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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.
It is my pleasure to provide CDRF’s 2020-2021 Annual Report. Despite the many challenges that the COVID-19 pandemic placed on all of us, like the dairy industry as a whole, CDRF pivoted and persevered. Through Zoom meetings, virtual symposia and seminars as well as good old fashioned phone calls, CDRF continued to steward the industry’s research investments on behalf of our California dairy farmers.

Our scientific education and research portfolio has transitioned to the areas of greatest impact for the industry today: environmental and economic sustainability. These areas are both top research priorities for CDRF as dairy alternatives continue to take up more space in the dairy case – often with messaging campaigns that focus on sustainability despite the fact that many dairy alternatives are both heavily processed and relatively nutrient-poor dietary options.

Consumers are increasingly well-informed, and multiple issues surrounding responsible food production have become ever-more important in food purchasing choices of all types. Consumers are no longer just interested in food safety and basic nutrition information, now they are also making their purchasing decisions based on environmental impacts, animal welfare, labor, and trade considerations. There is a growing need for higher level documentation and continuous improvement in these areas to bolster consumer awareness of how California producers implement best practices and maintain the highest standards.

In response to these, and other pressures on our producers, CDRF continues to offer both open and targeted calls for research proposals to seek out the most up-to-date and innovative scientific projects for filling current knowledge gaps and preparing the industry for a healthy and sustainable future. You’ll see from our recently completed projects summaries and our current research and educational portfolio included in this report, that CDRF is responding to the current challenges and opportunities of the California dairy community.

Within this report you will find research and educational programs focused on:

- Improved water and nutrient management practices: supporting producer implementation of innovative irrigation practices and/or the management of manure nutrients to minimize impacts on groundwater.
- Adoption of new technologies: helping producers understand the benefits and issues involved in acquiring and implementing existing and emerging technologies.
- Precision agriculture tool utilization: the use of digital tools for performance and compliance reporting. Better quality data availability enabling improved environmental management; optimizing yield and minimizing input costs.
- Discovering the bioactive dietary components in milk that set it apart from other foods; investigating the role of dairy in improving gut and immune health; communicating critical milk and dairy research for lay audiences.
- Scientific information support: collection of California dairy statistics, data and case study style information that can be used effectively by CMAB, Dairy Cares and others in promotion of the environmental credentials of the industry.

Multiple projects are co-funded with partners in the dairy industry and beyond as we continue to leverage both dollars and expertise to the maximum benefit possible. We have also continually been reaching out to new researchers and educators to expand our networks and knowledge base, aiming to bring a greater number of collaborators together to work across scientific disciplines.

As always, we appreciate the opportunity to continue to support our California dairy industry. We hope this report provides useful information regarding our project portfolio and are happy to provide addition information about any of our research and education projects.

We look forward to another year of service and wish good health upon our dairy communities and consumers.

Denise Mullinax
Executive Director
In 2019, CDRF established an Environmental Steering and Technical Advisory Committee (ESTAC) which includes representatives from key groups related to the dairy industry. CDRF works with our ESTAC and other invited participants to refine our annual environmental management research plan, identify gaps and eliminate redundancy. Our third annual meeting was held on May 6, 2021. The following topics of greatest need and interest were identified:

**Air Quality**
- Create methane reduction opportunities and incentives; Quantify co-benefits of reduction practices; Evaluate advanced technology on dairy digesters; Validate digester and Alternative Manure Management Program (AMMP) reductions (field vs. calculator).

**Water Quality/Manure Management**
- Utilize manure while achieving regulatory compliance; Advanced technologies for solids removal; Market support for exporting manure; Salinity: Dairy’s contribution compared to whole; Use of bacteria/microbiology to mitigate undesirable environmental effects.

**Water Quantity**
- Improve water use efficiency; Investigate recharge opportunities on dairies; Irrigation automation for water and labor savings; Use of alternative water sources to supplement ground water.

**Soil Health and Biodiversity**
- Research safety, efficacy, and benefits of applying manure-based products; Water retention and infiltration impacts of manure application on soil health; Maintaining soil health during drought.
 Completed Projects

6) Dairy Methane Reduction Strategies
7) Impact of Feed Formulation Variability
8) Benefits of California Dairy Using Byproducts as Feeds
10) 2020 California Dairy Quality Assurance Program (CDQAP)
11) 2020 Dairy Cares
12) Growing Sugarbeets on California Dairy Farms
13) Growing Safflower on California Dairy Farms
14) 2020 Dairy Feed Fellowship
15) International Milk Genomics Consortium (IMGC) and SPLASH!® Milk Science Update
Key Take-A-Ways

- Economic impact of methane emissions reductions varies by herd size and manure management practices employed.
- Methane emissions from California dairy manure management are declining with adoption of alternative manure management practices and installation of dairy digester projects with biogas capture and use.
- Continued funding of the Alternative Manure Management Program (AMMP) helps dairy producers regardless of herd size to participate in and contribute to manure methane emissions reductions.

OBJECTIVE:

To provide an economic evaluation of strategies for methane emission reduction effectiveness and appropriateness in small and large California dairies.

BACKGROUND, FINDINGS, AND OUTCOMES:

California lawmakers have set a target for reduction of greenhouse gases. Senate Bill 1383 (SB 1383) specifically requires that by 2030 methane emissions from dairy and livestock manure must be 40% lower than 2013 levels. Understanding the environmental and economic impacts of implementing methane emission reduction strategies for farms of all sizes is necessary to support the wise investment of time, management, and capital resources, and is paramount to achieving the reduction goal.

