



STATE OF THE SCIENCE SUMMIT: FEED STRATEGIES TO REDUCE ENTERIC EMISSIONS

California Department of Food and Agriculture, UC Davis College of Agricultural and Environmental Sciences, and UC Davis CLEAR Center

May 2-3, 2023



Organizers



Helene R. Dillard
Dean, UC Davis College of Agricultural and Environmental Sciences

Helene R. Dillard was appointed dean of the College of Agricultural and Environmental Sciences at UC Davis in January 2014. Her goal is to build upon the strengths of the college in research, teaching, extension and outreach, and maintain strong relationships with the broad range of stakeholders in California, nationally, and globally.

Prior to her appointment at UC Davis, Dillard was on the faculty at Cornell University since 1984 as a plant pathology professor. She also served simultaneously as associate dean in two colleges – the College of Agriculture and Life Sciences (CALs) and the College of Human Ecology (2002–January 2014).

Helene Dillard was born and raised in San Francisco, California. She completed her B.S. degree in biology of natural resources at UC Berkeley, an M.S. degree in soil science at UC Davis, and a Ph.D. degree in plant pathology at UC Davis.



Karen Ross
Secretary, California Department of Food and Agriculture

Karen Ross was appointed Secretary of the California Department of Food and Agriculture on January 9, 2019 by Governor Gavin Newsom. In re-appointing Secretary Ross, Governor Newsom cited her unmatched leadership experience in agricultural issues nationally, internationally, and here in California; including environmental stewardship, climate change adaptation, and trade. Secretary Ross was initially appointed by Governor Edmund G. Brown Jr. in 2011.

Before joining CDFA, Secretary Ross was chief of staff for U.S. Agriculture Secretary Tom Vilsack.

Secretary Ross has strengthened partnerships across government, academia and the non-profit sector in the drive to maintain and improve environmental stewardship and to develop adaptation strategies for the specific impacts of climate change.

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Science and technology are giving us creative, exciting, cutting-edge solutions to further mitigate animal agriculture’s environmental impact.



Karen Ross
Secretary, CDFA



Karen Ross
Secretary, California
Department of Food and
Agriculture

May 2023 was a milestone for those of us committed to mitigating animal agriculture’s methane emissions.

For perhaps the first time ever in one place, we gathered concerned representatives from government, nonprofits, academia, NGOs, media, and industry to discuss strategies aimed at reducing enteric methane emissions, plus the associated challenges and opportunities.

Indeed, State of the Science Summit: Feed Strategies to Reduce Enteric Emissions was a watershed moment in our journey to make the all-important animal agriculture industry more sustainable. The enthusiasm was palpable as we shared ideas, debated solutions and pledged to continue to move on this important path toward methane reduction. In that, we are not alone.

In fact, the desire to reduce the short-lived climate pollutant methane was demonstrated by the willingness of 108 countries and subnationals to sign a pledge at COP26 to reduce global methane emissions. Those of us who work with animal agriculture are on the same page, but it’s no small task. Nor is it simple. The job of trimming the livestock and dairy sectors’ methane emissions involves identifying the approaches that will work on a producer, consumer and regulatory level, and that includes addressing complex economic, supply chain and above all, safety concerns.

California has been working for years in partnership with dairy producers to decrease methane emissions from manure storage. We’ve created a successful model that has made it feasible – and even profitable – for dairy farmers

Forward



California is willing to do its part to remove obstacles to success, and to build trust and consensus among all stakeholders.

to install anaerobic digesters and adopt other alternative manure-management practices. Armed with the knowledge and experience gained through this work, we are now turning our attention to feed strategy as an additional way to reduce methane from farms.

Science and technology are giving us creative, exciting, cutting-edge solutions to further mitigate animal agriculture’s environmental impact. We heard about many of them at the summit, which gave us an extraordinary opportunity to see where science is today and to better understand the opportunities for further advancements, as well as the barriers to success. We discussed how to come up with effective strategies to reduce enteric methane emissions while working with our regulatory partners at the state and federal level to ensure

the strategies appropriately address the health of the animals and the safety of the food that comes from livestock, not to mention how certain strategies would affect the viability of our producers’ enterprises.

I’m grateful to our dairy families and partners, our colleagues at the California Air Resources Board, and our team members at CDFA who joined forces with UC Davis College of Environmental and Agricultural Sciences and the CLEAR Center to bring this conference to life. They invited the right people – giving them a seat at the table – so that we could better understand each other’s concerns as we move toward a singular goal: finding a workable solution for reducing enteric methane emissions.

California is fortunate to have legal and budgetary support from

Governor Gavin Newsom and the California State Legislature to bolster our efforts to reduce methane emissions. The state has already put forth \$1 million for preliminary proposals, and there’s an additional \$10 million in funding to help develop a workable plan to reduce enteric methane emissions. As the No. 1 dairy state, California is willing to do its part to remove obstacles to success, and to build trust and consensus among all stakeholders. Not only can this lead to significant environmental wins, but it also has the potential to serve as a model for 49 other American states and perhaps even the world.

The summit was a groundbreaking effort; one that must continue. On behalf of CDFA, thank you for your concern, your support, your ideas and your resolve to safeguard the future of our planet and our food system.

I believe the summit enriched our collective understanding of the science that can help us reduce enteric methane, bringing together the various groups needed to make real-world impacts.



