UPDATE

Dairy Feed Additives to Reduce Enteric Methane Emissions

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NEWTRIENT'S MISSION

Helping dairy farmers reduce the environmental footprint of dairy and make it economically viable to do so.

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INTRODUCTION

At just 2% of U.S. greenhouse gas emissions (GHG), U.S. dairy has made significant improvements to produce food more efficiently, conserve resources and reduce waste. Despite this very low contribution, dairy farmers remain committed to continuous improvement. New science discoveries and technology developments will foster dairy's continued improvements, reducing its environmental footprint. Some suggest dairy could go beyond to provide environmental solutions – using technologies and practices to generate clean energy, produce renewable fertilizers, and sequester carbon in soil.

Though the overall dairy contribution to U.S. GHG production is modest, enteric methane emissions (CH4), including gas produced by the cow's digestive system and released by flatulence and burps, account for approximately 1/3 of a dairy farm's GHG footprint (U.S. Dairy LCA, 2013). Consequently, emerging research and a growing number of companies have focused efforts on technologies and practices that reduce enteric methane emissions.

EMERGING SOLUTIONS TO REDUCE DAIRY ENTERIC METHANE EMISSIONS

Some of the most promising solutions to reduce enteric methane emissions are linked to the cow's diet. Improving feed quality, delivering a more balanced diet or introducing new feed additives can significantly improve digestibility and redirect production pathways of enteric methane emissions.

Feed additives including plant extracts, fats/oils and a variety of other by-products are often used to meet nutritional needs and may have secondary benefits of enhancing feed efficiency and/or reducing enteric methane emissions. Though much of the research is in the early phases, feed additives have been found to cut enteric methane emissions anywhere from 10 to 30% or even higher.

Considering the potential to significantly reduce enteric methane emissions, feed additive products are of high interest to the agriculture community. Current barriers, however, are preventing expedited market availability and widespread adoption. Feed additives require approval under the Federal Food, Drug, and Cosmetic Act (FD&C Act) and any manufacture claiming a product reduces enteric emissions must be backed by results obtained from long-term, controlled studies.

The purpose of this update is to provide the latest on emerging solutions for enteric methane emission reduction and the current availability of feed additives for U.S. dairy farms.

FEED ADDITIVES WITH ENTERIC METHANE IMPLICATIONS — AVAILABLE NOW

Yea-Sacc (Alltech, Inc., USA)

Yea-Sacc is a commercially available yeast culture based on Saccharomyces cerevisiae strain 1026 specifically selected for its influence on animal performance. The company claims the product promotes enhanced rumen efficiency through improved ration digestibility and the stabilization of rumen pH, allowing for increased milk production in a more efficient manner without compromising the body condition and fertility of the dairy cow. Yea-Sacc® received certification from the Carbon Trust based on evidence documenting its ability to improve the performance and feed efficiency of both dairy and beef animals and may therefore reduce GHG emissions per unit of product (emissions per gallon of milk produced).

Enogen (Syngenta, Switzerland)

Syngenta developed Enogen corn in the early-2000s with the goal of enhancing the efficiency and sustainability of biofuel production by delivering a key enzyme in the ethanol production process directly to the corn grain. When fed to dairy cows, reported data is encouraging with possible feed efficiency improvements of over 10%; however, more long-term studies are needed to substantiate claims. The implication for increased feed efficiency is a potential reduction in GHG emissions per unit of product (emission per gallon of milk produced). The Enogen corn hybrids are approved for food and feed purposes and are currently available at a cost consistent with conventional seed.

Agolin Ruminant (Agolin SA, Switzerland)

Agolin developed Agolin Ruminant, a blend of essential oil compounds for ruminant animals. The essential oils are highly concentrated extracts from herbs – all with food and feed flavor approval status. Agolin claims that by shifting the rumen microbial population, enteric methane emissions are reduced while improving feed efficiency and milk component yields in dairy cows. Agolin claims to reduce protozoa and to reduce methane forming archea, the net result being less enteric methane and increased total VFA production resulting in improved milk protein and butterfat. A number of animal research trials in Europe and in the U.S. have confirmed reductions in methane at 10% per animal and 15 to 20% reduction per kg of milk production. Agolin

Ruminant is commercially available and is already being fed to about one million dairy cows worldwide.