Researchers from the University of California, Davis, evaluated the economic impact of two baseline manure collection practices—flush system and scrape system—against five alternative practices: compost bedded pack barn, solid separation (with both open solar drying and composting), scrape conversion, and lagoon digesters.

The analysis showed that the economic impact of methane emissions reductions varied by herd size and manure management practices employed. Adoption of any of the alternative practices could reduce manure methane emissions per cow but come at a higher cost to the farm compared with their baseline practice. At any given herd size, freestall dairies were assumed to collect 2.4 times more manure and have greater emissions when compared with non-freestall dairies. This means freestall dairies have a greater chance to reduce emissions. For example, adopting a digester reduced methane emissions by almost 83% on freestall dairies and by almost 58% for non-freestall dairies.

Using these same simulations, the researchers project that while the aggregate number of cows remains unchanged into the future, the number of cows in the smaller herd size categories will decline rapidly. This means fewer dairies in the smaller herd size categories and more cows per herd in larger herd size categories. In addition, with the adoption of digesters by a high share of dairies in the larger herd size categories, their methane emissions per cow decline and are well below those of the smaller herds.

Investment of public and private funds is necessary to reduce manure methane emissions. Continued funding of the Alternative Manure Management Program helps dairy producers regardless of herd size to participate in and contribute to manure methane emissions reductions. Without public funds, smaller dairies likely will be disproportionately impacted by higher fixed costs per cow associated with these reductions.

This project was funded by the California Department of Food and Agriculture (CDFA) and managed by CDRF.

Dairy Methane Reduction Strategies Evaluation
Impact of Feed Formulation Variability

Key Take-A-Ways

- Differences between formulated feed and analyzed feed on overall carbon footprint was small.
- Variability in feed ingredients from year to year in response to availability and costs of production was associated with variable enteric emissions.
- Small increases (5.9%) in carbon footprint occurred from 2015 to 2017 due to greater use of feeds such as corn grains.
- Diets low in neutral detergent fiber (NDF) content can reduce enteric methane emissions but may not be financially viable for dairy farms.

OBJECTIVE:

To quantify year-to-year variability in carbon footprint due to differences in feed formulation, and determine the effect of price changes in formulations on carbon footprint of California dairy production systems.

BACKGROUND, FINDINGS, AND OUTCOMES:

Following up on previous research estimating the carbon, water, and land footprint of California dairy farms over 50 years, this study quantified the variability in feed formulation from year to year to determine its impact on carbon footprint. The researchers found that using the formulated diet to calculate the nutrient composition from the Nutrient Requirement of Dairy Cows (NRC) tables yielded a very close estimate to analyzed diet.

Researchers compared the expected nutrient composition, estimated from the NRC tables of feeds, with actual sampled nutrient composition from six dairies with known feed formulation. The difference between what is formulated and what is consumed is important to quantify because it changes estimates for emission intensity.

Next, the study investigated the effect of changing diets on the environmental impact of dairy production. Dairy cow diets vary year to year due to cost fluctuations and availability. Researchers evaluated dietary data from the 2013 through 2017 CDFA Cost of Milk Production reports for both milking and dry Holstein and Jersey cows.

Finally, the researchers investigated how changing prices of feed ingredients impacted emissions. The differences in diets resulted in variable enteric methane emissions between 2013 and 2017. Corn grains have one of the higher emission factors and contributed to the higher emissions for 2015-2017.

This study found that the optimal diet for dairy cattle in the state would have low neutral detergent fiber (NDF) content. Dietary NDF content has a positive relationship with enteric methane emissions. However, reducing NDF content comes at the expense of financial stability and might not be the most efficient way of lowering enteric methane emissions. Although diets varied in response to ingredient prices, the overall impact on carbon footprint was only 5.9%.
Benefits of California Dairy Using Byproducts as Feeds

Key Take-A-Ways

- Overall, this research shows that the use of byproducts in dairy rations benefits both agriculture and the environment, improving the sustainability of California agriculture.

- The average share of byproducts in the ration differs across dairy production regions in California, from lows of about 9% on the North Coast and 32% in Southern California, up to 37% in the southern Central Valley and a high of 42% in the northern Central Valley. The statewide weighted average of approximately 38% is dominated by the two valley regions, which produce more than 90% of the milk in California.

- Herd size was a major factor influencing byproduct use. In the northern Central Valley, the highest byproduct share was noted in herds with more than 3,000 cows, coming in at 45.8%. Interestingly, the shares of byproducts in rations in the northern Central Valley for herds with 1,001-2,000 cows and 2,501-3,000 cows were both substantially higher than for herds with 2,001-2,500 cows.

- Many individual byproducts have locally important impact for both economic and resource use. The inclusion of these byproducts in dairy rations also allows a productive outlet for many materials that may otherwise be sent into waste streams. If California dairies did not take byproducts from California producers and processors, direct economic and environmental implications would affect many of California’s agricultural industries.

- Byproducts are almost ubiquitous in California dairy rations. These byproducts are vital contributors to the nutrition of California dairy rations, and help to offset the costs of milk production.

**From almond hulls to winegrape pomace, use of agricultural byproducts in California dairy rations help keep dairies and crops financially viable while reducing waste and water use.**

**OBJECTIVE:**
To comprehensively assess byproduct usage in the state, and to quantify the economic and environmental costs and benefits of using byproducts as feeds in California dairy rations.

**BACKGROUND, FINDINGS, AND OUTCOMES:**
Dairy is California's largest farm commodity by revenue, generating around $7 billion in value. Dairy feed rations represent more than half of the cost of milk. California has approximately 1.7 million dairy cows, the highest number of any U.S. state. The majority (90%) of those cows are located in the Central Valley. These dairies are surrounded by millions of acres of nuts, fruits, vegetables, and cotton, which are often processed locally.