Helene Dillard
Dean, CAES



Helene Dillard
Dean, UC Davis College of Agricultural and Environmental Sciences

It's an exciting time at UC Davis, especially in our College of Agricultural and Environmental Sciences, our Department of Animal Science and the CLEAR Center. Our labs, lecture halls and campus buildings are filled with the best and brightest minds; we're producing world-class research; and there's a spirit of collaboration among our faculty, staff, students and outside partners that gives us reason to carry on ... and to do so with stalwartness and hope for the future.

Perhaps no event has done more to fuel my enthusiasm than the State of The Science Summit: Feed Strategies to Reduce Enteric Emissions, held May 2 and 3, 2023. As a co-host with the California Department of Food and Agriculture, we were honored to welcome to campus experts and stakeholders from virtually every corner of the agriculture system –

all with the goal of continuing on a path to reducing the industry's greenhouse gas emissions while we support its primary aim: feeding a worldwide population expected to reach 10 billion in just a few decades' time.

Californians are aware of what is being asked of our farmers – namely, a 40% reduction in methane emissions by 2030. That's one of the challenges motivating the likes of professors Frank Mitloehner, Ermias Kebreab and Matthias Hess, to name but three esteemed UC Davis researchers. They are working daily to find safe, effective, affordable and available ways to shrink agriculture's methane footprint and to understand better how to reduce livestock's enteric emissions. Not only because our legislators and policymakers have asked us to do so, but because it is the right thing to do in the face

Forward



The Golden State's goals cannot be met not without reducing enteric methane, an area that is flourishing with as many possible solutions as questions. That's what makes our summit so critical.

of unprecedented and precarious global warming. Indeed, it is so much bigger than our university, our state, our nation.

So, the work here continues, and dare I say with a heightened sense of urgency and purpose. We have encouraging reports of feed additives and manure digesters. The TED Audacious Project announced \$70 million in funding for a team that includes Dr. Kebreab, Dr. Hess and collaborators at UC Berkeley and UC San Francisco to study gene editing as another path to reducing enteric methane. More to the point: We know we're not chasing a dream. In December 2022, The California Dairy Research Foundation and the CLEAR Center laid out in detail how California can achieve the

world-leading target to reduce methane emissions from the dairy sector by 40% by 2030.

But the Golden State's goals cannot be met without reducing enteric methane, an area that is flourishing with as many possible solutions as questions. That's what makes our summit so critical. It was an important step toward a shared sense of purpose, the beginning of the exchange of proprietary data, the start of breaking down siloes, as it were. I believe the summit enriched our collective understanding of the science that can help us reduce enteric methane, bringing together the various groups needed to make real-world impacts.

I'm an academic and a dean, so I can't help but be buoyed by the

possibility of more investment in promising research, particularly in the public sector. However, I am first a member of our global community, and as such, I want us to do whatever we can – and what we must – to safeguard our planet and our food supply.

The clock is ticking loudly, but for two days in May, it seemed as if we may be able to keep up with the pressing climate timelines as we talked, listened, built bridges, broke bread, and established new relationships to tackle this problem together.

Thank you for being part of that amazing experience. As we go forward with a renewed sense of purpose, know this: What happens in California was never meant to stay in California.

Summit Background



The California Department of Food and Agriculture (CDFA), the University of California, Davis' College of Agricultural and Environmental Sciences, and the CLEAR Center at UC Davis hosted State of the Science Summit: Feed Strategies to Reduce Enteric Emissions, a two-day conference held May 2-3, 2023, at UC Davis.

The goal of the summit was to identify and articulate opportunities for collaboration and research that will help the dairy and beef industries meet their climate goals.

The summit included presentations and panel discussions involving leading experts in methane mitigation, animal science and governmental policy. Panelists discussed opportunities and barriers, and they offered insights into how to align the goals of the scientific and regulatory aspects of feed strategies to reduce enteric emissions from the livestock sector.

On the first day of the summit, presenters laid out the need for strategies to reduce enteric methane emissions. These strategies could be

used to achieve state, national and global goals for methane reduction, and more to the point, to curb global warming. Discussions revolved around what producers, and the livestock feed and supply chain can do to practically and sustainably support the implementation of feed strategies aimed at reducing methane emissions.

The second day of the summit provided state regulatory agency and producer perspectives on adoption, safety, claims and emissions accounting for feed strategies.

More than 300 people attended the summit in person and virtually. There were representatives from U.S. federal and state agencies, including the United States Department of Agriculture (USDA), the United States Food and Drug Administration (FDA), the California Air Resources Board (CARB), and the California Department of Food and Agriculture (CDFA). A representative from the Food and Agriculture Organizations of the United Nations spoke, and additionally, the summit hosted public and private entities from many states and countries such as Australia, Belgium, Canada, Denmark, France, Italy, Ireland, Netherlands, and Norway.

Seat at the Table

Over 300 people from NGOs, regulatory bodies, academia, and industry attended the State of the Science Summit.

Key Takeaways

- California will not meet its goal of 40% methane reduction from dairy and livestock by 2030 without developing and implementing a strategy aimed at the reduction of enteric methane emissions.
- Feed additives can be an important part of a strategy to mitigate enteric methane. At least one additive – 3-Nitrooxypropanol (3-NOP) – may be available in the next year, and several other intervention strategies are being explored.
- Critical to implementation of feeding practices to reduce enteric methane emissions is a modernized and efficient pathway for FDA approval of feed additives under the Federal Food, Drug, and Cosmetic Act. While the process needs to be expeditious, it must also be effective in protecting animal and human health.
- There is a significant need for data to improve the understanding of livestock emissions and how they are influenced by key factors such as rumen microbiome, animal health, diet and genetics.
- Animal and human safety are non-negotiable requirements of any and all feed products, including those designed to reduce enteric methane emissions.
- It's necessary to have a standard methodology for conducting feed trials, including measurement techniques and reporting.
- Producer adoption of feed additives is influenced by multiple factors, including cost, availability, productivity and consumer acceptance.

