shared in newsletter articles and presented at industry conferences over the next year.

CONCLUSIONS
There is value in quantifying byproduct usage on dairy farms as a means of describing the sustainability efforts of the California dairy industry. With over 936,000 lactating cows represented in the current study responses, the results are the most comprehensive data set on the topic of byproduct feeding in California to date.

The results indicate opportunities to increase byproduct inclusion rates in California dairy rations. For example, the survey results showed that 80% of responding nutritionists expect increased use of byproducts in the next five years. While the practice of incorporating byproducts is not a new concept, it may become increasingly important as dairies are faced with water and forage availability issues, as well as with increasingly unpredictable feedstuff procurement issues.

Case studies of dairies with high byproduct inclusion rates are forthcoming and will inform future outreach efforts, including elucidating the dairy industry’s critical role in environmental stewardship for California.
DAIRY MANURE AND ALMOND WOOD COMPOST FOR HEALTHY SOILS (2020)

Researcher: Dr. Ruihong Zhang, UC Davis

KEY TAKE-A-WAYS

• Composting of dairy manure and almond woody biomass can be used to create valuable and safe soil amendments that return carbon to the soil and improve key soil properties and provide nutrients for crops.

• The experimental compost treatments made from manure or manure and almond woody biomass were associated with increases in soil organic carbon, total nitrogen, cation exchange capacity and exchangeable potassium.

• There is a need for more composting research to define the best processes and conditions for manure solids from different sources and their mixture with biomass materials to produce high-quality, pathogen-free and consistent compost products.

BACKGROUND AND OBJECTIVE

Most of the almond acreage in the San Joaquin Valley is located adjacent to dairies. This proximity minimizes the cost of dairy manure compost transportation and enables project scalability. In addition, many dairy farmers have the necessary equipment and space to launch new composting enterprises. The application of dairy manure and other organic amendments to almond orchards could potentially add organic carbon and nutrients to the soil, reduce greenhouse gas emissions, and contribute to California’s goals of building healthy soils. The goal of this project was to research and demonstrate a novel and practical method for improving carbon sequestration and soil health in California almond orchards using dairy manure and almond woody biomass.

METHODS, FINDINGS AND OUTCOMES

Composting experiments were conducted over a two-year time period (2019 and 2020) on a dairy in Hilmar, CA. The dairy was also the source of the manure solids. Aerated windrows were turned weekly in accordance with the practice on the dairy. Active composting was monitored for a minimum of six weeks. During this time, compost temperature, bulk density, moisture content, and windrow dimensions were monitored on a weekly basis. Active composting was followed by assembly of compost into static piles, which were then covered for a curing period of two to four months prior to pelletization and application.

There were two experimental compost treatments: manure only (100% fine manure solids) and manure-stick compost (co-composted fine manure solids with sticks and twigs separated in the processing line at an almond processing facility). Almond sticks and twigs were ground and then processed an additional time in a hammer mill prior to composting. Each treatment was tested in replicate (two windrows per treatment).

The average loss over both years of dry matter during the composting was 29.9% for manure alone and 33.4% for manure plus almond biomass, the loss of volatile solids was 34.5% for manure and 51.3% for manure plus almond biomass, and the Carbon to Nitrogen (C/N) ratio of the final compost product was 15:1 for manure and 16:1 for manure plus almond biomass. The effectiveness of the composting products was then tested on an almond orchard in Hilmar, CA.
Loose and pelleted compost were applied using a randomized block design. The five treatments were: (1) control (unamended); (2) composted dairy manure; (3) manure-stick compost, (4) pelletized dairy manure compost, and (5) pelletized manure-stick compost. Each treatment was replicated four times, each at an application rate of four dry tons/acre and applied using a traditional applicator of fertilizer.

After two years, the researchers assessed soil health, specifically soil organic matter and soil chemical properties. They did not identify any statistically significant differences between the treatments, including the unamended control. However, there was an observed trend for an increase in soil organic carbon and total nitrogen in the manure-stick compost treatment relative to the control. In all treatments, there was an increase in soil exchangeable potassium (a primary micro-nutrient required by almonds and other tree crops) compared with the unamended control which suggests the amendments are changing soil properties in a relatively slow fashion. Additional years of treatments would be necessary to realize more gains in soil health. Ongoing monitoring of soil electrical conductivity (related to soluble salts in the soil) and sodium levels in leaves is also recommended to ensure salinity effects of treatments are minimal.

Emissions of greenhouse gases from the soil were measured at five time-points between July 2020 and March 2022. Emissions of carbon dioxide and nitrous oxide were higher post-irrigation than pre-irrigation. For most of the emission measurements, there were no significant emissions of nitrous oxide from the amended and unamended fields. There were significant differences in carbon dioxide emissions between some of the treatments, control, and alleyway (area between tree lines). Negative methane flux was determined for all treatments and control.

CONCLUSIONS
The results of this project suggest that manure solids can be used alone or mixed with almond woody biomass for producing pathogen-free and nutrient-rich compost. Moreover, this compost can be pelletized into easily transferable and applicable soil fertilizers and amendment. Pelletized compost could potentially be another source of income for dairies.

Further research is needed to study the breakdown and nutrient release rates of pelleted manure compost and their impact on crop yields and soil properties under different application and production methods, and compare the pelleted manure compost with loose manure compost and uncomposted manure.

GROWING AND STORING SUGAR BEETS AS SILAGE FOR DAIRY COWS IN CALIFORNIA (2022)

Researchers: Dr. Stephen Kaffka and Dr. Peter Robinson, UC Davis

KEY TAKE-AWAYS
- Sugar beets are water-thrifty compared to summer crops, can be produced with good yields, and are readily consumed by cattle as part of a total mixed ration (TMR) with no losses in milk production, body condition, or other performance characteristics when fed.

- Co-ensiling sugar beets with an absorbent, like almond hulls, helps to stabilize sugar beet silage and appears necessary to prevent bag failures during harvest. Preservation without an absorbent like almond hulls remains challenging and many silage bags require venting or will burst within days of being filled.

- This study confirmed that co-ensiling sugar beets with almond hulls remains the best potential path forward to achieve full benefits from the use of sugar beets as a winter forage.

BACKGROUND AND OBJECTIVE
Previous research on sugar beets grown as a winter crop in the San Joaquin Valley found the crop had relatively low production costs and used less water than competing summer crops. Fertilizer is generally not required, and water use is half that required for a summer beet crop and approximately half that for a corn silage crop. When co-ensiled with almond hulls, sugar beets created a highly digestible dairy feed. However, almond hulls are expensive. The objective of this study was to create and evaluate the nutritional value of beet silage (beetlage) with a lower level of almond hulls (4:1 dry matter (DM) ratio of sugar beets/almond hulls) than used in previous studies to determine the minimum amount needed to achieve preservation targets. An additional objective was to further evaluate the practice of using silage bags with greater resiliency than those used in the past.
METHODS, FINDINGS AND OUTCOMES
This study was designed to create an absorbent stabilized beetlage, and evaluate the nutritional value of beetlage with a lower level of almond hulls than used in previous research studies (i.e., 4:1 DM ratio of sugar beets/almond hulls) preserved with three levels of a heterolactic silage inoculant under southern San Joaquin Valley dairy conditions.

Harvest and bagging began in mid-June 2022 at the test dairy near Tulare, CA. Five-hundred-foot long silage bags were divided into two 250-foot lengths. Initial bagging was filled into a 12-foot diameter (9.5 MIL) silage bag manufactured from high tensile plastic. Pack pressure had to be reduced on multiple occasions due to bag failures (bags required venting or demonstrating other indications that they would burst). Some bags with low pack pressure burst within 36 hours of ensiling. The study had several modifications to the planned protocol due to silage bag failures.

This beetlage was sampled during the feedout period, and later assayed for its chemical and nutritional profile including DM, ash, crude protein, fat, amylase neutral detergent fiber, lignin, free sugars, as well as all relevant alcohols and volatile acids created during fermentation.

Preservation of the feeding value of ensiled beets during storage was still inadequate but improved compared with prior years’ research. Dry matter percent was 24.7 with 7.5% crude protein and 14.7% amylase neutral detergent fiber. It appears that approximately 2.50 tons/foot of whole beets in the high tensile 12-foot bags is at the very upper end of bag performance, at least relative to the bags holding together if they were vented.

Preservation without an absorbent like almond hulls, which the farm cooperators were unwilling to use due to their high cost, remains challenging and requires additional research and development.

CONCLUSIONS
Sugar beets grow well, are water thrifty compared to summer crops, can be produced with good yields, and are readily consumed by cattle as part of a TMR with no losses in milk production, body condition, or other performance characteristics.