Byproducts from the production of these crops are then used, with minimal processing and transportation costs, to feed dairy cows. Using these byproducts to feed cows not only benefits the California dairy industry, but also benefits other agricultural industries in California (and in North America more broadly) by helping them to reduce their economic and environmental impacts. Without dairy use as feed, these industries would need to find alternative (and likely less environmentally friendly) outlets for dealing with their byproducts.

The research explored the symbiotic relationship between California dairies and local crop producers that substantially reduces the waste from both industries and saves land and water resources for food production.

Results of the authors’ 2019 survey of California dairies showed that 95% of respondents used byproducts in feed and more than 70 distinct byproducts, most of which are produced in California are used in dairy rations. California dairies feed cows a huge range of products, including items like carrots, grape pomace, and brewers’ spent grains.
With a ration share of approximately 38% of feed on California dairies, byproducts were found to be the largest feed category by cost and dry matter share, exceeding shares of silage, hay, or grains. Almond hulls (3.5%), canola meal (8%), cottonseed (6%), and distiller grains (4.5%) are the top four major byproduct feeds as measured by dry matter. California-produced byproducts dominated the list of feeds and make up the majority of the byproduct dry matter in the state.

About 95% of the 2.55 million tons of California almond hulls are used as dairy feed, and if they were not available, milk production could fall by about 2%. Other crops such as cotton, with 20% of its revenue generated through sales of cottonseed for dairy feed, would suffer if dairies were not able to buy these byproducts.

Benefits of the close relationship between dairies, crop industries and processors are not only economic. For many crops, other uses of byproducts require additional processing and transportation, increasing the cost, resource use, and carbon footprint. Byproducts without alternative uses would be wasted and likely would end up in landfills, adding to methane emissions.

A key benefit of byproduct use in dairy feeds in California is the reduced environmental and resource pressures on other dairy crop land and irrigation water in the San Joaquin Valley. If byproducts were not available for use as feeds, then thousands of additional acres of crops would need to be produced, causing significantly more stress on California’s natural resources, especially groundwater.

The overall findings showed that the inclusion of byproducts in dairy rations also allows a productive outlet for many materials that may otherwise be sent into the waste stream.
Key Take-A-Ways

- Facilities certified in CDQAP’s Environmental Stewardship program were eligible for fee discounts from the State Water Resources Control Board totaling nearly $2 million, approximately $2,500 per facility.

- COVID-19 impacted delivery of in-person educational workshops, but four were still held (following public health guidelines) in the North Coast region, and online water quality courses were accessible through a new online platform called eXtension.

- CDQAP provided decisive leadership in the face of several unanticipated issues, including maintaining employee health during the COVID-19 crisis, assisting with on-farm milk disposal procedures due to supply chain disruption, and mortality disposal plans in response to the shutdown of two of the state’s three rendering plants early in 2020.

- CDQAP continues to expend significant effort to monitor regulatory changes and provide free, concise compliance guidance and support to producers.

OBJECTIVE:

To provide educational assistance and outreach programs that focus on environmental stewardship, animal care, and food safety for the benefit of California dairy producers.

BACKGROUND, FINDINGS, AND OUTCOMES:

In 2020, CDQAP showcased two of its most distinguishing characteristics: partnering with regulatory agencies in anticipation of new regulations and exhibiting a nimbleness to address unexpected concerns of producers.

CDQAP completed nearly 150 environmental stewardship evaluations, resulting in a total of 780 certified facilities by the end of 2020. CDQAP-certified facilities were eligible for a 50% reduction in State Water Resources Control Board fees totaling nearly $2 million. The CDQAP education and third-party certification programs continued to be the most efficient and cost-effective method for dairy producers to remain current on environmental stewardship, animal care, and farm security topics.

Due to COVID-19 restrictions, in-person educational workshops were fewer in number than originally intended. Online water quality courses were successfully exported from the University of California server to a new online national agricultural Cooperative Extension platform called eXtension.

CDQAP remained dedicated to ensuring that all regulatory changes were monitored, and that free, concise compliance guidance and support were available to producers. CDQAP worked diligently to stay current with critical regulatory and issue developments, including the Central Valley Dairy Regional Monitoring Program (CVDRMP), the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) program, and the Alternative Manure Management Program (AMMP).

Several emergencies in 2020 required decisive CDQAP responses and leadership: COVID-19 and wildfire smoke required outreach related to Cal/OSHA employee health requirements; pandemic supply chain disruption and a natural gas service disruption necessitated environmentally safe, on-farm milk disposal that protected both producers and the environment; and the shutdown of two of the state’s three rendering plants required leadership and outreach on emergency mortality disposal plans. In addition, CDQAP continued to coordinate with partners, such as the California Milk Advisory Board (CMAB), and state and local law enforcement on emerging security issues such as activist plans for “open rescue” and robberies of milkers in April.

Finally, Dr. Deanne Meyer, CDQAP environmental stewardship lead, received two awards in 2020: the Eric Bradford & Charlie Rominger Agricultural Sustainability Leadership Award and the North Coast Regional Water Quality Control Board’s Water Quality Stewardship Award.
Key Take-A-Ways

• Dairy Cares communication efforts included academic papers, e-newsletters, virtual conference sessions, and key messaging to media outlets. They focused on addressing climate concerns, informing stakeholders of the most up-to-date science on methane emissions, and showcasing the California dairy industry’s leadership in fighting climate change.