Session 1

Pathways to Meeting 2030 Climate Goals

Frank Mitloehner, Ph.D.
Professor and Air Quality Specialist,
UC Davis Department of Animal Science
Director, CLEAR Center



Dr. Frank Mitloehner is a professor and air quality specialist in cooperative extension in the Department of Animal Science at UC Davis. As such, he shares his knowledge and research, both domestically and abroad, with students, scientists, farmers and ranchers, policy makers, and the public at large. Frank is also director of the CLEAR Center, which has two cores – research and communications. The CLEAR Center brings clarity to the intersection of animal agriculture and the environment, helping our global community understand the environmental and human health impacts of livestock, so we can make informed decisions about the foods we eat and while reducing environmental impacts.

Without the adoption of a feed-additive strategy, it's unlikely the goal of reducing 40% of methane emissions will be met.



California has embarked on an ambitious goal of reducing methane emissions from the dairy and livestock sector as outlined in SB 1383, which mandates a 40% reduction in methane emissions from the dairy sector by 2030. To meet the targets set by this legislation, the dairy industry must decrease methane emissions by 7.2 million metric tons (MMT) of carbon dioxide equivalents (CO₂e) by 2030, while the beef sector is tasked with reducing emissions by nearly 1.8 MMT CO₂e during the same time frame.

The contributing factors to decreasing methane emissions in the state of California are from attrition of dairy herds, alternative manure management practices, dairy digesters and, eventually, methane-reducing feed additives.

Methane reductions from programs in place today, along with new feed-additive strategies, would put California on track to reduce methane emissions above the stated goal of 7.2 MMT CO₂e to between 7.6 to 10.6 MMT CO₂e by 2030 from the dairy sector alone. Without the adoption of a feed-additive strategy, it's unlikely the goal of reducing

40% of methane emissions will be met.

Feed additives offer the greatest potential for methane reductions throughout the sector and could be feasibly implemented at existing operations. The most effective feed additive may not be the most appropriate, as there may be unintended consequences and undesirable side effects, such as palatability issues, toxicological effects, and challenges with efficiency and supply chain availability.

These side effects must all be considered in addition to the effectiveness of the particular feed additive to reduce methane emissions. With a comprehensive review of the effectiveness to reduce methane emissions and analysis of any side effects a feed additive may have, there is an opportunity to select the most feasible and effective feed additive to help achieve goals for methane emissions.

By emphasizing research, innovation and collaboration, California can strive toward a future with significantly reduced methane emissions from the dairy and livestock sectors, making vital progress in combating climate change.



Session 2

U.S. Perspective on Enteric Methane



Robert Bonnie Under Secretary for Farm Production and Conservation USDA

Robert Bonnie is the Under Secretary for Farm Production and Conservation at USDA. Prior to joining USDA, Bonnie was at Duke University first as a Rubenstein Fellow and later as an Executive in Residence at the Nicholas Institute for Environmental Policy Solutions working on conservation and environmental issues in rural America. In 2020, Bonnie also worked with the Bipartisan Policy Center on its Farm and Forest Carbon Solutions Initiative. Bonnie was Under Secretary for Natural Resources and Environment at USDA from 2013 to 2017, and a senior advisor to Secretary Tom Vilsack from 2009 to 2013. Prior to joining USDA, Robert was vice president for land conservation at Environmental Defense Fund where he focused on developing incentives to reward stewardship on private lands. Robert has master's degrees from Duke in forestry and environmental management. He lives with his wife, Julie, and daughter, Lilly, in Loudoun County, Virginia.

The USDA is taking a voluntary, incentive-based approach to implementing enteric methane reducing strategies. The USDA recognizes the importance of maintaining agricultural productivity while simultaneously decreasing greenhouse gas emissions to ensure livestock products are available to provide food and fiber for the approaching 10 billion world population. There is an opportunity for innovation, new technologies and agricultural systems that work for producers and allow them to meet their economic objectives while simultaneously applying climate-smart strategies to decrease greenhouse gas emissions.



In prior years, there was an emphasis on establishing a carbon offset market. Although offsets may play a strong role in widespread adoption of enteric methane reducing products, they are not the only pathway forward. Additional incentivization, such as tax incentives and carving out new market space for climate-smart products, will play a role in ensuring the sustainability of the economic investment of methane-reducing feed additives while tackling the challenges of greenhouse gas emissions from the livestock sector.

Yet, government incentives alone are not enough to make the use of enteric-methane-reducing feed additives a feasible solution for animal agriculture. The USDA has evolved in policy from an emphasis on incentives toward attaining feasible solutions with on the ground partnerships between federal and state government, private entities, industry stakeholders and academic institutions.

The recently established Climate Smart Commodities Program has created 141 agreements, with a federal government investment of \$3.1 billion to provide technical and financial assistance to producers to implement climate-smart production practices on a voluntary basis on working lands; to pilot innovation and cost-effective methods for quantification, monitoring, reporting and verification of greenhouse gas benefits; and to develop markets and promote the resulting climate-smart commodities. It is anticipated that much of the work in the upcoming years will revolve around the implementation of these programs.