However, due to the unresolved issues with whole beet preservation, the use of sugar beets as a water-thrifty feedstuff for dairy cattle remains in the experimental stage, not yet ready for widespread use.
increased, safflower crops declined in metabolizable energy and crude protein, but also in nitrate content. By harvest, nitrate content reached levels that were safe for feed and declined even further after ensiling. The objective of this study was to use results from these previous trials, particularly those related to mowing height and windrow formation under late spring conditions, to evaluate the nutritional value of harvested and ensiled safflower at a site in Tulare County, CA.

METHODS, FINDINGS AND OUTCOMES
The 2022 safflower harvest strategy was built on experiences from harvests in 2020 and 2021. Safflower crops were cut more than three weeks later than in 2021 (late April vs. late March) to avoid overnight dew that is common in late winter and early spring, and to allow for more maturation of the plant to reduce its moisture content prior to drying. Later harvest produced a crop higher in nutritional value. The 2022 crop had a higher dry matter (DM) percent, lower nitrate level, higher structural fiber fermentability, and lower ash levels than the 2021 crop, resulting in a higher net energy (NE) value.

Compared with cereal and corn silages, the 2022 safflower silages were low in NE (0.49 Mcal/lb DM vs. 0.63 Mcal/lb for cereal, 0.78 Mcal/lb for corn). This finding is explained by differences in the neutral detergent fiber (NDF) values in these different crops; as the NDF in a crop rises, its fermentability declines. Importantly, the remaining analytes were similar among the three forage crops.

A previous concern about using safflower silage was the potential for high nitrate levels. The later harvest in 2022 and transformation of nitrate during fermentation eliminated this concern. Later harvest and a more mature crop increased spines that were noticeable at harvest and ensiling. However, these were not noticeable at the time of silage pile opening and there were no reported acceptance problems by replacement and dry stock cattle who consumed the safflower silage during the feed-out study.

CONCLUSIONS
The timing of the harvest is a critical issue when using safflower as an alternative winter forage for dairy cattle. Changes made to the 2022 harvest to simultaneously delay harvest by a few weeks to minimize impacts of overnight dew on the crop dry-down and to direct-cut rather than create windrows for drying had highly desirable impacts on increasing the DM content of the fresh cut crop while decreasing its ash (dirt) contamination level. Chemical assays at feed-out indicate that safflower silage is inferior to cereal and corn silage in NE content. However, in all other analytes, safflower was similar to cereal and corn silages, including DM yield. Therefore, safflower is efficient with respect to water use, removes more soil nitrogen than other forage crops, and could serve as a viable alternate forage crop for water-stressed California dairy farms.

FEED ADDITIVE PROTOCOL AND Stakeholder Engagement (2022)

Project Leaders: Dr. Garth Boyd, Context Consulting and Dr. Ermias Kebreab, UC Davis

KEY TAKE-AWAYS
• By using the carbon markets, entities can neutralize, offset, or claim reductions of their emissions by retiring carbon credits generated by projects reducing greenhouse gas (GHG) emissions elsewhere or by driving emission reduction projects in their supply chain.
• There is a lack of consistency in protocols and methodology for generating, trading, and retiring carbon credits across carbon markets and registries, which may be constraining scalable climate solutions. To allow for market growth and increased participation, industry alignment on methodology and verification are critical and immediate.

• Verra Verified Carbon Standard (VCS) Program developed ‘VM0041, Methodology for the Reduction of Enteric Methane Emissions from Ruminants Through the Use of Feed Ingredients.’ The protocol provides procedures to estimate enteric methane emission reductions generated from the introduction of a feed modifier or additive into ruminants’ diets.

• Based on the results of the extensive stakeholder feedback and expert input, it is suggested that California Air Resource Board (CARB) adopt a customized protocol for enteric methane emission reductions from feed additives based on VM0041 with updates to meet the specific needs of California dairies and impacted stakeholders.

BACKGROUND AND OBJECTIVE
Corporations around the world are recognizing the importance of reducing their GHG emissions. As a result, many are reducing their carbon footprints through energy efficiency and other measures. Quite often, however, it is not possible for these entities to meet their targets or eliminate their carbon footprint in the near term with internal reductions alone, and they need a flexible mechanism to achieve these aspirational goals. This is currently the case for the California dairy industry.

By using the carbon markets, or insetting, entities can neutralize, offset or claim reductions of their emissions by retiring carbon credits generated by projects that are reducing GHG emissions elsewhere or by driving emission reduction projects in their supply chain. It is critical to ensure, or verify, that the emission reductions generated by these projects are actually occurring. This is the work of the VCS Program – to ensure the credibility of emission reduction projects.

The VCS Program is the world’s most widely used voluntary GHG reduction program. Over 1,808 certified VCS projects have collectively reduced or removed more than 966 million tons of carbon and other GHG emissions from the atmosphere. VM0041, Methodology for the Reduction of Enteric Methane Emissions from Ruminants Through the Use of Feed Ingredients, Version 2.0, was approved in December 2021.

The overall objective of this project was to facilitate the stakeholder engagement process to determine if the VCS VM0041 v2.0 Feed Additive protocol to reduce enteric emissions would be sufficient for use in California or if it needed to be modified before submission to CARB.

Specific objectives included: Develop educational materials on the protocol, and implications and importance to the industry; Recruit stakeholders; Schedule, and host meetings and feedback periods; Provide professional facilitation of stakeholder working sessions and feedback periods.

METHODS, FINDINGS AND OUTCOMES
Key stakeholders were identified and attended an initial virtual educational meeting in November that provided an overview of the specifics of the protocol. To educate stakeholders about the VM0041 protocol, the Context consulting team prepared an educational video including a history of the VCS Program and the VM0041 protocol, including testimonials from key industry players. Context also prepared written pre-read materials outlining details of the protocol, key changes from v1.0 to v2.0, implications, and importance to the
industry to accompany the video. The virtual session was followed by an in-person meeting at the Sustainable Agriculture Summit in Glendale, AZ.

CONCLUSIONS
Based on stakeholder feedback, the project conclusions suggest CARB should adopt or create a protocol based on the VM0041 methodology with updates to meet the specific needs of California dairies and impacted stakeholders.

This suggestion was based on the following findings: 1) Methane emissions reductions in livestock agriculture cannot happen with manure solutions alone; 2) Enteric solutions are needed to help the dairy industry meet California’s 40% methane reduction target by 2030; 3) A vetted protocol for feed ingredients and verified GHG emissions reductions are vital.

CARB’s approval of such a protocol could bring producers potential economic returns through the sale of carbon credits in California’s Cap and Trade program. The preferred approach would be a methodology that was credible for carbon insets with optionality for offsets.

THE EFFECTS OF ANTIBIOTIC USE AT DRY-OFF ON MILK QUALITY (2019)

Researchers: Dr. Maria Marco and Dr. Heidi Rossow, UC Davis

KEY TAKE-A-WAYS

• **Current practices on dairy farms for antibiotic use when cows are dried off may reduce bacterial infections but may also reduce beneficial bacteria and white blood cells.**

• **Although data analysis are still ongoing, preliminary data from this research project suggest antibiotic treatment at dry-off does not appear to influence the bacterial diversity on the cow teat but does influence bacterial diversity in milk.**

• **Further research based on this study can direct recommendations for antibiotics that are effective at preventing intramammary infections, but also do not cause disruptions to somatic cell count function or enrich undesirable microorganisms on skin or in milk.**

BACKGROUND AND OBJECTIVE
The goal of this study was to understand the influence of antibiotic teat treatments on the health of lactating cows and their subsequent milk production. Currently, California dairy industry practices involve injecting antibiotics into the teat when cows are dried off at the end of lactation. Although this practice is believed to treat current bacterial infections and prevent future infections and mastitis, it could instead reduce some populations of beneficial bacteria and the efficacy of white blood cells. The researchers hypothesized that different antibiotic teat treatments applied at dry-off would result in lasting shifts to the teat microbiome and alter the somatic cell count (SCC) as well as the quality of the milk produced in the next lactation period. Testing this hypothesis would allow for the identification of beneficial bacterial profiles and antibiotic profiles that do not impair somatic cell function, thereby improving the quality of milk produced in California.

METHODS, FINDINGS AND OUTCOMES
The researchers designed a study with four treatment groups that varied with respect to antibiotic use and low or high SCC (group 1: low SCC, no antibiotics; group 2: high SCC, no antibiotics; group 3: high SCC, given ceftiofur at dry-off; group 4: high SCC, given cephapirin at dry-off). The pilot study was conducted using three cows for each treatment group on one dairy, but the larger study design had ten cows per treatment from five dairies. For each cow, milk, blood, and teat swabs (of two different teats) were collected at dry-off, seven days after dry-off, and finally at >40 days (in their next lactation).