• Dairy Cares co-hosted and led the second California Dairy Sustainability Summit in November 2020. The virtual event included over 60 speakers. It generated important conversations among dairy farmers, industry leaders, government officials, leading researchers, technology providers, and sustainable food, consumer, and nutrition experts.

• Dairy Cares supported CDQAP in creating event flyers and a monthly e-newsletter.

OBJECTIVE:

To increase awareness and understanding of how California dairy farmers continue to improve environmental performance and are world leaders in the development of planet-smart, sustainable farming practices, and to support the California Dairy Quality Assurance Program (CDQAP) communications.

BACKGROUND, FINDINGS, AND OUTCOMES:

Since its formation in 2001, Dairy Cares has actively worked on behalf of California dairy farmers on issues related to sustainability, including environmental stewardship, responsible animal care, and community involvement. A vital component of the successes of Dairy Cares has been a strong communications program that informs opinion leaders and news media personnel about dairy farmers’ commitment to, and accomplishments in, sustainability.

Dairy Cares communication projects focused on climate concerns, working to inform the narrative about methane emissions, and showcasing the California dairy industry’s leadership in fighting climate change. These included in-person outreach, virtual meetings, e-newsletters, video conference sessions, and a co-authored scientific publication.

In-person outreach opportunities for opinion leaders to enhance awareness of dairy sustainability accomplishments and initiatives were limited to the beginning of 2020 because of the COVID-19 stay-at-home and social-distancing guidelines. However, Dairy Cares staff members remained busy with virtual presentations.

Dairy Cares staff worked to maximize the use of aggregate data gathered from a variety of sources to craft positive messages to communicate about clean air and energy practices on California dairy farms. Staff members utilized multimedia and online media tools to engage target audiences with key messages. These tools included: a new scientific brief (white paper) co-authored by Dr. Ermias Kebreab, Dr. Frank Mitloehner, and Michael Boccadoro, discussing how methane impacts climate; the development and publication of a series of short videos to promote the California Dairy Sustainability Summit; a video featuring 11 dairy farmers to promote California’s leadership in planet-smart dairy farm practices; electronic distribution of 12 monthly newsletters; and creation of 22 videos as sessions for the virtual California Dairy Sustainability Summit, which were later made publicly available on the event’s website.

Dairy Cares continues to provide ongoing communications support to CDQAP by creating event flyers and the monthly e-newsletter publication.
Growing Sugarbeets on California Dairy Farms

Key Take-A-Ways

• Sugarbeets grown in winter on San Joaquin Valley dairy farms could reduce costs and maximize the value of feed produced with less available water.

• Sugarbeet-almond hull silage created a high digestibility and high dietary net energy dairy feed that was readily consumed by cows.

OBJECTIVE:

To validate the use of sugarbeets as a winter forage crop for dairies, measure the nitrogen uptake and yields, and evaluate key quality aspects of sugarbeet roots co-ensiled with almond hulls.

BACKGROUND, FINDINGS, AND OUTCOMES:

Sugarbeets were once widely grown in the San Joaquin Valley for sugar, and their byproducts—beet pulp and molasses—were used as dairy feeds. The last sugarbeet factory closed in the San Joaquin Valley 13 years ago, but sugarbeets could have an important role in the sustainability of California dairy rations and were investigated as a potential winter crop.

Sugarbeets have a high yield, use less water than competing summer crops, and produce a high-energy feed. Previous research on sugarbeets grown as a winter crop found they had relatively low production costs and higher yields than expected. This study continued this work and investigated the production capabilities of sugarbeet silage crops grown from October 2019 to June 2020, comparing them with other crop alternatives, with particular attention paid to the overall cost of production, water use, and nutrient management.

Beets are salt-tolerant and deep-rooted, and have shown the ability to use water and nutrients at depth in the soil profile. In this study, beets recovered water from up to six feet by harvest. Beets recovered on average approximately 260 lb. total N per acre in roots, and 370 lb. per acre in tops.

Sugarbeet silage provides a new opportunity to formulate dairy rations in California, complementing current winter cereal and summer corn silage production. Sugarbeets have a high level of dietary net energy (NE), digestible fibers and sugars, and provide rumen function benefits due to a reduced risk of acidosis and favorable fiber characteristics.

Beets were co-ensiled with almond hulls in Ag-Bags immediately after harvest in June 2020. Samples were collected at ensiling and as feeding occurred throughout the summer. Silage quality from the 2020 harvest was similar to that from 2019 despite differences in soil conditions, yield, and farm management. This suggests a high likelihood that beet-almond hull silage quality will be consistent across farms and over time.

Winter beets use less water than summer crops with equivalent feeding value and thereby extend limited irrigation supplies. The high feed quality of beet-almond hull silage, the ability of beets to be grown in winter with limited water, and the potential of beets to recover nutrients and water at greater depths than other crops indicate that sugarbeets could be an increasingly important crop in the San Joaquin Valley in future years.
Growing Safflower on California Dairy Farms

Key Take-A-Ways

- Safflower has value as a silage feed when harvested at a vegetative state in early spring following November planting.
- Safflower as winter forage has greater water use efficiency with a large amount of forage dry matter biomass.
- Safflower silage stored well and was stable over a six-month period, did not accumulate nitrate to excess, or result in harmful silage gas production under study conditions.

OBJECTIVE:
To determine the potential for safflower as a winter forage for dairy farmers by measuring safflower's capacity to recover residual soil nitrogen and water from a deeper soil profile than other annual crops, and evaluate forage yield and feed quality of fall-planted safflower under different planting and harvest dates.