The National Institute of Food and Agriculture (NIFA) is investing \$45 million in climate change and agriculture initiatives to support these research efforts. A significant portion of this new funding is derived from the recently passed Inflation Reduction Act, which allocates \$300 million to enhance the measurement, recording and validation (MRV) of enteric methane emissions on a larger scale.

Few technologies and approaches necessary to achieve future goals in reducing enteric methane emissions are currently known or tested. There is a need for collaborative efforts spanning academia, producers and organizations working directly in the field to identify and scale up interventions that can effectively bring about substantial reductions. 🐾

Session 3

Global Perspective on Enteric Methane

Aimable Uwizeye, Ph.D.
Livestock Policy Officer
Food and Agriculture Organization of the United Nations



Dr. Aimable Uwizeye is interested in global change toward a low-emission livestock sector. He is a Livestock Policy Officer at the Food and Agriculture Organization of the United Nations (FAO) in Rome, Italy. He has more than 12 years of experience in livestock development, animal health and environmental assessment of the global livestock sector. At FAO, Aimable leads a program aiming at Policy Analysis to support Nationally Determined Contributions for Climate Action in livestock systems and leads several projects on reducing enteric methane emissions from ruminants and assessing greenhouse gas emissions from livestock systems in different countries. He also supports the Koronivia Joint Work of Agriculture (KJWA) and provides technical expertise to the Livestock Environmental Assessment and Performance (LEAP) Partnership. He also contributes to the Global Agenda for Sustainable Livestock (GASL).

The United Nations has defined three planetary crisis areas: air pollution, biodiversity loss and climate change.

The livestock sector encompasses nearly 1 billion people who keep livestock, often for multiple functionalities. These livestock produce a large portion of the food supply, are responsible for a significant portion of caloric intake and are the largest source of proteins in diets worldwide. The livestock sector continues to grow globally, with new markets emerging due to increased demand for livestock products. Livestock production accounts for approximately 14.5% of anthropogenic greenhouse gas emissions, with enteric fermentation being the primary contributor. Global methane emissions from the livestock sector total around 104 million metric tons, distributed globally.

The Livestock Environmental Assessment and Performance (LEAP) partnership is a multi-stakeholder initiative with professionals who have been working for the past decade to develop internationally agreed upon methodologies, data and metrics to assess the environmental performance of the livestock sector. LEAP has developed several documents to help provide guidance for reduction of methane emissions (environmental performance of feed additives in livestock supply chains); one to assess the possibility of reducing methane emissions when utilizing a feed additive

targeting enteric methane and other gases, such as nitrogen; and a report that explores the quantification, mitigation, and metrics of methane emissions in livestock and rice systems. (FAO report on methane emissions in the livestock and rice systems: sources, quantification, mitigation and metrics to be released in September 2023).

Diet manipulation and maximizing the potential of animals within livestock systems are two methods of decreasing methane emissions.

The importance of financing and capacity-building in methane-reduction strategies was underscored. Dr. Uwizeye emphasized the need for increased climate finance investment in the livestock sector. Currently, only 2-5% of climate finance is allocated to livestock, with a mere 2% dedicated to methane mitigation. To address this imbalance, various financial mechanisms were suggested, including grants, private sector financing and results-based financing.

Finally, Dr. Uwizeye emphasized the need to raise ambition in methane-reduction commitments globally. The potential of methane-reduction strategies to help curb the increasing global average temperature was highlighted, while acknowledging the need for comprehensive actions across sectors.

The presentation concluded with a showcase of recent reports on the contribution of terrestrial animal-sourced food to healthy diets and the carbon sequestration potential of grasslands, urging policymakers and stakeholders to recognize the importance of livestock and to invest in sustainable solutions.



Session 4

Enteric Research Efforts and Opportunities



Juan Tricarico - Dairy Management Inc.

Denise Mullinax - California Dairy Research Foundation

Charles Brooke - California Department of Food and Agriculture (formerly)

Aimable Uwizeye - UN FAO

Moderator: Frank Mitloehner - UC Davis CLEAR Center



Foundational research in the field of methane reduction encompasses various focus areas, including dairy and beef nutrition, rumen microbiology, dairy and beef genetics, sensing and data technology, and socioeconomic analyses of interventions. Additionally, there are ongoing developments in emissions accounting and modeling, with a particular emphasis on verification, baseline modeling, and the development of reporting and evaluation standards.

The Greener Cattle Initiative, initiated by the Foundation for Food and Agriculture Research (FFAR), stands as the pioneering grant mechanism specifically aimed at reducing emissions of enteric methane. Currently, the first round of proposals is being finalized for funding under this initiative. California has developed the California Livestock Methane Measurement, Mitigation, and Thriving Environments Research Program (CLIM3ATE-RP), which is the first state funding mechanisms to include support for research into mitigation of enteric methane. The first set of awards is expected in 2023.

Highlighted during panel discussions was the importance of fostering partnerships between academia, the private sector, the public sector and producers' organizations.

Most research on various feed additives has been sponsored by private companies, and there is a lack of exploration into the effects – pro and con – of combining multiple feed additives. It remains uncertain whether feeding multiple additives simultaneously would yield greater methane reduction than feeding a single additive. Nevertheless, the five principles of feed additives — human/ animal safety, efficacy, tradeoffs and benefits, and adoption — are the focal points for successful implementation.