Results from the pilot study suggested a relationship between antibiotic use, teat and milk microbiota, and SCC. Antibiotic treatment at dry-off reduced the activity of mitochondrial Complex IV in SCC from cows in group 4 and in peripheral blood mononuclear cells (PBMC) from cows in group 3 (both at 7 days after dry-off). High SCC cows tended to have a higher bacterial diversity on the skin and a lower diversity in the milk, which included reduced *Staphylococcus* on the skin of cows receiving antibiotics. Although only three cows were included, the pilot study results suggested greater microbial diversity among cows than between teats on individual cows.

When the research team combined results from the pilot study with those from the first two dairies investigated, they found no direct effect of antibiotic use on milk quality.
use on the richness of the bacterial community on the cow teat. Moreover, due to the high variability in the teat microbiota among individual cows over time, there was no clear impact of antibiotic treatment although there was a slight effect of individual dairy farm factors.

Further statistical analyses suggested that both dairy farm factors and time of sample collection impacted the microbial diversity on the cow teat, whereas antibiotic treatment remained a non-significant effect. The effect of dairy farm factors on the diversity and specific types of bacteria (measured at the level of the family) demonstrates the importance of the facility in shaping the teat microbiota.

The second part of the study plan focused on the effect of antibiotic treatment on the milk microbiome. The team developed a method that allowed them to have as pure of a milk microbiome sample as possible (no contamination from cow skin cells or environment). Pre-treatment with Cetrimonium Bromide followed by phenol-chloroform DNA extraction increased Polymerase Chain Reaction (PCR) success by 80%. Results from milk samples collected in the pilot study suggest milk from cows with higher SCCs have lower bacterial diversity. The microbiota from cows receiving cefiofur were more diverse than those receiving Cephapirin, suggesting an effect of antibiotic treatment on milk microbiome diversity. However, these data should be considered preliminary as they come from small sample sizes.

CONCLUSIONS
This study examined the effects of antibiotic teat treatment methods on the teat and milk microbiome and determined the impact of antibiotic treatment on the efficacy of somatic cells by measuring the energy status of milk and blood SCCs.

First, this project lays the groundwork to better understanding of the short- and long-term impacts of antibiotics on udder health and the udder microbiome. Next, it can direct recommendations for antibiotics that are effective at preventing intramammary infections, but also do not cause disruptions to SCC function or enrich undesirable microorganisms on skin or in milk.

The findings will help in identifying what a healthy cow and milk udder microbiome should look like and which individual microbial species promote cow health. And finally, the results can help reduce antibiotic use overall, thereby mitigating antibiotic resistance gene spread.

ECONOMIC OPPORTUNITIES AND RISKS OF IMPLEMENTING AUTOMATIC MILKING SYSTEMS (2020)

Researchers: Dr. Fabio Lima and Dr. Fernanda Ferreira, UC Davis, and Dr. Daniela Bruno, UC ANR

KEY TAKE-A-WAYS

- The risk factors associated with the economic feasibility of current automatic milking systems (AMS) in large dairies are not well understood and previous research mainly comes from sites with small herd sizes or with older, less efficient AMS than currently available.

- For this study, the researchers conducted a systematic literature review and meta-analysis to investigate the economic feasibility of installing AMS on large dairies and found that several factors affect profitability including milk production, labor costs, and the life span of the equipment.

- Survey results suggest that AMS met producers’ expectations with regard to improving animal production and welfare, as well as labor reduction, but updated simulation models for economic evaluations, including updated wage, inflation, and milk production scenarios are needed to assist farmers in accurately predicting the economic risks and benefits of AMS adoption.

BACKGROUND AND OBJECTIVE
There has been growing interest in automatic milking systems (AMS) in the U.S. due to their flexibility and efficiency of labor. Understanding the economic feasibility of this technology is an important consideration for dairy farmers before deciding to adopt an AMS.

However, most research studies investigating economic feasibility of AMS were based on their use in Europe (where herd sizes are smaller than those in California), or conducted on sites with older and less efficient AMS than currently available.
The objective of this study was to evaluate the risk factors associated with the economic feasibility of current AMS in large dairies (>500 cows) through a systematic literature review and meta-analysis and collection of survey data from dairy farmers currently using AMS.

METHODS, FINDINGS AND OUTCOMES
The literature review screened a total of 4,292 titles and abstracts on economics and risk factors associated with AMS profitability. A total of 536 studies published between January 2000 and September 2022 were included in the meta-analysis. The majority were from Europe (73.5% vs. 16.2% from North America), focused on commercial herds using Lely or DeLaval brands and free flow cow traffic. The primary study topics were milk production, milk composition, and AMS efficiency, although many also looked at herd behavior, health and welfare, especially mastitis. In the last five years, studies demonstrated an increased interest in energy and water consumption, technological development, environment (e.g., enteric emissions), reproduction, genetics, and longevity. Based on the literature search, the implementation of AMS in the U.S. is clearly growing. However, the lack of studies on nutrition, reproduction, and health disorders in the U.S. suggests that there are opportunities to improve AMS efficiency through herd performance.

In addition to pulling data from the literature, the study also surveyed producers on their practical experience with using AMS, the decision making process of adopting AMS, and perceptions of transitioning to AMS on large dairies in the U.S. (defined as farms operating >7 AMS boxes). The survey had 164 questions and was completed by nearly half (27 out of 55) of solicited producers. The main reasons for adopting AMS were to reduce labor costs, improve cow’s welfare, and improve herd performance. Almost all respondents reported that cows were calmer and over half said cows spend more time laying down. Over 60% of respondents reported an increase in milk production and the majority found improvements with mastitis detection, probably due to the robot feature in identifying cows with mammary gland inflammation.

Survey results suggest that AMS met producers’ expectations about improving animal production and welfare, as well as labor reduction. The economic assessment was more challenging. Several factors affect profitability when the farm implements AMS, including milk production, labor costs versus savings, and the life span of the equipment.

CONCLUSIONS
The literature review and subsequent meta-analysis of AMS research topics worldwide over the last 20 years highlighted research gaps in U.S. studies compared with Europe and other regions. In the last five years, there has been an increased interest in energy and water consumption, technological development, environment, reproduction, genetics, and longevity/culling. Implementation of AMS is growing in the U.S. but there are still many opportunities to improve AMS efficiency through herd performance research. Survey data indicate that AMS met expectations of most producers and they would recommend AMS technology to other farmers, keeping in mind that success of AMS depends on farm aspects, farmer expectations, and proximity to dealers. Updated simulation models for economic evaluations, including updated wage, inflation, and milk production scenarios are needed to help farmers accurately predict the risks and opportunities of adoption AMS.
In 2015, the National Resources Conservation Service awarded $1.1 mil under its Regional Conservation Partnership Program (RCPP) to start a partnership consisting of Dairy Cares, Audubon California, the California Farm Bureau Federation, Sustainable Conservation, and Western United Dairies to protect, restore, and enhance Tricolor habitat in the San Joaquin Valley. This study evaluated the effectiveness of the RCPP along with other programs aimed at Tricolor conservation in the San Joaquin Valley.

METHODS, FINDINGS AND OUTCOMES

The numbers of colonies and breeding individuals in silage colonies that were conserved or lost to harvest were compared from 2005 to 2009 and 2015 to 2022. From 2005 to 2009, 58% of the total number of Tricolored Blackbirds (approximately 133,000 birds) were conserved, whereas 42% of the total population were lost to silage harvest. The researchers estimated that roughly 11% of the species’ productivity in California was lost during these five years. From 2015 to 2021, conservation efforts appear to be highly effective with 93% of colonies protected and an annual average of 119,500 breeding birds (96% of all breeders with known outcomes) were protected. From 2017 to 2021, the number of colonies in silage increased by two-thirds with the number of breeding adults increased by 99,00 (127%). Over the three time periods for which data are available, the cost of protection per breeding bird nearly quintupled suggesting that funding efforts are clearly associated with conservation results.

BACKGROUND AND OBJECTIVE

Tricolored Blackbirds often make nests in fields of triticale that are being grown for dairy silage in the San Joaquin Valley. Their population has been in decline over the last three decades due to many factors, including destruction of breeding colonies during agricultural harvest. Independent analyses estimated a population decline of 40% between 2008 and 2017. The species was listed under the California Endangered Species Act, and their penchant for nesting in triticale fields has prompted concerns over the species’ conservation. Efforts to protect colonies nesting on farms started in the early 1990s but were sporadic due to inadequate and inconsistent funding and lack of legal incentives for protection.
CONCLUSIONS
The RCPP and related actions were highly successful in minimizing losses of Tricolor colonies to silage harvesting. This success is attributable to several factors.

First, the RCPP provided much needed multi-year funding for conservation efforts. Listing the species under the California Endangered Species Act prompted attention and funding, as well as added incentives for dairy producer participation in conservation efforts. So far, good progress has been made by the dairy industry in bird conservation, however efforts have yet to restore the population to the full goal of 700,000 Tricols.