BACKGROUND, FINDINGS, AND OUTCOMES:
Safflower is deep-rooted and can recover water and nutrients from deeper in the soil profile than any other annual crop. As a result, safflower could help dairy producers maximize water use efficiency across their crop production system and better manage nutrients in manure, especially nitrogen.

This was the first study in California to evaluate the potential for safflower as a winter forage for dairy cows. Safflower can be grown at any time of the year in California, but the researchers hypothesized that planting in fall would produce large amounts of total biomass that could be ensiled for feed use. They also predicted that safflower could be ensiled successfully and safely to preserve feed quality and without harmful off-gassing from potentially high-nitrogen biomass.

The study found that safflower used less than 1.5-acre feet of water from all sources to produce nearly seven tons of dry matter biomass per acre of silage by the late April 2020 harvest. Estimated water use in total was approximately 15 to 18 acre-inches. As predicted, winter forage production was more efficient in water use than summer production.

No direct comparisons for yield were made with cereal silages, but safflower was comparable in feed quality to cereal silages made from small grains like triticale and wheat, typically planted during the same period. Wrapped bales of safflower silage were stable over a six-month period, preserved easily, and had no harmful off-gassing under the study ensiling conditions.

Researchers documented soil water depletion to nine feet in the soil profile. Most nitrate uptake occurred in the upper portion of the profile, where roots were denser, but some uptake was observed at depths to nine feet. The limit for most competitive crops is four to six feet in the soil profile.

This study suggests that there are many benefits for using safflower as a winter forage for dairy producers in the San Joaquin Valley. Growing crops in winter rather than summer allows for greater water use efficiency, and growing deep-rooted crops, such as safflower, allows for recovery of nutrients and water left behind by shallow-rooted crops. This could help producers demonstrate regulatory compliance and sustain feed production with decreasing water supplies in the future.
Key Take-A-Ways

• Dairy feed fellowships provided practical experience to animal nutrition graduate students through on-site partnerships with feed manufacturers, feed companies, and nutrition consultants.

• The 2019-2020 fellowship supported two students in on-farm research projects and internships with nutrition consulting groups.

• Through these research and internship opportunities, fellows gained important networking contacts, and both continue to work with two nutrition consulting groups largely based on experiences achieved from the fellowship.

OBJECTIVE:

To support animal nutrition graduate students in their first or second year of study by partnering with feed manufacturers, feed companies, and nutrition consultants to provide a well-rounded, qualified workforce for the dairy and feed industries.

BACKGROUND, FINDINGS, AND OUTCOMES:

Graduates from animal nutrition degree programs are well trained in the science of nutrition but often lack practical knowledge of the dairy farm industry. Conversely, many feed industry and nutrition positions are available but qualified applicants are lacking because they have no experience with feeding systems and nutrient management in a large dairy herd environment.

To solve these problems, this fellowship partners university-educated interns with the feed industry. Students in their first or second year of study conduct an on-farm research project and then partner with feed manufacturers, feed companies, and nutrition consultants to gain understanding of dairy feeding systems through internships. These students will go on to become leaders who can identify potential areas of concern and can use their scientific knowledge balanced with real-world experience to make informed recommendations.

The 2019-2020 funding supported two graduate students who completed their project research at two dairies. One fellow’s project, which was also his master’s thesis, examined the effects of feeding a fibrolytic enzyme product on milk production in lactating Holstein cows from 21 days prior to freshening to 100 days in milk. The other examined changes in blood mitochondrial activity in Holstein dairy cows with and without an immune challenge.

Both fellows were able to complete full internships. Fellows interned with two different nutrition consulting groups to learn ration formulation, monitoring of feed management, and records analyses.

Fellows were able to interact in-person with industry members at the American Registry of Professional Animal Scientists (ARPAS) continuing education conference during the fall of 2019, and virtually participated in the online version of the American Dairy Science Association annual meeting.

Through these experiences, fellows gained important networking contacts with whom they shared their research results. They also gained a solid understanding of how a feed company works and monitors product manufacturing. Both fellows are completing their thesis preparation and continue to work with two nutrition consulting groups as a result of their experiences enabled through this fellowship.
Key Take-A-Ways

• The International Milk Genomics Consortium (IMGC), supported and funded through world-wide sponsorships, successfully held its annual symposium via a virtual platform. The change in venue (from in-person only to virtual) increased its accessibility and was the most-attended symposium in its 18-year history.

• SPLASH!® milk science update is a bimonthly e-newsletter that highlights notable scientific articles on milk science, the dairy industry, and nutrition. SPLASH!® was accessed from every major city in the world and remains an important educational resource for visitors to the IMGC website.

• Website visitor data show that many users access SPLASH!® via Facebook, and the e-newsletter plans to develop strategies to increase access through social media.

OBJECTIVE:
To produce an e-newsletter with content mirrored on the International Milk Genomics Consortium (IMGC) website to highlight emerging research trends in the scientific research literature; to translate the content of those articles for the non-expert in an effort to educate interested parties; and monitor uptake by industry representatives and scientists.

BACKGROUND, FINDINGS, AND OUTCOMES:
The rapid pace of scientific progress makes it challenging to keep up with the most recent topics in milk science and human health. In 2020, more than 20,000 new scientific articles were published and indexed with the keyword “milk” in the major medical and agricultural databases.

SPLASH!® milk science update provided a bimonthly e-newsletter of compelling short pieces that translated findings from notable scientific articles into engaging and accessible pieces for a non-expert audience. This type of science communication is essential for bridging the gap between researchers, industry, and the general public.