At present, there is no universally accepted baseline standard utilized by all companies and commodity groups as the benchmark for emissions reductions. Moreover, methane research is costly, requiring significant investments in equipment and research facilities. This financial burden poses challenges to the long-term development of the research sector, as there are limited research funds available to establish the essential infrastructure required to meet baseline measurement standards.

Addressing these gaps in research funding, establishing consistent baseline standards and promoting collaboration across sectors is crucial to advancing methane-reduction efforts and fostering the growth of the research field. 🐄

Session 5

Methods and Protocols for Evaluating Methane Reduction In-vivo

Ermias Kebreab, Ph.D.
Associate Dean for Global Engagement,
UC Davis College of Agricultural and
Environmental Sciences
Director, World Food Center



Ermias Kebreab is associate dean for global engagement in the College of Agricultural and Environmental Sciences, as well as director of the World Food Center. He is a renowned scholar and skilled administrator with extensive experience in sustainable agriculture and animal science. Kebreab oversees the advancement of the college's international goals while working in collaboration with extensive internal and external partnerships to magnify the grand challenges facing our global food systems. Kebreab is the Sesnon Endowed Chair in the Department of Animal Science. He has conducted extensive research in developing strategies for using feed additives to reduce methane emissions from livestock and has authored more than 200 peer-reviewed publications. He is chair of the United Nations FAO Technical Working Group on Feed Additives, a committee member for the National Academy of Sciences (NAS) Panel on Anthropogenic Methane Emissions in the United States and also serves on the NAS Committee for Nutrient Requirements of Dairy Cattle. He is a contributing author to the Intergovernmental Panel on Climate Change (IPCC) 2019 Update on Good Practices Guideline in Chapter 4, "Emissions from Livestock and Manure Management."

The pursuit of standardized evaluation protocols and collaborative research initiatives will contribute to more accurate and reliable assessments of enteric methane reductions.

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Dr. Ermias Kebreab delivered a comprehensive presentation on various methods used to assess enteric methane mitigation in-vivo. Although the methods discussed were not exhaustive, the overview provided valuable insights.

The respiration chamber was identified as the gold standard for precise measurements; however, its implementation on a large scale is impractical due to the need for animal confinement, which does not reflect normal animal activity.

The C-Lock GreenFeed® system is a valuable tool that strikes a balance between precision and scalability. The Green Feed system, which requires some animal training, can accommodate multiple animals in each unit.

Another method examined was the use of sulfur hexafluoride (SF6). The SF6 method can be a sensitive and accurate method, although it is not generally used for larger studies due to the equipment cost and expertise required to implement the method.

Laser-based spot-measurement techniques also were reviewed. Although these devices may be suitable for screening animals based on methane phenotypes (such as low-methane emitters vs. high-methane emitters), they are currently not suitable for evaluating and quantifying enteric methane reductions.

To establish a standardized protocol for evaluating methane reduction claims, ongoing efforts are underway as part of an international collaboration involving UC Davis, Cornell University and the Global Research Alliance of New Zealand. Dr. Kebreab's work in this area is partially funded by the California Department of Food and Agriculture along with the California Air Resources Board.

The pursuit of standardized evaluation protocols and collaborative research initiatives will contribute to more accurate and reliable assessments of enteric methane reductions, furthering the understanding and implementation of effective mitigation strategies in the field.



Session 6

Research Overview of Products and/or Strategies



Matthias Hess - UC Davis

Frank Mitloehner - UC Davis

Joe McFadden - Cornell University

Kim Stackhouse-Lawson - AgNext, Colorado State University

Tim McAllister - Lethbridge Research and Development Centre

Peri Rosenstein - Environmental Defense Fund

Moderator: Charles Brooke - CDFA (formerly)

The next era of deploying feed additives on farms will require a strong foundation of rigorous scientific expertise to thoroughly evaluate the full life cycle of these additives.

It is crucial to understand how compounds are metabolized and excreted, and the subsequent impact they have on animal performance and the local environment before implementing them on farms. While some studies have explored emissions reductions focusing on enteric methane in lactating cows, there has been limited attention given to downstream emissions from manure, nitrogenous emissions and growing heifers. The future of the feed-additive space should prioritize holistic approaches to incorporating these additives.

A significant aspect of understanding enteric methane lies within the rumen microbiome. Exciting projects have been announced, utilizing interventions such as CRISPR technology to produce low-methane microbes or direct-fed microbials. These initiatives have garnered focus from USDA and other government agencies. However, it is important to note that previous research has shown that interventions

aimed at reducing or eliminating undesirable microbes can have short-term effects, with those microbes reappearing in the intermediate term, demonstrating similar responses as before the treatment was implemented.

It is worth mentioning that many of the technologies currently being used to address these questions did not exist five years ago. Furthermore, the field is expected to undergo significant evolution in the next five years, with changes occurring at every academic level. An area that holds immense untapped potential is grazing herds, which have been relatively understudied compared to dairies and feedlot settings.