Recovery efforts will require a continued partnership between public and private organizations to secure funding, conduct research, and spread awareness of this issue.

The research and educational aspects of this project are ongoing through CDRF between 2020-2024.

BACKGROUND AND OBJECTIVE
The International Milk Genomics Consortium (IMGC) is made up of hundreds of scientists and innovators from around the world who share the overarching goal to discover the functions and impact of lactation and milk. SPLASH! Milk Science Update is a key component of the success of the IMGC. Its platforms are designed to bring scientific discoveries to practice for human health.

Every year, there are nearly 24,000 new scientific articles published and indexed in the major medical and agricultural databases related to “milk.” SPLASH! is a bi-monthly e-newsletter that helps researchers and industry experts stay up to date with the most important topics in milk science and human health. Each e-newsletter features four compelling articles that highlight cutting-edge milk science research in a way that is accessible to non-specialists while still engaging and informative for academics and industry professionals.

In addition to supporting SPLASH!, the IMGC is host to several other scientific educational and networking workshops and symposium. The annual symposium is instrumental in building a collaborative, multi-disciplinary, pre-competitive platform for scientific discoveries of the structures, functions, actions, and benefits of milk and to facilitate the application of that knowledge into practice for human health.

METHODS, FINDINGS AND OUTCOMES
SPLASH! translated important scientific findings for both a scientific and lay audience, and also provided a space to explore synergistic opportunities between human milk science, nutrition, and dairy sciences.

Each edition of SPLASH! was featured on the IMGC website and other social outreach platforms. This year, SPLASH! published 24 pieces covering emerging topics in milk sciences, the dairy industry, and human nutrition. This year’s e-newsletters brought attention to research that demonstrated how drinking the daily recommended intake of milk can boost brain health in older adults, why human milk oligosaccharides vary across mothers, and the potential for fermented dairy foods to delay cognitive decline and improve markers of bone health in humans.

In 2022, the IMGC introduced a new interface for readers, improving search functions and making it easier to access SPLASH! articles and the archives for topics of interest by using tags and key words. This redesign allowed SPLASH! to more effectively interface with other social media platforms, and to be able to distribute content more widely.
CONCLUSIONS
SPLASH! was published bi-monthly and served to inform the dairy industry, academics, and non-specialists about emerging topics in milk science. SPLASH! continued to be a major draw for traffic to the IMGC website. The newly designed WordPress site enhanced the user experience and improvements to search engine optimization directed traffic to SPLASH! and the IMGC website.

The 2022 IMGC Annual Symposium was held as a joint virtual and in-person symposium hosted at the University of California, Davis. The Most Valuable Presentation (MVP) designation was awarded to Tian Tian, Thermo Fisher Scientific, USA, for the presentation: Structural Insights on Oligosaccharides in Commercial Infant Formula Products with Ion Chromatography-Mass Spectrometry. Additionally, five international students were awarded a Student Travel Award, which sponsored their travel and attendance to the symposium.

Read SPLASH! Milk Science Update and details about the 2023 IMGC Annual Symposium in Cork, Ireland, at milkgenomics.org

BACKGROUND AND OBJECTIVE
Procream is a co-product of whey protein isolate production and is currently an undervalued dairy product with promising health properties. In another CDRF-funded research project, Procream was found to be a source of milk fat globule membrane (MFGM) and bioactive glycoproteins that could positively impact the gut microbiome. Earlier studies demonstrated that Procream supplementation was associated with decreased weight gain and improvements in inflammation and memory in animal models. The current study built on this research by providing a more comprehensive characterization of Procream’s lipid and protein fractions and conducting additional mouse studies to determine the impacts of different Procream fractions on the gut microbiome, intestinal barrier function, and markers of gut and systemic inflammation.

METHODS, FINDINGS AND OUTCOMES
To understand which compounds in the protein and lipid fractions of Procream were specifically responsible for the benefits to the host gut microbiome observed in their previous study, the researchers separated Procream into its protein and lipid fractions. Then, within the lipid fraction, the small fat globules were further separated and tested individually. The researchers created four fractions: 1) cream, which was enriched in lipids; 2) skim, that had no milk fat globule particles; 3) retentate or ultrafiltered skim, which was enriched in glycoproteins; and 4) permeate that had non-glycosylated proteins, such as ß-lactoglobulin.

These fractions and the starting material (whole Procream) were each characterized by a comprehensive compositional and proteomics analysis.

Using a well-established mouse model of high-fat diet-induced obesity, the researchers investigated the potential beneficial effects of dietary supplementation with various Procream fractions on metabolic phenotype, intestinal barrier function, intestinal inflammation, and microbial dysbiosis. Contrary to the study’s hypothesis, there were no observable changes in the composition of the mouse gut microbiome from any of the Procream fractions. However, the researchers had a particularly interesting finding when examining the activity of the gut hormone cholecystokinin (CCK). Previous research shows that CCK has the ability to increase satiety. High-fat diets have been shown to impair this signal and lead to chronic overeating. In mice fed a high-fat diet, however, CCK had no effect on food intake. Adding the skim fraction from Procream to the mice’s water also had no effect on CCK’s ability to inhibit food intake in mice on a high-fat diet, but the addition of the cream fraction to the high-fat diet did result

BIOACTIVITY OF MILK FAT GLOBULES (2021)

Researcher: Dr. Daniela Barile, UC Davis

KEY TAKE-A-WAYS

- **The aim of this research was to identify novel uses for an undervalued dairy co-product, Procream, also known as whey protein phospholipid concentrate (WPPC).**

- **This was the first study to investigate the effects of different Procream fractions on gut health in a mouse model.**

- Although the researchers found no significant shifts in the mouse gut microbiota or intestinal permeability, they did see effects related to gut-brain signaling and food intake. The results clearly differentiated the activity of Procream fractions in the mouse model, with the cream fraction showing increased sensitivity to hormones which regulate food intake.
in CCK inhibition of food intake. The researchers believe that the cream fraction restored the ability of CCK to decrease food intake due to impacts on the gut-brain axis. This was the first time this effect has been shown with a Procream fraction.

CONCLUSIONS
Contrary to the study’s hypothesis, supplementation with Procream fractions had no significant effect on the microbiome or gut permeability. However, supplementation with the cream fraction did result in significant improvements to impaired gut-brain signaling induced by high-fat diets.

PROCREAM AS A SOURCE OF BIOACTIVE COMPOUNDS THAT IMPROVE HUMAN HEALTH (2019)

Researcher: Dr. Daniela Barile, UC Davis

KEY TAKE-A-WAYS
- This study investigated the structures, properties, and sources of health-modulating compounds in Procream, also known as whey protein phospholipid concentrate (WPPC), through both in vitro cell cultures and in vivo animal model experiments.
- In vitro experiments with Procream demonstrated that it is a source of prebiotics that enrich beneficial gut bacteria and can also inhibit the growth of pathogenic bacteria.
- In vivo rodent studies suggest Procream supplementation has anti-inflammatory and potentially anti-obesogenic effects.

BACKGROUND AND OBJECTIVE
Procream is an underutilized product in the dairy industry that is produced when whey protein isolate (WPI) undergoes microfiltration to remove fat. This microfiltration process concentrates whey proteins for WPI and leaves a permeate that is rich in phospholipids and bioactive compounds. This study investigated the structures, properties, and sources of health-modulating compounds in Procream through both in vitro cell cultures and in vivo animal model experiments.

METHODS, FINDINGS AND OUTCOMES
To better understand the composition of Procream, the researchers first quantified total fat, total protein, and total solids. A more detailed analysis of the protein profile suggested the presence of various glycoproteins, which are carbohydrate-containing proteins that are involved in many important human physiological processes. To understand the composition of Procream in even more detail, the team conducted glycoproteomic and lipidomic analyses. These approaches quantify the complexity of glycoproteins and lipids by identifying and measuring all the hundreds of different proteins and fats that are present in a sample. An advanced proteomics analysis revealed the presence of 180 unique milk proteins, many of which were glycosylated (having gone through the process by which a carbohydrate is attached to a target macromolecule, typically proteins and lipids) and originated from the milk fat globule (MFG) membrane.

Due to the lack of standardization in Procream production, the researchers took samples from six different manufacturers and analyzed them for chemical composition, protein profiles, and MFG size.
They focused specifically on the absolute quantification of several key glycosylated proteins (IgA, IgG, lactoferrin, and GlyCAM1) that are involved in immune function. This analysis revealed significant variation in the glycosylated protein concentrations across manufacturers between 4 to 25 times higher than what is normally found in raw milk samples.