The IMGC mirrored the content and provided an archive, thus increasing traffic to its website. Analysis of website visitor data demonstrates that SPLASH!® was a major draw for visitors to the IMGC website in 2020, with over 156,500 page views, and 89% of IMGC website visitors accessing SPLASH!® articles. SPLASH!® was accessed from five continents and from every major city in the world. SPLASH!® is read not only by IMGC members and the established SPLASH!® professional network, but also by non-IMGC members and the general public.

In 2020, SPLASH!® became bimonthly and produced 24 pieces covering emerging topics in milk sciences, the dairy industry, and nutrition. The 2020 e-newsletters brought attention to how human milk oligosaccharides can influence bone biology, how COVID-19-positive mothers pass on neutralizing antibodies in milk, how California’s dairy industry is becoming more environmentally friendly, and how yogurt consumption can reduce mortality in women.

2020 IMGC SYMPOSIUM
The annual IMGC symposium brought together international experts in lactation, milk science, chemistry, microbiology, immunology, nutrition, genomics, anthropology, and bioinformatics. Participants discussed and shared outcomes and implications of the latest discoveries in scientific research on lactation, milk, and dairy for human health.

The 2020 virtual symposium was attended by 277 individuals from all over the world. The program was livestreamed and included an interactive Q&A and live chat rooms to maximize information sharing and professional networking.
Current Projects

CDRF manages an adaptive portfolio of projects. Our Board has demonstrated increased flexibility and commitment to fund and manage emerging research and outreach programs in real time as required to support today’s California dairy producers. The objectives of our current portfolio are listed on the following pages.

- **Human Health & Nutrition**
  - Dairy and Gastrointestinal Inflammation Protection
  - ProCream as a Source of Bioactive Compounds
  - Discovering the Bioactivity of Milk Fat Globules from Dairy Streams
  - 2021 International Milk Genomics Consortium (IMGC) and SPLASH!® Milk Science Update

- **Social Responsibility**
  - The Effects of Antibiotic Use at Dry-Off on Milk Quality
  - Precision and Accuracy of Cow-Side Tests for Quarter SCC
  - Protection, Restoration, and Enhancement of Tricolored Blackbird Habitat
  - Economic Opportunities and Risks of Automatic Milking Systems
  - Impacts of Milk Microbiota Composition on Whey Quality in California

- **Environmental Management**
  - Regional Dairy Farm AMMP Tours and Outreach
  - Validating Nitrogen Fixing Microbes in Manure
  - Characterization of California Dairy Manure
  - 2021 Dairy Cares
  - Dairy Manure and Almond Wood Compost for Healthy Soils
  - Automation of Surface Irrigation Systems in Dairy Production Systems in the Central Valley
  - Growing Sugarbeets on California Dairy Farms Pt. 3
  - Growing Safflower on California Dairy Farms Pt. 2
  - Evaluation of Enteric Methane Reduction Protocol Issues
  - Evaluation of California’s Timeline for Reaching Climate Neutrality

- **Capability Building**
  - 2021 California Dairy Quality Assurance Program (CDQAP)
  - 2021 Feed Industry Fellowship

- **Product Innovation**
  - Milk Protein Concentrates as Emulsifiers in Clean-Label Ice Cream
  - Innovative Dairy-Based Emulsion Systems for Controlled Nutrient Delivery
Current Projects

- **Dairy and Gastrointestinal Inflammation Protection**
  RESEARCHER: Danielle Lemay, USDA WHNRC and UC Davis
  
  **OBJECTIVES AND BENEFITS:** To determine whether dairy intake is associated with protection against gastrointestinal inflammation in order to counter media misinformation suggesting that milk is detrimental to gut health.

  This study will provide evidence on the relationship between dairy intake and good gut health in California consumers, with the goal of maintaining consumer confidence in the health and safety of traditional dairy products. Preliminary data suggest that dairy intake is not associated with gastrointestinal inflammation. Investigation on the potential protective effects is ongoing.

- **ProCream as a Source of Bioactive Compounds**
  RESEARCHER: Daniela Barile, UC Davis
  
  **OBJECTIVES AND BENEFITS:** To identify the composition of ProCream—also known as Whey Protein Phospholipid Concentrate (WPPC)—to determine its health effects and add value to this byproduct/waste stream.

  This study explores and documents the great potential of this byproduct in the human food supply based on its components (lactoferrin, immunoglobulins, xanthine oxidase, etc.) and potential beneficial health effects.

  *CDRF is a minority co-funder of this project; National Dairy Council (NDC) is the majority co-funder.*

- **Discovering the Bioactivity of Milk Fat Globules from Dairy Streams**
  RESEARCHER: Daniela Barile, UC Davis
  
  **OBJECTIVES AND BENEFITS:** To identify novel uses for a dairy co-product, ProCream, that is currently valued at less than $1/lb, and demonstrate the value of ProCream as an value-added ingredient. Comprehensive compositional analysis of ProCream will provide a greater understanding of the beneficial effects of milk as a whole and its component parts, for the ability to address a variety of disorders marked by poor gut health.

  *This project builds on the ProCream work being conducted with NDC, and is part of a larger project being co-funded by American Dairy Products Institute (ADPI).*

- **2021 International Milk Genomics Consortium (IMGC) and SPLASH!® Milk Science Update**
  PROJECT LEAD: Carl Whithaus, UC Davis
  
  **OBJECTIVES AND BENEFITS:** To provide a bi-monthly e-newsletter, with content mirrored on the IMGC website, to highlight emerging research trends in the scientific research literature and to translate the content of those articles for the non-expert. IMGC is an international collaboration dedicated to the advancement of milk and dairy sciences.