Each producer and research institution is on its own sustainability journey, and the implementation of these strategies will be specialized for each production site. With new researchers joining the movement and new ideas emerging regularly, there is a remarkable level of academic and human capital supporting the ongoing efforts to find effective solutions for reducing emissions of enteric methane. 🐄



Session 7

Supply Chain Drivers to Adopt Methane-Reduction Strategies



Leah Wilkinson - American Feed Industry Association

Jennifer Bockhahn - Barry Callebaut (formerly)

Vrashabh Kapate - Environmental Defense Fund

Moderator: Michael Boccadoro - Dairy Cares



Most food and consumer product companies recognize the importance of sustainability and have implemented sustainability plans to reduce their emissions, particularly their scope 3 emissions, which encompass all emissions associated with sourcing ingredients. In many cases, beef and dairy products account for a significant portion of their overall emission footprint, sometimes up to 50%.

Therefore, it is clear that these companies cannot achieve their sustainability goals without addressing the emissions present in their livestock supply chains.

However, there are currently limited programs available that can establish verifiable carbon credits. Instead, there has been a shift toward carbon claims, which are not easily verifiable and often rely on various assumptions in their implementation. To truly

reduce the carbon footprint of supply chains, it is necessary to implement supply chain insetting, where emissions reductions are sold exclusively within the supply chain. If feed additives are used to reduce emissions in the beef and dairy industry, but the associated carbon credits are sold outside these industries to offset emissions from the oil-and-gas sector or technology companies, the environmental impact of the supply chains for beef and dairy will not be addressed adequately.

Furthermore, there is potential in the regulatory process for methane-reducing feed additives to be classified as feed ingredients rather than drugs. However, there is a lack of experts in this field who can navigate the regulatory requirements and help achieve this goal.

In the United States, for instance, there are only seven

technical experts approved to work on feed management standards and plans.

To facilitate the smooth transition of products from research settings to practical implementation in the field, it is essential to enhance regulatory capacity among federal and state agencies, ensuring sufficient expertise and support.

Addressing emissions in livestock supply chains is crucial for companies to achieve their sustainability objectives. Verifiable carbon credits and supply chain insetting can play a significant role in reducing carbon footprints, but there is a need for further development in these areas. Additionally, enhancing regulatory capacity and expertise is necessary to effectively navigate the regulatory process and establish feed additives as feed ingredients. 🐄

Session 8

Development and Requirements for Offset Compliance Protocols



Ermias Kebreab - UC Davis

Amy Hughes - Environmental Defense Fund

Jeffery Coronado - California Air Resources Board

Dave Isen - Denali Water Solutions

Moderator: Charles Brooke - CDFA (formerly)



The livestock sector holds great potential for generating highly certain carbon credits due to its capacity to achieve permanent and verifiable emissions reductions. There is currently a strong interest in ensuring that producers receive appropriate credit while maintaining investor trust in the carbon-credit system.

To pursue these emission reductions effectively, accurate measurement, reporting and validation of studies are crucial. It is important to note that the implementation of solutions on farms must be cumulative, meaning that historical practices such as feeding byproducts or utilizing common ionophores like monensin do not count toward emissions goals.

Although the livestock industry aims to double its organic waste diversion to meet California's SB 1383 goals by 2030, there are questions pertaining to the point at which new practices should be accounted for in order to achieve these goals, raising discussions among regulators, industry members and academia.

The emissions reductions achieved through feed additives can be influenced by the diet

used in a study and other environmental factors. Publications on this topic need to adhere to Vera protocols, which require three publishable studies in indexed journals to establish verifiable emissions reductions.

As more studies are conducted, the assumed reduction achieved by feeding these additives can be updated. It is crucial to conduct life-cycle evaluations of feed additives to assess their impact on enteric methane, the emissions associated with their production, the downstream effects on manure chemistry, and potential nitrous-oxide emissions in storage or in the soil. Understanding the true environmental impact of feed additives is essential for effectively reducing the carbon footprint of the beef and dairy system.

Carbon-trading markets present a complex challenge, with a significant strategic risk of over-crediting carbon and potentially undermining investor confidence and trust in the current model-based approach. Nevertheless, the permanent nature of mitigating emissions of enteric methane makes these offsets highly desirable and worth pursuing with a cautious and meticulous approach. 🐾

Session 9

Evaluating Product Safety and Claims. Outlook and Industry Guidance



Holly Pearen - Environmental Defense Fund

Jed Asmus - January Innovation Inc.

Jenna Leal - CDFA, Commercial Feed Regulatory Program

Stephen Beam - CDFA, Milk and Dairy Food Safety Branch

Leah Wilkinson - American Food Industry Association

David Edwards - U.S. Food and Drug Administration,

CVM DAFI

Moderator: Rachelle Kennedy - CDFA



Ensuring food safety, and human and animal health must always remain paramount when considering potential solutions for the livestock sector. It is crucial that no compromises are made in this regard, and all stakeholders, including farmers, consumers and regulators, should prioritize the well-being of humans and animals as well as the consumer acceptance of products that come from animals that eat methane-reducing feed additives.

One significant area of concern in feed-additive studies is the lack of variability and diversity in the populations under investigation, particularly in the context of California production. As a leader in the dairy sector, California has a unique feeding system that incorporates a wide range of environmentally friendly byproducts. However, existing research on feed additives has not fully captured the nuances and complexities of this diverse population.

To ensure the effectiveness and applicability of solutions, future studies should actively involve nutritionists who

possess in-depth knowledge of the California dairy system. By incorporating their insights, research outcomes can better reflect the specific characteristics and requirements of this distinct setting, leading to more relevant and reliable results.

Dairy production and processing are highly regulated at the state and federal level to ensure consumer safety. Use of approved feed additives that have been properly evaluated for safety is critical for the protection of animal and human health, and to keep California's milk and milk products eligible for interstate commerce.