The researchers then tested Procream’s ability to selectively grow or inhibit key bacterial strains. The levels of GlyCAM1 in Procream was found to be particularly effective for assisting the growth of select probiotics like *bifidobacteria* strains, suggesting that Procream’s glycoprotein content may provide a source of prebiotic compounds that can be utilized by beneficial gut microbes. The researchers also identified antibacterial properties of whole Procream via in vitro studies that showed impaired growth of the pathogens *Enterotoxigenic Escherichia coli* and *Listeria monocytogenes* in a dose-dependent manner.

To study the biological activity of Procream in vivo, the team conducted research using different rodent models. This first study was on adult mice and helped establish the metabolically relevant dose of Procream. Two Procream concentrations, 1.6% and 4%, were then tested in the context of a whey-based control diet. After 8 weeks, the 1.6% Procream diet reduced the high-fat diet-induced body weight gain and fat mass of the mice but had no effect on food intake. The second study looked at the physiological effects of Procream supplementation in weanling mice on a high-fat diet. Procream supplementation was associated with a significant reduction in lipocalin-2, which is a measure of intestinal inflammation, suggesting an anti-inflammatory effect of Procream. In this study on weanling mice, Procream also increased femur length independent of diet, a finding that is interesting considering the links between dairy intake and skeletal growth and development. The final mouse study investigated whether a higher dose (10%) of Procream supplementation could reduce the cognitive impairment caused by a high-fat diet in young rats. For this study, electrodes were implanted on each study animal’s brain. Preliminary findings indicate that the higher dose of Procream may improve memory and novel object recognition compared with rats consuming only the high-fat diet and no Procream.

**CONCLUSIONS**

Procream is a source of bioactive glycoproteins that may provide beneficial gut health effects. Understanding which specific compounds in Procream are key for gut function will help guide the future selection and production of dairy ingredients that can alter the microbiota-gut-brain axis and improve overall health. In vitro experiments found that the compounds in Procream were utilized by most of the *bifidobacterial* strains tested and could therefore have beneficial effects on gut health. In vivo experiments demonstrated the potential for Procream supplementation to beneficially influence body weight, inflammation, and memory. The researchers suggest combining Procream with select commercial strains of *bifidobacteria* in future studies to improve the chances of observing health effects.
to California dairy producers and associated allied industry focusing on the program’s sustainability components of public health, animal care, and environmental stewardship.

CDQAP has worked with California’s dairy farmers to make continuous improvements in their processes, adhering to the highest standards for protecting the environment, optimizing animal care, and ensuring food safety. As CDQAP completed its 23rd year of service, the program showcased two of its most unique characteristics: a nimbleness to address diverse and unexpected concerns of producers and processors and partnering with regulatory agencies.

**METHODS, FINDINGS AND OUTCOMES**

CDQAP’s flagship education and third-party certification program performed 193 certifications or recertifications in 2022. CDQAP certification verifies compliance with all local, state and federal dairy environmental regulations and provides a 50% reduction in state water board fees for eligible producers meeting the program’s evaluation standards. This program continues to be the most efficient and cost-effective method for dairy producers to remain current on environmental stewardship, animal care, and farm security topics. To date, 784 California dairies are currently certified with a cumulative savings of over $2.5 million annually to producers.

Because of regulatory deadlines specific to the region, this year’s Environmental Stewardship outreach focused on supporting North Coast producers. There was also significant planning for outreach directed to the Central Valley regarding new requirements from the pending Region 5’s Central Valley Dairy General Order and the existing Nitrate Control Program. CDQAP brought together experts from academia and industry to assist with developing curriculum that addresses the requirements. This curriculum will be offered in 2023 with a focus on how producers can determine their Whole Farm Balance for nitrogen, address a nitrate imbalance, and access financial support for facility improvement.

Environmental outreach also focused on describing the various non-digester practices used in the Alternative Manure Management Program (AMMP). CDQAP, with support from a grant from CDFA to CDRF and UC Davis’ Cooperative Extension (UCCE), developed webinars and a comprehensive website with videos, fact sheets, and operational costs of AMMP. The website was also used to promote the availability of financial assistance for AMMP projects.

In 2022, CDQAP provided significant program leadership on animal health and food safety by addressing dairy mortality disposal in the Central Valley and developing outreach related to securing the food supply, livestock medication, and antibiotic resistance. CDQAP utilized non-industry funding to partner in developing tools that would assist producers in establishing pre-approved enhanced biosecurity plans known as Secure Food Supply (SFS) plans. SFS plans promote producers’ ability to continue to ship milk from uninfected farms during “stop movement” or “quarantine” orders that could accompany foreign animal disease outbreaks such as Foot and Mouth disease. CDQAP supported California dairy industry success in livestock medication use requirements as put forth by CDFA’s Antimicrobial Use and Stewardship (AUS) program.

Further progress was made in developing solutions related to mortality disposal emergencies. CDQAP continued to assist CDFA in their drafting of a county-specific emergency carcass disposal plan and provided unique training and hands-on experience with three different types of composting and best management practices to use in emergencies.

CDQAP responded decisively to several unexpected issues in 2022, including farm security concerns related to employee robbery and processor ransomware attacks. CDQAP generated two comprehensive web pages titled, Theft & Robbery and Dairy Security and Crime Prevention, and worked...
CONCLUSIONS

CDQAP continued to provide essential outreach and support to California dairy producers, focusing on the areas of public health, animal care, and environmental stewardship. A key part of these efforts is CDQAP’s environmental stewardship certification program which provides a 50% reduction in State Water Board fees to eligible certified facilities, resulting in savings to producers of over $2.5 million annually. Environmental outreach efforts were focused on in-person and online training for producers in California regions with the most urgent regulatory deadlines.

CDQAP developed webinars and a comprehensive website with videos, fact sheets, and operational costs of AMMP and used the website to support producer understanding of practices and promote the availability of financial assistance for AMMP projects.

Animal health and dairy food safety were addressed by developing tools and outreach materials related to dairy mortality disposal in the Central Valley, livestock medication, antibiotic resistance, and a secure food supply.

CDQAP addressed unexpected concerns regarding farm security, including education on employee robbery and processor ransomware attacks.

FEED INDUSTRY FELLOWSHIP WITH A FOCUS ON DAIRY FEEDING SYSTEMS (2021)

Researcher: Dr. Heidi Rossow, UC Davis

KEY TAKE-AWAYS

• The 2021 Feed Industry Fellowship supported two graduate students while they conducted on-farm research projects and completed industry internships in dairy nutrition and feed management.

• Fellows communicated research results at the California Animal Nutrition Conference (CANC) and the American Dairy Science Association (ADSA) meetings and helped teach a course in applied dairy nutrition at UC Davis.

• Both Feed Industry Fellows are continuing work on their master’s theses and one fellow is continuing their internship with a dairy nutritionist consulting firm as a direct result of connections made from this fellowship.

BACKGROUND AND OBJECTIVE

The Feed Industry Fellowship partners university educated interns with the feed industry to develop a qualified, well-rounded workforce for the dairy and feed industries. For this fellowship, graduate students in their first or second year of study conduct an on-farm research project and then partner with feed manufacturers, feed companies, and/or nutritional consultants to complete an internship and gain practical knowledge of the dairy farm industry. The on-farm research project provides the opportunity to learn the day-to-day challenges of a dairy operation and the internships...
allow for real-world learning and networking with practicing nutritionists and dairy producers. These fellowships train future leaders in the dairy feed and nutrition industries to be able to identify potential areas of concern and use their scientific knowledge and real-world experience to make informed recommendations.

**METHODS, FINDINGS AND OUTCOMES**

The 2021 Fellowship supported two graduate students, one from UC Davis and one from the Cal Poly, San Luis Obispo. One fellow’s project was focused on dairy cows that were previously enrolled as calves in a pre- and probiotic study during the pre-weaning period. The fellow examined how these types of supplements influenced milk production and health events in adulthood. The second fellow’s project involved feeding a probiotic to calves from birth to 180 days of age on a commercial dairy farm and then examining immune function and rumen development. This project was additionally supported by a bioscience company that manufactures probiotics.

After completing their on-farm research projects in the spring of 2022, both fellows interned with nutrition consulting groups. One fellow completed their internships at Pine Creek Nutrition and another for John Kennedy (Dairy Nutrition Consulting). The second fellow completed their two internships with the MILC group, one focusing on nutrient analysis and the other on feed management software. These internships enabled fellows to gain practical understanding of the application of nutritional principles to dairy feeding systems and to make important networking contacts with nutritionists and dairymen.

Both fellows presented their research results at the CANC and the ADSA meetings in 2022 and early 2023. The results of both projects speak to the role of feed supplements, such as probiotics, in improving health and productivity of dairy cows, research that will ultimately support the sustainability of the dairy industry. Additionally, both fellows had the opportunity to assist with teaching a one week intensive Applied Dairy Nutrition course for dairy graduate students, qualified undergraduates, and veterinary students at the UC Davis Veterinary Medicine Teaching and Research Center (VMTRC).