FEED ADDITIVES WITH ENTERIC METHANE IMPLICATIONS — AVAILABLE IN THE SHORT TERM

3-Nitrooxypropanol (3-NOP), (DSM, Netherlands)

3-nitrooxypropanol (commonly known as 3-NOP; outside the US, the trade name is Bovaer), is a molecule synthesized from two natural compounds. Over 35 trials have been completed globally to date demonstrating 3-NOP is capable of sustained enteric methane reduction of ~30%. 3-NOP appears to have a persistent effect because the compound inhibits an enzyme that is critical to the final step of methanogenesis in all archea.

DSM is seeking registration and approval globally, including in U.S., Canada, the EU, Oceania and Latin America. It's anticipated that first approvals could be granted by late 2020 or early 2021. In the U.S., DSM has commenced work with U.S. FDA-CVM several years ago and anticipates it will still take multiple years to complete, given the long duration of several of the U.S. specific trials.

As a result, U.S. dairy farmers will have access to this technology later than other major export markets yet will gain from some of the insights gained from use of the product in other markets.

FDA and Claims on Enteric Emission Reductions

The use of food products is governed by the provisions of the Federal Food, Drug, and Cosmetic Act (FD&C Act) and expressed or implied claims that establish the intended use is to cure, treat, prevent or mitigate disease (e.g. claim enteric methane reduction), or affect the structure or function of the body in a manner other than food (nutrition, aroma, or taste), can identify an intent to offer the product as a "new animal drug." The FDA Center for Veterinary Medicine (FDA-CVM) approval as a "new animal drug" involves long-term trials as part of the evaluation process before approval may be obtained. Though drugs with an environmental label claim must pass the FDA-CVM approval process, other "natural additives" might simply be declared "Generally Recognized as Safe (GRAS)", which does not require the above process.

Mootral, (Mootral SA, Switzerland)

Mootral SA is a Swiss AgriTech company that has developed a garlic and citric acid-based natural feed supplement for inhibiting enteric CH_4 production. The supplement is a combination of allicin obtained from garlic as well a byproduct of orange processing, referred to as citrus extract. The company claims that the product directly inhibits the activity of the archaea leading to the profound methane reduction. A trial conducted in 2018 at UC Davis showed a reduction in methane yield (per kg of dry matter intake) of about 23% after 12 weeks. Follow up work is planned at UC Davis during winter of 2020 to better understand dosage and timing requirements. Mootral is not yet commercially available.

FEED ADDITIVES WITH ENTERIC METHANE IMPLICATIONS — EARLY STAGE DEVELOPMENT

Fortis, (Bezoar Laboratories, USA)

Inclusion of supplemental nitrate in the diets of ruminants is one strategy for reducing enteric methane generation by diverting energy produced during ruminal fermentation of feed away from the production of methane. The amount of methane mitigated is directly related to the quantity of nitrate supplied and nitrite toxicity (when overfed) is the main negative effect of feeding nitrate to mitigate enteric methane.

Fortis is the tradename for the denitrifying bacterium *Paenibacillus* 79R4, a probiotic that has been shown *in vivo* to prevent against the negative effects of high nitrate feeding including methemoglobin and suggest a potential for increased feed efficiency. Available scientific publications provide proof of concept for Fortis, but additional research with animals is required to demonstrate safe and effective implementation and to illustrate the potential for sustained enteric methane reduction. A dairy trial was recently competed at University of New Hampshire with publication expected spring/summer of 2020.

Red algae Seaweed

Promising data from a preliminary study conducted with several Holstein dairy cows at UC Davis in the spring of 2018 using red algae seaweed (Asparagopsis taxiformis) as a ruminant feed supplement suggested a 50%+ reduction in enteric methane production. Bromoform and halogenated, compounds found in red algae seaweed, are known to provide persistent CH_4 reduction and explain why feeding experiments using small quantities of red algae seaweed have exhibited encouraging results. However, these compounds are associated with animal health and

environmental concerns leading to questions about diet and long-term impact. And, though future studies may show these compounds do not present health concerns in seaweed fed cattle, there may be human perception issues to overcome. A 6-month trial was conducted at UC Davis under the direction of Ermias Kebreab in 2019 with 21 steers.