Discussions are centering around the need to address regulatory challenges in the approval process for feed additives. A particular focus has been on potential amendments to the Federal Food, Drug, and Cosmetic Act, specifically to include zootechnical animal-feed substances within the existing pathway for approval of feed additives.

This discussion acknowledges that certain items may not

fit neatly into the traditional definitions of feed or drugs, and instead, belong to a distinct category of zootechnical animal feed.

By proposing a new regulatory pathway applicable to such substances, it will be possible to establish a comprehensive framework that accommodates emerging solutions while maintaining rigorous safety and efficacy standards.

These ongoing discussions underscore the industry's commitment to addressing regulatory complexities and creating an environment that encourages the evaluation and approval of feed additives that are safe and effective. It is crucial to establish clear guidelines and frameworks that promote safety, efficacy and sustainability while allowing for the integration of innovative solutions.

By prioritizing human and animal health and safety throughout the regulatory process, stakeholders can work together to advance the livestock sector and ensure its long-term viability. 🐄

Session 10

Outlook on Adoption of Feed Strategies



Chuck Ahlem - Dairy Producer

Vrashabh Kapate - Environmental Defense Fund

Hannah Stefenoni - Clover-Sonoma

Dan Rice - Western Milling

Moderator: Michael Boccadoro - Dairy Cares

The Environmental Defense Fund (EDF) has conducted extensive research on 400 beef and dairy producers, which reveals an overall reluctance among farmers to incorporate new technologies and additives in their production systems unless the technologies and/or additives are proven to be productive. This highlights the critical importance of identifying feed additives that mitigate methane emissions and provide tangible returns on investment, and/or create additional revenue streams for producers.

To truly drive motivation among farmers, it is imperative to conduct comprehensive studies that span an entire lactation period, focusing on methane abatement and on key metrics related to animal health and productivity.

Building trust and fostering collaboration among all stakeholders are paramount to successfully implementing feasible and sustainable strategies for methane mitigation. This necessitates gathering representatives from various sectors, including industry, academia and regulatory agencies, to engage in open and inclusive dialogues that address the needs and aspirations of each party. This level of engagement and cooperation marks a significant departure from the past, as does the State of the Science Summit. Given the rapid developments and

advancements in the field, it's necessary for dairy producers to have up-to-date and relevant information to make informed decisions about the adoption of methane-reducing feed additives. This calls for equipping nutritionists, veterinarians, representative groups and feed manufacturers with the knowledge they need to effectively disseminate information and support dairy farmers in their sustainability efforts. Peer-to-peer sharing of experiences and observations within dairy networks has proven to be an effective means of inspiration and knowledge exchange.

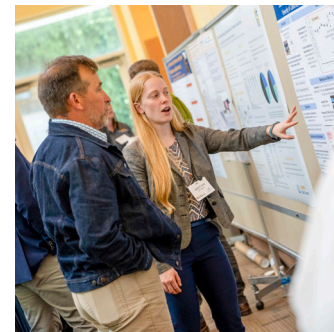
The dairy sector has made notable strides in methane reduction, and it's equally important for the beef industry to do so as well. The beef sector's challenges may stem from the fragmented nature of producers, the lack of well-defined pathways for implementation and the scarcity of comprehensive data on the impacts of incorporating feed additives.

Moreover, the adoption of methane-reducing additives entails upfront costs for producers, and the financial payoffs are often realized over the long term. Finding a way to help ranchers pay for emission-reducing programs – when they're adopted and on an ongoing basis – can break down this barrier and lead to broader acceptance.



By addressing these concerns head on, nurturing collaboration among stakeholders, and offering financial support, the livestock industry can overcome barriers to the adoption of methane-reducing feed additives.

This concerted effort will contribute significantly to the industry's journey toward sustainable and environmentally responsible practices, ensuring a more resilient and prosperous future for farmers, consumers and the planet.



Conclusion

Emissions of enteric methane from livestock are a significant contributor to agricultural greenhouse gas emissions in California, across the United States and globally. Recognizing the urgency to address climate change, consumer product companies are committed to reducing emissions throughout their supply chains. However, achieving their emission-reduction goals will be impossible without effectively tackling emissions from the livestock sector, particularly within the supply chains for dairy and beef.

Numerous studies demonstrate the potential of various feed additives to effectively reduce emissions of enteric methane in research settings, showing medium to strong efficacy. However, the widespread adoption of these additives on farms has been hindered by the current regulatory framework established by the U.S. Food and Drug Administration (FDA). Updating this framework is essential to facilitate expedited and appropriate classifications of feed products designed to reduce emissions of enteric methane, enabling their approval for use on farms.

Once regulatory approval is obtained, the focus must shift to scaling up and implementing these projects in actual production facilities. To encourage independent adoption of feed-additive interventions by farmers, it is crucial to highlight the benefits beyond emissions reduction. Farmers rely on multiple sources of information, including nutritionists, veterinarians and feed mills. Building trust and fostering collaboration among these stakeholders are essential for the successful implementation of these initiatives.

There is a growing interest and commitment among value-chain groups to integrate livestock systems in order to reduce global methane emissions. This reflects a shared vision of making a positive impact on producer livelihoods and the climate. By aligning the interests of various stakeholders, including farmers, industry organizations, researchers and regulatory bodies, it's possible to develop comprehensive strategies that address enteric methane emissions while supporting the sustainability and economic viability of the livestock sector.