**CONCLUSIONS**

The 2021 fellows gained important, real world experience in dairy feed management, and valuable research and teaching experience in their academic field and networking contacts with nutritionists and dairy producers. These fellowships ensure that the dairy industry gains a more educated, well-rounded workforce that has experience in many aspects of the feed industry.

---

**MILK PROTEIN CONCENTRATES AS EMULSIFIERS IN CLEAN LABEL ICE CREAM (2021)**

Researcher: Dr. Vincent Yeung, Cal Poly SLO

**KEY TAKE-AWAYS**

- **Milk protein concentrates (MPC) and reduced calcium MPC (RCMPC) are natural emulsifiers derived from milk protein powders that could improve a food’s texture, increase its protein content, and be used in place of synthetic emulsifiers for “clean label” products.**

- **Ice cream samples with MPC and RCMPC (at 85% protein) at three different levels were produced and tested for viscosity, storage capability, and texture.**

- **Results support the use of MPC above 1% and RCMPC at 1%, 2%, and 3% as natural emulsifiers in ice cream. These emulsifiers improved the storage stability of ice cream, maintained viscosity within the typical range, and increased protein content without influencing fat or total solids.**

**BACKGROUND AND OBJECTIVE**

“Clean label” is a rising trend in the food industry as more than 80% of consumers prefer simple, easy-to-understand ingredients on their food labels. Dairy ingredients are well positioned to meet the demand for clean label foods through milk protein concentrates (MPC). MPCs are natural emulsifiers that could potentially increase a food’s protein content while improving texture. The object of this research project was to investigate the textural properties, shrinkage (% volume lost), and meltdown rates of ice cream made with two milk-based emulsifiers, MPC and reduced-calcium milk protein concentrate (RCMPC) (both at 85% protein) to determine their suitability as natural alternatives to synthetic emulsifiers.

**METHODS, FINDINGS AND OUTCOMES**

Ice cream samples used in analyses included one control (3% non-fat dry milk and no added emulsifiers)
and six experimental ice creams: 1% MPC, 2% MPC, 3% MPC, 1% RCMPC, 2% RCMPC, and 3% RCMPC. Different levels of MPC or RCMPC were produced by replacing equivalent amounts of non-fat dry milk and keeping the total solids content unchanged.

Substituting non-fat dry milk with MPC or RCMPC did not influence the fat, moisture, or total solids in the ice cream mixes but did increase the protein content. Additions of MPC or RCMPC at 1%, 2%, and 3% were associated with protein increases of 15%, 30%, and 45% respectively.

All experimental ice creams had higher viscosities than the control and higher levels of MPC or RCMPC were associated with higher viscosities.

Ice cream samples were analyzed for meltdown rate, shrinkage, and textural properties on days 1, 14, 30, 60, 90, and 180. On day 1, there were no differences in meltdown rate across samples. RCMPC had the lowest meltdown rate by days 90 and 180. Both the control and MPC 1% showed significant shrinkage over the study period in a household freezer whereas none of the RCMPC samples demonstrated any shrinkage in a household freezer. These findings indicate that MPC at 2% or higher and RCMPC at 1% or higher could function effectively as natural emulsifiers in clean label ice creams.

CONCLUSIONS
It is highly beneficial for dairy manufacturers to align with the consumer trend toward clean label foods and reformulate existing products to minimize the use of synthetic ingredients. Study results support the use of MPC or RCMPC (both at 85% protein) as a natural emulsifier to improve the storage stability of ice cream. While MPC and RCMPC both increased ice cream viscosity, all treatments remained within the typical range for ice cream processing. Every 1% increase of the emulsifier was associated with a 15% increase in the protein content of the ice cream sample. Because many ice cream manufacturers already use non-fat dry milk as an ingredient, the formulations developed in this study could be easily adopted for clean label formulations that improve protein content.

INNOVATIVE DAIRY-BASED EMULSIONS SYSTEMS FOR CONTROLLED NUTRIENT DELIVERY (2021)

Researchers: Dr. Vincent Yeung, Cal Poly SLO and Dr. Haotian Zheng, North Carolina State University

KEY TAKE-AWAYS

- Natural dairy ingredients derived from whey proteins can be used to replace synthetic emulsifiers in foods and beverages. These newly developed emulsifiers can assist with delivery of water-insoluble compounds (i.e., fat-soluble compounds) while boosting the total protein content of food.

- At present, the functionality of whey protein particle stabilized emulsions as delivery systems is not well understood. This study...
provided experimental data that demonstrated the functionality of a whey protein-based Pickering/Mickering emulsion in regulating lipid digestion dynamics and cellular delivery efficacy for curcumin, a water-insoluble compound with anti-inflammatory properties that comes from turmeric.

- Whey protein derived emulsions showed great potential for influencing lipid digestion, cellular uptake of curcumin, and end-product heat stability. This discovery shows promise for future innovations and applications focused on the delivery of water insoluble nutrients/bioactives/pharmaceuticals in a variety of formulas and beverages.

BACKGROUND AND OBJECTIVE
Oil-in-water Pickering/Mickering emulsions are different from conventional emulsions because they are stabilized by soft, solid particles. These emulsions have become a hot topic for the food and pharmaceutical industries because of their potential functions in regulating lipid digestion in the gastrointestinal tract and their carrying capacity for water-insoluble nutrients or pharmaceuticals. The objective of this study was to provide experimental data on the functionality of whey protein-based Pickering/Mickering emulsions. In this study, researchers manufactured three different whey protein aggregates and characterized their emulsion properties, measured their fat digestion kinetics, and investigated how each emulsion improved the bioavailability of curcumin, a water-insoluble compound with anti-inflammatory properties that comes from turmeric.

METHODS, FINDINGS AND OUTCOMES
Three differently structured whey protein aggregates were manufactured for use as Pickering emulsifiers: fractal aggregates (FA), microgel particles (WPM), and spherical aggregates (SA). Non-heat treated emulsion samples were coded as WPI-E and FA-E, while heat treated samples are WPI-HE and FA-HE. Of these, FA particles had the smallest mean particle size, indicative of a relatively acceptable phase stability when presented in a dispersion system.

To understand the stability of particle stabilized emulsion systems before and after heat treatment, the researchers prepared four emulsions samples using FA dispersion and whey protein isolate (WPI) solution.

Prior to heat treatment, WPI and FA stabilized emulsions showed no significant differences in lipid digestion dynamics as indicated by their free fatty acid release rate. Heat treatment did increase the fat digestion rates for both WPI and FA emulsions, but the lipolysis rate for FA-HE was lower than WPI-HE for the first half of the digestion period. The higher lipid digestion degree for FA-HE did not result in high cellular uptake of curcumin. Instead, the slow lipid digestion rate and relatively low degree of lipid digestion found in FA-E resulted in a relatively high bioaccessibility of encapsulated curcumin.

The FA-E emulsion digesta samples were the only samples that had a micelle cubic structure. The presence of micelle cubic structures of FA-E could explain their relatively high cellular uptake of curcumin despite the relatively low degree of lipid digestion. This type of structure has an advantage in oral and transdermal drug delivery.

CONCLUSIONS
The results of this research contribute significant value to the food industry regarding the design of new formulas with improved heat stability and delivery of water-insoluble compounds. Experimental data from this study demonstrated the functionality of whey protein particle stabilized emulsions as delivery systems of water-insoluble compounds. Although the non-heat-treated FA-emulsion showed relatively slow lipid digestion, the sample resulted in relatively higher cellular uptake of curcumin as compared with the other emulsions that were tested. The phenomenon could be attributed to the formation of a unique structure (“micellar cubic”) of assemblies of digestive lipid products. Future research should focus on how to improve the absolute phase stability of FA emulsions, as they show great potential for future applications regarding innovative formulas and beverages with superior heat stability.
CDRF manages an adaptive portfolio of scientific education and research which targets the areas of greatest impact for the industry today.

For 35 years, CDRF has supported the California dairy industry through our capacity to manage relevant and emergent research, and critical producer education.

Though primarily funded by the California Milk Advisory Board (CMAB), CDRF partners with other dairy industry organizations and seeks project co-funding wherever applicable to maximize funding and research investment opportunities.

The objectives of our current portfolio are listed on the following pages, categorized by program.
The Dairy PLUS Program is a new program under California Department of Food and Agriculture’s (CDFA) Office of Environmental Farming and Innovation (OEFI) that will award competitive grants to California dairy farms for the implementation of advanced manure management practices that reduce both methane emissions and nutrient surplus.