Preliminary results support a significant CH_4 reduction, consistent with the preliminary dairy trial in 2018. Tests to measure efficiency, product quality, taste as well as impacts on overall health implications are ongoing.

If seaweed proves to be an effective and safe tool for CH_4 reduction, the next question relates to accessibility. Access to red algae seaweed is limited (Asparagopsis for research is currently imported from Australia, Asia and Europe) and is cost prohibitive. In addition, challenges associated with cultivating and growing red algae seaweed must be overcome to offer the potential for meaningful impact. Several other projects are ongoing around the world, and it is anticipated they will add to the body of knowledge relative to efficacy of seaweed for enteric CH_4 reduction. If red algae seaweed can be shown safe and the challenges of wide-scale cultivation and production overcome, gaining approval for use will likely take in excess of four years.

SUMMARY

Several feed additives are currently available in the U.S. that are marketed to provide GHG reduction benefits. The available products include Agolin, Yea-Sacc and Enogen. Agolin SA has been awarded a Certificate of Achievement from The Carbon Trust Assurance Ltd for their dairy and cattle product, Agolin Ruminant, in the reduction of methane emissions and improvement in feed efficiency and is commercially available in the U.S. market. Both Yea-Sac and Enogen are available; however, their claims focus on feed efficiency rather than CH_4 reduction. Several other potential products are in various stages of development and a summary of current and developing products are outlined in Table 1.

Newtrient will continue to work with dairy farmers, innovators, policymakers and academia to identify and address research gaps, technologies and best practices to help dairy farms reduce their environmental footprint.

Table 1. Summary of Feed Additives

Feed Additive or Feed Ingredient	Manufacturer or Developer	Specific Claims	Anticipated Market Entry in the US or Research Status	Strength of Evidence – Provide Quantitative Info Like Count of Studies
CURRENTLY AVAILABLE				
Yea-Sacc	All-Tech, Inc.	Carbon Trust conducted a validation report for Alltech's Yea-Sacc indicating there is evidence supporting increased milk production and composition, ruminal bacteria and pH.	Currently available	Substantial amount of published refereed scientific journal articles supporting the claims on ruminal bacterial growth, ruminal pH, feed digestibility, and milk production. No direct measurements on enteric methane emissions available.
Enogen	Syngenta	Improved starch and organic matter digestibility, milk production improved 3-4 lbs/head/day with no loss in body condition or milk components	Currently available	A few recent refereed scientific journal articles and conference proceedings support increased starch and organic matter digestibility, and feed efficiency claims. No direct measurements on enteric methane emissions currently available.
Agolin Ruminant	Agolin SA	10% enteric CH_4 reduction	Currently available	Trials have been conducted at UC Davis and results are now available but have not yet been published. Three in vivo and one in vitro published refereed scientific journal articles.
AVAILABLE IN THE SHORT TERM				
3-NOP	DSM	30% enteric CH_4 reduction	Available in the short term In the US, 3-NOP will be regulated as a veterinary drug and is going through the FDA-CVM regulatory pathway. Approval is anticipated sometime in 2024	Invented ten years ago and there are 28 published refereed scientific journal articles on mode of action and efficacy with both in vitro and in vivo studies and 35 trials conducted to date.
Mootral	Mootral, SA	23% enteric CH_4 reduction	Available in the short term Marketing data states Fall 2019; however, as of this writing, it was not commercially available	Two in vivo published refereed scientific journal articles and numerous in vitro studies. Most recent publication from UC Davis indicates a need for further investigation under various dietary regimen.
EARLY STAGE DEVELOPMENT				
Fortis	Bezoar Laboratories	50% enteric CH_4 reduction	Early Stage Development	One in vivo published refereed scientific journal article. A dairy trial is underway with results anticipated spring/summer 2020.
Red Algae Seaweed	None Identified	50% enteric CH4 reduction	Early Stage Development	Trials are being conducted at UC Davis but results are not expected until at least January 2020.