  *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.*
Current Projects

• The Effects of Antibiotic Use at Dry-Off on Milk Quality
  RESEARCHERS: Maria Marco and Heidi Rossow, UC Davis

  OBJECTIVES AND BENEFITS: To determine whether antibiotic use at dry-off negatively impacts mammary immune function and microbiome composition in cows with low somatic cell counts (SCC). To identify potentially beneficial bacteria that might be used as future alternatives to antibiotics.

  This study will demonstrate how dry-cow therapies can be more specifically applied to benefit the cow while reducing overall antibiotic use and costs due to selectively treating high SCC cows.

• Precision and Accuracy of Cow-Side Tests for Quarter SCC
  RESEARCHERS: Heidi Rossow and Maria Marco, UC Davis

  OBJECTIVES AND BENEFITS: To determine which cow-side tests are better predictors of individual quarter SCC for reduced treatment of non-infected quarters, reduce antibiotic use, and decrease costs associated with mammary treatments at cessation of milking.

  Using a cow side test that can identify mammary quarters with high SCC will reduce treatment of non-infected quarters, reduce antibiotic use, and decrease costs associated with mammary treatments at cessation. This study will result in information to help dairy producers target their dry-cow therapies specifically to benefit the cow without increasing antibiotic use. And provide producers with information to help meet the expectations of the consumer and maintain confidence in milk as a healthy, wholesome food.

• Protection, Restoration, and Enhancement of Tricolored Blackbird Habitat
  PROJECT LEADS: Audubon California, California Farm Bureau, Dairy Cares, and other invested groups and organizations.

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

  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.
Current Projects

• Economic Opportunities and Risks of Automatic Milking Systems
  RESEARCHERS: Fernanda Ferreira and Daniela Bruno, UC Davis

  OBJECTIVES AND BENEFITS: To identify risk factors associated with the economic success of implementing box robots and robotic rotary parlors in large dairies, and provide a reliable, scientific-based source of information for producers in California.

  This study will contribute to a better understanding of the economic risks and benefits of investing in box robots and robotic rotary parlors on large dairy operations in California.

• Impacts of Milk Microbiota Composition on Whey Quality in California
  RESEARCHER: Maria Marco, UC Davis

  OBJECTIVES AND BENEFITS: To identify sources of microbial contaminants in whey powder in order to determine whether milk is the main source of these contaminants in whey powder produced in California. 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.

  This study will identify thermoduric 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.

• Regional Dairy Farm AMMP Tours and Outreach
  PROJECT LEADS: Mark Cooper and Deanne Meyer, UC Davis; Denise Mullinax, CDQAP/CDRF

  OBJECTIVES AND BENEFITS: To expand awareness of Alternative Manure Management Program (AMMP) practice options to dairy farmers. Provide substantial information and awareness opportunities to bolster dairy farmer understanding of AMMP practices through farmer-to-farmer information and experience sharing.

  This project will provide economic implication information and awareness opportunities, and real-world accounts of whole-farm impacts and benefits.

  To access outreach materials for this project, visit https://cdqap.org/ammp-outreach-project

  Funding for this project provided by California Department of Food and Agriculture Contract Nos. 17-0750-000-SG and 19-0930-000-SO through California Climate Investments. Project managed by CDRF.
• **Validating Nitrogen Fixing Microbes in Manure**  
  **RESEARCHER:** Elizabeth Maga, UC Davis  

**OBJECTIVES AND BENEFITS:** To validate predictions from a previous CDRF-funded study that identified potential microbial populations that can fix atmospheric nitrogen into more usable forms.

This study will determine if these strains are able to fix nitrogen and potentially enable the future development of strategies such as dietary manipulation or post excretion treatment technology to modify microbial populations within facilities or throughout the storage/treatment/utilization environment to either enhance or reduce bacteria related to the nitrogen cycle.

• **Characterization of California Dairy Manure**  
  **RESEARCHERS:** Nick Clark, UCCE and Deanne Meyer, UC Davis  

**OBJECTIVES AND BENEFITS:** To identify chemical and physical characteristics of dairy manure streams from commercial dairies located in the Central Valley.

This study will provide in-depth knowledge of manure characteristics and provide critical information for those interested in adopting advanced manure treatment technologies and those interested in modifying their animal management practices to improve manure composition.

• **2021 California Dairy Quality Assurance Program (CDQAP)**  
  **PROJECT LEADS:** Michael Payne and Deanne Meyer, UC Davis; Denise Mullinax, CDQAP/CDRF  

**OBJECTIVES AND BENEFITS:** To offer free, universal access to the most current science-based management practices and compliance assistance; and environmental classes and certification, specific to California industry needs. To create and manage producer-friendly, outreach related to animal care, food safety and other emerging issues impacting California dairy. To provide environmental evaluation/certification to interested producers allowing for continued water quality permit fee savings.

**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.*
Current Projects

• 2021 Dairy Cares
  PROJECT LEADS: Michael Boccadoro and Jennifer Bingham

OBJECTIVES AND BENEFITS: 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 CDQAP communications.

To access outreach materials from Dairy Cares, visit https://www.dairycares.com

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

• Dairy Manure and Almond Wood Compost for Healthy Soils
  RESEARCHER: Ruihong Zhang, UC Davis

OBJECTIVES AND BENEFITS: To develop innovative methods for the production of pelletized compost from manure solids that can slowly release nutrients to plants and reduce nutrient leaching. To provide new scientific knowledge on the co-composting of manure solids and woody biomass and the pelletization of the mixtures of both materials.

Pelletized, composted products made up of dairy manure and almond wood biomass will help enable manure export off dairy facilities, improve nutrient balance and enhance sustainability.