CDRF (along with CDFA, the University of California, Dairy Cares and several other California dairy organizations) was awarded up to $85 million in funding by the U.S. Department of Agriculture (USDA) under the Partnerships for Climate-Smart Commodities program in 2022. Over the next five years, this project will provide incentives to producers to adopt advanced climate-smart manure management practices along with outreach and technical assistance, measure green-house gas and nitrogen benefits associated with implemented practices, and develop markets for climate-smart commodities.

Approximately $75 million of the award will support the implementation of advanced manure management practices and be administered to California producers through the Dairy PLUS Program starting in 2023. Grant awardees for 2023 will be notified in late fall.

Interested in the 2024 and 2025 application rounds?

California dairy producers are eligible to apply for Dairy Plus Program dollars, including producers that have previously completed DDRDP or AMMP projects in the past. Producers should refer to the CDFA solicitation for cost-share funding eligibility amounts and specific program details.

See our Climate-Smart Grants page at cdrf.org or go directly to the CDFA-OEFI site at cdfa.ca.gov/oefi/dairyplus.

---

2022 THE EFFECTS OF GRAPE MARC ON REDUCING ENTERIC METHANE EMISSIONS*

RESEARCHER: Dr. Ermias Kebreab, UC Davis
TIMELINE: 2022 - 2023

OBJECTIVES: To analyze different grape marc components for their condensed tannins and other potential methane abatement compounds, such as fatty acids and organic acids; to conduct an in vivo trial to investigate the potential of grape marc to reduce methane emissions in dairy cattle; and to analyze the milk of grape marc-fed cows for constituents and fatty acid profile with human health implications.

BENEFITS: The outputs will include a description of anti-methanogenic compounds from various types of grape marc, determination of methane reduction potential, and characterization of milk fatty acid profile with links to positive modulation of the human gut microbiota.

Potential economic benefits include increased use of an abundant byproduct that may replace other more expensive feeds; potential inclusion of grape marc in newly created protocols that may be used for carbon credits; and promotion of milk and dairy products that have beneficial health attributes.

*Unsolicited funds from a philanthropic organization will be used by the researchers to co-fund this project. The California wine industry will provide grape marc at no cost to the project.
ENVIRONMENTAL MANAGEMENT

2022 PRODUCTION OF PATHOGEN-FREE PELLETIZED AND GRANULATED PRODUCTS FROM DAIRY MANURE SOLIDS

RESEARCHER: Dr. Ruihong Zhang, UC Davis
TIMELINE: 2022 - 2023

OBJECTIVES: To characterize different manure solid streams on selected dairy farms and create and characterize pelletized or granulated products from manure solids; investigate the application of infrared heating technology for destroying the pathogens in manure products; conduct an economic analysis of the pelletized and/or granulized products and develop recommendations for creating biofertilizer products from different types of manure solids; and disseminate project results to interested parties.

BENEFITS: This project will develop potential manure product production processes and specify their operation parameters for creating valuable biofertilizer products from manure solids which can help dairies utilize excess manure nutrients and/or export them off farm. Producing pelletized or granulized products from manure solids will allow easy storage, transportation, and application.

2023 DAIRY CARES COMMUNICATIONS AND CDQAP SUPPORT*

PROJECT LEAD: Michael Boccadoro, Dairy Cares
TIMELINE: 2023

OBJECTIVES: To increase awareness and understanding of how California dairy farmers continue to improve environmental performance and are world leaders in the development of sustainable farming practices. To have a positive impact in promoting beneficial partnerships between dairy farmers, state agencies, researchers, and other key stakeholders throughout the state. To support California Dairy Quality Assurance Program (CDQAP) communications.

BENEFITS: Dairy Cares’ communication and outreach efforts will continue to have a positive impact in promoting beneficial partnerships between dairy farmers, state agencies, researchers, and other key stakeholders throughout the state. The industry will benefit from the development of metrics and outreach materials (videos, publications, presentations, etc.) showing how California’s dairy farmers are leading the world in sustainable dairy farm practices.

Visit https://dairycares.com for more information.

*Dairy Cares receives contributions from industry stakeholders for environmental and animal-care communications; CDRF contributes on behalf of California dairy producers.

2023 BENCHMARKING AND DESCRIBING CALIFORNIA DAIRY SUSTAINABILITY METRICS

PROJECT LEAD: Jennifer Heguy, UC ANR
TIMELINE: 2023 - 2024

OBJECTIVES: To establish benchmarking data for energy and water use for the development of future sustainability metrics. To evaluate nutrient management mitigation options to improve
Objective one will provide benchmark information for energy and water use. The outcome of this objective will provide essential information for producers (and their supply chain buyers) to identify realistic opportunities for improvement.

Objective two will identify the potential for limited infrastructure manure mitigation options (pipelines, scrape, compost) to aid dairies’ increased access to land for on-site manure use while reducing supplemental commercial fertilizer usage or densification of manure for export.

**BENEFITS:** Identification of water and energy use benchmarks and future manure mitigation options will have the potential to inform decisions that assist producers in reaching their sustainability goals, as well as the potential to inform funding needs to assist producers in future nitrogen management efforts.

---

**2023 THE EFFECTS OF DRY CO-EXTRUDED FLAXSEED ON REDUCING ENTERIC METHANE EMISSIONS**

**RESEARCHER:** Dr. Ermias Kebreab, UC Davis  
**TIMELINE:** 2023

**OBJECTIVES:** To investigate the potential of a flaxseed-based product to reduce methane emissions and result in higher concentration of omega-3 fatty acids in milk.

Milk production, milk quality (including fatty acid profile), feed intake and methane emissions will be measured.

**BENEFITS:** Use of flaxseed in dairy diets could benefit California dairy in two ways: 1) reducing methane emissions could help in meeting the 40% reduction mandated by the state and, 2) encouraging changes in milk omega-3 fatty acid composition in milk to benefit human health.

**RESEARCHER:** Dr. Michael Payne, UC Davis  
**TIMELINE:** 2023-2026

**OBJECTIVES:** The primary goal of the project is to measure or estimate what potential impacts, if any, occur to groundwater, surface water and air quality when proper carcass compost methodologies are implemented. A secondary goal of the project is to develop mitigation procedures and best management practices for poultry and livestock composting when rendering services have been disrupted or are otherwise unavailable.

Test sites at various locations throughout California will be developed and monitored. Studies performed will include: 1) continuous, real-time temperature, salinity and moisture content of piles, 2) pathogen reduction during composting, 3) infiltration of nutrients into soil, 4) nutrient/heavy metal content of feedstock and finished compost, and 5) air quality emissions during the life-span of the compost piles.

**BENEFITS:** Any method (or methods) of animal mortality management systems must be efficient, logistically feasible, cost-effective and environmentally sustainable. Systems must be adequate for routine mortalities, and also be able to absorb mortality surges. When the primary management systems are interrupted, alternative management methods must be available. This project will demonstrate the use of compost technology to manage routine and catastrophic animal mortalities during emergency situations as both economically feasible and environmentally sustainable.

*Funding for this project is provided by California Department of Food and Agriculture (CDFA).*
2020 PROTECTION, RESTORATION, AND ENHANCEMENT OF TRICOLORED BLACKBIRD HABITAT*

PROJECT LEADS: Audubon California, California Farm Bureau, Dairy Cares, Western United Dairies, and others
TIMELINE: 2020 - 2024

OBJECTIVES AND BENEFITS: Tricolored blackbirds are America’s most colonial land bird. They nest in very large groups and dairy forage crops provide an ideal location for the birds to build nests. This 5-year project aims to support research that will explore ways to draw tricolored blackbirds to non-dairy habitats or otherwise minimize financial losses to dairy farms.

*Audubon California has partnered with dairy organizations, conservation groups, and several farmer-funded groups, to support dairy farmers as they protect the threatened tricolored blackbird species.

2021 IMPACTS OF MILK MICROBIOTA COMPOSITION ON WHEY QUALITY IN CALIFORNIA*

RESEARCHER: Dr. Maria Marco, UC Davis
TIMELINE: 2021 - 2023

OBJECTIVES: To identify sources of microbial contaminants in whey powder to determine whether milk is the main source of these contaminants, or if contamination occurs in transport, processing, or storage environments. Determine microbial genotypes consistent with increased survival in whey powder to identify control points that may be used to minimize microbial survival and contamination of whey powder produced in California.

BENEFITS: Annual losses to the California dairy industry due to microbial contamination of whey are between $5-10 million. Identification of those contaminants and their sources is a critically important step for preventing those losses from occurring. This study will identify spoilage bacteria and genes that can be targeted in subsequent methods aimed at eliminating those bacteria in whey products.

*This project is co-funded with a California dairy processor.