Emissions of enteric methane are a global problem. Thus, addressing this issue in the livestock industry is of paramount importance. Feed additives can be effective tools to reduce enteric methane, but more work must be done. For instance, we need further research, regulatory updates, collaboration and cooperation, and finally, sharing of information.

By harnessing the collective power of stakeholders, we can create a more sustainable future for the livestock sector, mitigate climate change, and promote the well-being of animals, producers, consumers and the environment.

Note: The State of the Science Summit was co-hosted by The California Department of Food and Agriculture and the University of California College of Agricultural and Environmental Science. The event was sponsored by the California Grain and Feed Association and the UC Davis CLEAR Center.



**State of the Science Summit
Feed Strategies to Reduce Enteric Emissions
May 2-3, 2023**

Co-Hosted by the California Department of Food and Agriculture and UC Davis College of Agricultural and Environmental Sciences

PURPOSE OF THE SUMMIT

Identify/articulate opportunities for collaboration and research that will help the dairy and beef industries – and all of animal agriculture – meet climate goals.

Day 1 Goal:

Provide an overview of the need and opportunities for enteric methane emissions reduction strategies to achieve, State, National, and Global methane reduction goals. Explore producer and supply chain support for adopting methane reducing feed strategies.

Item	Topic	Speaker(s)	Format	Time
1.	Welcome / Opening	California Department of Food and Agriculture Secretary, Karen Ross	Presentation	9 - 9:15 a.m.
2.	Review of the Summit Agenda and Format	California Department of Food and Agriculture Deputy Secretary for Climate and Working Lands- Virginia Jameson	Presentation	9:15 - 9:25 a.m.
3.	Pathways to Meeting 2030 Climate Goals	Frank Mitloehner - UC Davis CLEAR Center	Presentation	9:25 - 9:45 a.m.
4.	National Perspective on Enteric Methane	United States Department of Food and Agriculture , Under Secretary for Farm Production and Conservation, Robert Bonnie	Presentation	9:45 - 10:15 a.m.
5.	Global Perspective on Enteric Methane	Aimable Uwizye United Nations Food and Agriculture Organization	Presentation	10:15 -10:45 a.m.
Break				10:45 - 11:00 a.m.
6.	Enteric Research Efforts and Opportunities	Juan Tricarico - DMI Denise Mullinax - CDRF Moderator: Frank Mitloehner - UC Davis CLEAR Center Charles Brooke - CDFA Aimable Uwizye UN FAO	Panel Discussion	11:00 – 12 p.m.
LUNCH - Provided				12 - 1:30 p.m.
7.	Methods and Protocols for evaluating methane reduction In-vivo	Ermias Kebreab - UC Davis	Presentation	1:30 - 2 p.m.



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Item	Topic	Speaker(s)	Format	Time
8.	Research Overview of products and/or strategies	Matthias Hess – UC Davis Frank Mitloehner – UC Davis Moderator: Charles Brooke - CDFA Joe McFadden - Cornell Kim Stackhouse-Lawson- Colorado State Tim McAllister - Lethbridge Research and Development Centre Peri Rosenstein – Environmental Defense Fund	Panel Discussion	2 – 3:45 p.m.
Break				3:45-4:00 p.m.
9.	Supply chain drivers to adopt methane reduction strategies	Leah Wilkinson- AFIA Jennifer Bockhahn - Barry Callebaut Moderator: Michael Boccadoro - Dairy Cares Vrashabh Kapate - Environmental Defense Fund TBA - California Cattlemen's Association	Panel Discussion	4 – 5 p.m.
Reception				5:00-6:30 p.m.



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Day 2 Goals:

Agency and producer perspectives on adoption, safety, claims, and emissions accounting for feed strategies.

Item	Topic	Speaker	Format	Time
10.	Welcome and Intro to Day 2	UC Davis, College of Agricultural and Environmental Sciences Dean Helene Dillard	Presentation	9 - 9:15 a.m.
11.	Development and Requirements for Offset Compliance Protocols for Feed strategies. Requirements and current efforts	Ermias Kebreab - UC Davis Amy Hughes - Environmental Defense Fund Jeffery Coronado - CARB Dave Isen- Denali	Panel Discussion	9:15 - 10:30 a.m.
Moderator: Charles Brooke - CDFA				
BREAK				10:30 -10:45 a.m.
12.	Evaluating product safety and claims. Outlook and industry guidance	Holly Pearen- Environmental Defense Fund Jed Asmus - January Innovation Inc. Jenna Leal - Commercial Feed Regulatory Program Stephen Beam - CDFA- Milk and Dairy Food Safety Leah Wilkinson- AFIA	Panel Discussion	10:45 - 12:15 p.m.
Moderator: Rachelle Kennedy - CDFA				
LUNCH - Provided				12:15 - 1:45 p.m.
13.	Overview of the Outlook on Adoption of Feed Strategies	Chuck Ahlem - Dairy Producer Vrashabh Kapate - Environmental Defense Fund TBA- California Cattlemen's Association Hannah Stefenoni- Clover-Sonoma Dan Rice- Western Milling	Panel Discussion	1:45 - 3:15 p.m.
Moderator: Michael Boccadoro - Dairy Cares				
14.	Closing Remarks	California Department of Food and Agriculture Under Secretary Christine Birdsong	Presentation	3:15 - 3:30 p.m.

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