_This project is co-funded with the Almond Board of California._

• Automation of Surface Irrigation Systems in Dairy Production Systems in the Central Valley
  RESEARCHER: Khaled Bali, UC Davis, ANR

OBJECTIVES AND BENEFITS: To demonstrate the use of automated surface irrigation in commercial dairy systems; determine the time of irrigation to reduce surface runoff and increase irrigation efficiency by redesigning the surface irrigation system based on local constraints such as available flow rate, field length, slope, and other field variables.

This study will provide essential information and confirmation that automation of surface irrigation systems on Central Valley dairies, particularly when liquid manure is mixed with irrigation water, has the potential to greatly improve irrigation efficiency, reduce the losses of water and nutrients below the root zone.
Current Projects

- **Growing Sugarbeets on California Dairy Farms Pt. 3**  
  **RESEARCHER:** Stephen Kaffka, UC Davis

  **OBJECTIVES AND BENEFITS:** To measure yields, analyze feed quality and costs of producing sugarbeets as a winter crop on dairy farms in the San Joaquin Valley. To estimate water use and nutrient budgets to optimize farm water use though winter crops and create a feeding model that optimizes on-farm water use. Conduct a feed study comparing different levels of beet silage with other total mixed rations without beets.

  This study will outline additional options and benefits that producers may take advantage of for winter forage crops that can improve soil health and optimize on-farm water use while also providing a high-energy feed. In addition, since beets are salt-tolerant, this study can confirm that sugarbeet crops can be successful in situations where corn silage crops are inhibited by salinity.

- **Growing Safflower on California Dairy Farms Pt. 2**  
  **RESEARCHER:** Stephen Kaffka, UC Davis

  **OBJECTIVES AND BENEFITS:** To assess the potential of safflower as an alternative winter forage crop that also helps improve water and nitrogen management on California dairy farms. To create a dairy ration feeding model that adds safflower silage and includes on-farm crop water use requirements. To optimize available water-use on representative dairy farms using this model under increasing restrictions due to the Sustainable Groundwater Management Act (SGMA).

  This study will outline the potential to incorporate a new crop into crop rotations that can improve nitrogen utilization by recovering water from deeper in the soil profile. Both traits will help dairy farmers with state regulatory compliance. Winter safflower would provide a new low-cost alternative feed on farms.

- **Evaluation of Enteric Methane Reduction Protocol Issues**  
  **RESEARCHER:** Ermias Kebreab, UC Davis

  **OBJECTIVES AND BENEFITS:** To produce a publication that will be used to inform the development of a standardized protocol for acquiring credits for reducing enteric methane emissions.

  This project is the first necessary step towards a goal of developing a protocol so that dairy farmers can participate in the carbon offset program and be able to claim credit for implementing enteric methane reducing technologies such as using feed additives or animals with greater feed efficiency. Currently, the only project approved by California Air Resources Board that benefits dairy is the use of digesters.

  The results of this project will lay out issues regarding enteric methane emissions, strategies to mitigate methane production, the use of feed additives, as well as quantification, monitoring, verification, and ownership of carbon offset credits for California.
Current Projects

• **Evaluation of California’s Timeline for Reaching Climate Neutrality**  
  **RESEARCHER:** Frank Mitloehner, UC Davis  
  **OBJECTIVES AND BENEFITS:** To re-evaluate methane’s global warming potential based on new models that distinguish between methane source (e.g., agricultural methane vs. fossil fuels) for historical and future California emission dynamics. Predict future California methane emissions under business-as-usual and various reduction scenarios and estimate the timeframe under which the California dairy industry will reach climate neutrality.  
  This work will foster the dairy industry’s understanding of emission reduction potentials and warming impacts and enable informed communication on goals and progress to stakeholders.

• **2021 Feed Industry Fellowship**  
  **PROGRAM LEAD:** Heidi Rossow, UC Davis  
  **OBJECTIVES AND BENEFITS:** 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 dairy and feed industries.  
  The fellowship program develops animal nutrition leaders who can identify potential areas of concern and can use their scientific knowledge balanced with real-world experience to make informed recommendations to enhance the sustainability of the dairy industry.

• **Milk Protein Concentrates as Emulsifiers in Clean-Label Ice Cream**  
  **RESEARCHER:** Vincent Yeung, Cal Poly SLO  
  **OBJECTIVES AND BENEFITS:** To compare the properties of ice cream made with synthetic vs. more natural milk protein-based emulsifiers, and to determine the optimum levels of these these milk-based “clean label” ingredients for shelf-stable ice cream products. To support California as the top ice cream producing state in the U.S. by promoting the use of milk protein concentrates as a premium ingredient. The resulting products will contain higher protein contents, which could improve product messaging and command higher product premiums.

• **Innovative Dairy-Based Emulsion Systems for Controlled Nutrient Delivery**  
  **RESEARCHERS:** Vincent Yeung, Cal Poly SLO and Haotian Zheng, NC State  
  **OBJECTIVES AND BENEFITS:** To compare whey protein-based emulsifiers for the purpose of stabilizing milk fat (and its fat-soluble vitamins), with the goal of improving the delivery and absorption of fat-based ingredients, nutrients, and/or drugs. Research could produce a novel technology that could transform conventional dairy ingredients into functional foods or drug delivery systems that improve the bioavailability of various compounds for health and wellness. This emulsion delivery system could be applied in infant formulas to improve the absorption of fat-soluble nutrients, making the structure/function of infant formula closer to that of human breast-milk or could be potentially used to improve the timed-release of fat-soluble drugs.
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