2021 OPTIMIZED CONTROLS FOR COOLING CALIFORNIA DAIRY COWS*

PROJECT LEADS: Dr. Vinod Narayanan, Derrick Ross, and Theresa Pistochini, UC Davis Western Cooling Efficiency Center (WCEC), and Dr. Cassandra Tucker, UC Davis
TIMELINE: 2021 - 2025

OBJECTIVES: The aim of this 5-year project is to save electricity and water though the development of a novel control algorithm for the fans and sprayers used to cool cows at commercial California dairies; to develop and test additional features, such as integration of weather forecasts to predict the amount of cooling needed for the day and to operate systems earlier if needed to decrease total water use and avoid heat stress during peak temperatures.

BENEFITS: The controller would help optimize the use of water (sprinkler cycling schedule) and fan energy (fan speed setting) while maintaining a comfortable core temperature for the dairy cow and minimizing electricity and water use. Resource and economics savings could be significant.

*CDRF is a minority funder of this project. The California Energy Commission is the majority funding source. Agreement #: EPC-20-043. Agreement term: 6/30/21-3/31/25. CDRF is seated on the project’s Technical Advisory Committee and will receive annual progress reports throughout the project timeline.
HUMAN HEALTH AND NUTRITION

5 CURRENT PROJECTS

2022 THE YOGURT MATRIX DURING DIGESTION: BENEFITS OF MILK COMPOSITION AND STRUCTURE*

RESEARCHER: Dr. Maria Marco, UC Davis
TIMELINE: 2022 - 2023

OBJECTIVES: Although plant-based products are frequently made using the same bacteria as dairy yogurt, plant matrices have very different nutritive and structural properties. This project’s aim is to clarify the structural and functional differences between traditional dairy-based yogurts and various plant-based yogurt-like products.

BENEFITS: The approach used here will lead to an improved understanding of how dairy-based yogurt impacts intestinal, immune, and metabolic health. This project supports efforts to differentiate dairy yogurt from plant-based alternatives.

* This project is funded in partnership with National Dairy Council.

2022 MICROBIAL TAXA AND FUNCTION IN LACTASE NON-PERSISTERS

RESEARCHER: Dr. Danielle Lemay, USDA ARS
TIMELINE: 2022 - 2023

OBJECTIVES: To investigate and document the relationship between lactose intolerance, dairy consumption, gut microbes, and gut-derived short chain fatty acids. Determine whether the gut microbiome’s of genetically lactose intolerant adults who consume lactose adapt to dairy intake to produce more short chain fatty acids, especially acetate. Determine which microbes are the source of microbial lactase in genetically intolerant people.

BENEFITS: This information is needed to develop personalized dietary recommendations for dairy foods for both lactose tolerant and intolerant populations. Currently, lactose is not considered a health benefit. However, if it is shown that increased lactose consumption is associated with increased beneficial metabolic compounds, this could create marketing opportunities and bring more consumers back to dairy foods.

2023 BOVINE MILK AND NON-DAIRY ALTERNATIVES: CHARACTERIZATION OF OLIGOSACCHARIDES STRUCTURES, ABUNDANCE AND FUNCTIONS

RESEARCHER: Dr. Daniela Barile, UC Davis
TIMELINE: 2023 - 2024

OBJECTIVES: To demonstrate the unique nature of milk bioactives in comparison to non-dairy milk alternatives. To recover oligosaccharides from bovine milk and non-dairy alternatives and characterize and quantify them by advanced mass spectrometry; compare in vitro functional activity of all purified oligosaccharides; investigate their anti-inflammatory and antiviral activity.

BENEFITS: The results from this work will aid in building a positive image for dairy products by displaying the beneficial activities of milk oligosaccharides which are simply not replicated in alternative dairy-free products.

2023 THE EFFECT OF YOGURT ON MUCOSAL IMMUNITY IN THE GASTROINTESTINAL TRACT*

RESEARCHER: Dr. Danielle Lemay, USDA ARS
TIMELINE: 2023 - 2024

OBJECTIVES: In a prior CDRF-funded observational study, researchers identified a trend for increased mucosal protection among yogurt consumers compared to non-consumers. Therefore, the aim of this study is to measure mucosal protection in an intervention trial in which adults are supplied with twice daily servings of yogurt.

BENEFITS: Will provide a better understanding of the potential of dairy products to impact a novel
HUMAN HEALTH AND NUTRITION

aspect of gut health. Conclusions will inform future trial design for comparisons against non-dairy alternatives which would not be expected to confer similar gastrointestinal protection.

*This project is funded in partnership with National Dairy Council.

2023 SPLASH! MILK SCIENCE UPDATE AND SUPPORT OF THE INTERNATIONAL MILK GENOMICS CONSORTIUM (IMGC)*

PROJECT LEAD: Dr. Carl Whithaus, UC Davis
TIMELINE: 2023

OBJECTIVES: This project has two main objectives: The first is to produce SPLASH! Milk Science Update, which is a bi-monthly e-newsletter focused on highlighting emerging research trends in the scientific research literature; and to translate and disseminate the content of those articles for the non-expert. The second objective is to provide support for the International Milk Genomics Consortium (IMGC), which is an international collaboration dedicated to the advancement of milk and dairy sciences. Each year, the IMGC hosts an annual symposium and other educational opportunities for researchers, industry, communicators, and educators in a variety of disciplines related to milk, lactation, and human health.

BENEFITS: SPLASH! and the IMGC symposium keep the milk science community up-to-date and engaged on the most cutting-edge information on milk and dairy science from around the world.

For more information on the IMGC and SPLASH!, visit https://milkgenomics.org

*CDRF is the managing sponsor of the IMGC.
SPLASH! is funded by the IMGC.

CAPABILITY BUILDING

2023 CALIFORNIA DAIRY QUALITY ASSURANCE PROGRAM (CDQAP)*

PROJECT LEADS: Dr. Michael Payne and Dr. Deanne Meyer, UC Davis, and Denise Mullinax, CDQAP/CDRF
TIMELINE: 2023

OBJECTIVES: To provide California dairy producers with free, universal access to the most current science-based management practices and compliance assistance, as well as environmental classes and certifications specific to California’s dairy industry needs. To create and manage producer-friendly outreach materials and events related to animal care, food safety, farm security, and other emerging issues impacting California dairy. To provide environmental evaluation and certification to interested producers allowing for continued water quality permit fee savings.

BENEFITS: CDQAP environmentally-certified facilities have less risk for enforcement actions than non-certified facilities, and benefit from reduced on-farm regulatory inspection frequency and annual permit fees. Producer-friendly outreach related to new CDFA policies regarding livestock medications and business continuity during outbreaks of catastrophic animal disease. Outreach created with law enforcement raises producer awareness of actions they can take to minimize theft and adverse effects of animal activist actions. Positive public messaging for industry.

To access outreach materials from CDQAP, visit https://cdqap.org

*CDQAP is an industry-academia-government partnership that serves to support California dairy producers. CDRF funds CDQAP outreach activities.
PRODUCT INNOVATION

1 CURRENT PROJECT

2022 INCREASING THE ECONOMIC VALUE OF PERMEATE STREAMS FROM CHEESE

RESEARCHERS: Dr. Vincent Yeung, Cal Poly SLO and Dr. Haotian Zheng, North Carolina State University

TIMELINE: 2022 - 2023

OBJECTIVES: To create a scalable enzymatic method for manufacturing Lactobionic Acid (LBA) to optimize key manufacturing parameters (such as pH and ionic strength); and to construct LBA-whey protein delivery systems for nutrients.

BENEFITS: LBA—a lactose derivative—has received recent attention due to its antioxidant, chelating, and emulsifying properties. LBA can be manufactured from lactose, which has relatively low commercial and functional value, however, there is no standard enzymatic manufacturing method available for cost-effective and efficient use in industrial scale production. Developing a scalable enzymatic method for manufacturing LBA would add significant value to lactose streams.

CAPABILITY BUILDING

2023 Feed Industry Fellowship with a Focus on Dairy Feeding Systems

PROGRAM LEAD: Dr. Heidi Rossow, UC Davis

TIMELINE: 2023

OBJECTIVES: To partner graduate level student interns with feed companies and dairy consultants to provide real-world research and on-farm technical support experience, ultimately resulting in a more qualified workforce for the California dairy and feed industries.

BENEFITS: The fellowship program develops animal nutrition leaders who can identify potential areas of concern and can use their scientific knowledge balanced with real-world large facility nutrition management experience to make informed recommendations to enhance the sustainability of the dairy industry.
ABOUT THE CALIFORNIA DAIRY RESEARCH FOUNDATION:

CDRF is a non-profit 501(c)(3) public research management corporation. CDRF’s mission is to lead and deliver the most relevant research and science-based education programs, while collaborating and partnering with other dairy industry organizations to maximally support an innovative and sustainable California dairy industry.