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Preliminary findings of northeast organic and conventional dairy farmers' perception of benefits and challenges in feeding algae

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Abstract

Enteric fermentation from livestock accounts for over a quarter of the United States' methane emissions. A potent greenhouse gas, methane has 80 times the global warming potential of carbon dioxide over a 20-year period. An emerging focus of research is the incorporation of algae (e.g., kelp, seaweed or microalgae) into livestock feed, with several studies documenting dramatic suppression of enteric methane emissions in cattle. As part of a nationwide multidisciplinary study of using algae feed supplements to reduce methane emissions and improve dairy productivity, we used focus groups and individual interviews to measure organic and conventional dairy farmer's knowledge and opinions of algae-based feed supplements. Our goals were to learn what both organic and conventional dairy farmers know about algae-based feed supplements, why they do or do not feed them to their cows and if they were interested in the methane-reducing potential of these algal-based feeds. We also sought to understand where they get valued information about animal nutrition. We found most farmers were aware of algae-based feed supplements on the market, but organic farmers were more familiar with marketing claims. Farmers reported feeding algae-based feed supplements to address herd health concerns, especially reproductive issues and pink eye, but expressed rising costs of the supplements as an obstacle. Both organic and conventional farmers expressed interest in suppressing methane emissions, but only if incentives are provided. Lastly, participants receive trusted information about feed supplements from their dairy nutritionists, who help them make decisions around feed purchasing and rations.

Introduction

As climate change increasingly threatens ecological sustainability, more attention is directed to finding innovative mitigation strategies. While carbon dioxide emissions are the primary focus of carbon reduction targets, methane emissions deserve more scrutiny. Methane has 80 times the global warming potential of carbon dioxide over a 20-year period (Black *et al.*, 2021) and accounts for about 11% of greenhouse gas emissions in the United States alone (Myhre *et al.*, 2013). The leading anthropogenic source of global methane is from cattle (Chang *et al.*, 2019), specifically from enteric fermentation, or cow burps. These burps are responsible for 28% of the United States' total methane emissions (Carrazco *et al.*, 2020). Any effort to seriously curb methane emissions necessitates changes be made to livestock production.

Efforts to tackle livestock methane reduction include improving the quality or type of feed, carefully breeding for improved genetics, and manipulating the microbes of rumens (Pickering *et al.*, 2015; Haque, 2018; Matthews *et al.*, 2018). One emerging area of study is incorporating algae (e.g., macroalgae like kelp and seaweed or microalgae like phytoplankton) into livestock feed, with studies documenting dramatic suppression of enteric methane emissions in cattle (Roque *et al.*, 2019). For instance, the red seaweed *Asparagopsis taxiformis* has been shown to reduce cattle's enteric methane emissions by up to 98% *in vitro* (Machado *et al.*, 2014; Kinley *et al.*, 2020) and 80% *in vivo* (Roque *et al.*, 2021; Stefenoni *et al.*, 2021).

While studies of the anti-methanogenic properties of algae are relatively new, seaweeds have been used as livestock feed since antiquity (Allen *et al.*, 2001; Vijn *et al.*, 2020). Algal-based feed supplements have been included in livestock feed for decades and are widely available (Antaya *et al.*, 2019). Currently, there are numerous products on the market in North America identified as dried kelp meal which are made from a seaweed species called *Ascophyllum nodosum*, commonly known as rockweed. Much of this *A. nodosum* is harvested in Coastal Maine and Canada. Some companies have even achieved organic certification of algae feed supplements. These feed companies market their dried seaweed meal as a preventative health care input, touting the benefits of the many vitamins and micronutrients the seaweed provides, but are not yet making methane reduction claims. While *A. nodosum* is

perhaps the most studied seaweed for agricultural purposes (Allen *et al.*, 2001), researchers are only recently evaluating its anti-methanogenic potential (Antaya *et al.*, 2019). Additional research is underway on the methane reduction potential of other macro-algae species that can be cultivated in North American waters (Molina-Alcaide *et al.*, 2017; Vijn *et al.*, 2020; Min *et al.*, 2021).

As part of a nationwide multidisciplinary study of using algae feed supplements to reduce methane emissions and improve dairy productivity, we measured dairy farmer's knowledge and opinions of algae feed supplements. Our goals were to learn what both organic and conventional dairy farmers know about algae feed supplements, why they do or do not feed algae supplements to their cows, and if they were interested in the enteric methane-reducing potential of algae. We also sought to understand where they receive valued information about animal nutrition.

Methods

Personnel from [Maine and New York Cooperative Extension Services] and [University of Vermont College of Agriculture] identified conventional and organic dairy farmers in the Northeast United States to be interviewed, as this is the locus of the research project currently with a plan to expand nationwide as research progresses. An incentive of $100 was paid to all interviewees and interviews lasted approximately one hour. All interviews took place in-person, and were voice recorded with participant permission. Participant names were removed from collected data for anonymity. IRB approval for this study was granted by [Syracuse University].

Focus group interviews were preferred as they can make respondents more comfortable speaking and remind individuals of details they might not otherwise recall (Adler and Clark, 2015). Interviews employed a structured interview guide (see Appendix for interview questions) leaving room for discussion amongst participants.

When focus group participation was not possible due to the farmer's schedule, individual interviews were conducted. In total, 27 farmers were interviewed through four focus group interviews and three individual interviews. One conventional and one organic focus group interview each occurred in Maine and New York. Additionally, one organic farmer in New York and two organic farmers in Vermont were interviewed individually. Table 1 summarizes the number of milk cows on participating farms using the lowest and highest number reported per group while Table 2 displays the total number of participants in each focus group and their gender. Women were underrepresented in our study, as the USDA's 2019 Agricultural Resource Management Survey (ARMS) reports that 54% of dairy farms have at least one operator that is a woman (USDA ERS, 2020). Future studies should prioritize interviewing a more representative number of women.

Interviews were recorded and later transcribed. Following research protocols (Adler and Clark, 2015), we analyzed transcriptions using standard qualitative analysis methods of data reduction, data display and conclusions drawing. We reduced data by reviewing responses to interview questions and searching for patterns. Once categories emerged from the transcript data, we displayed the data through the process of cutting and pasting quotations from the subjects for each question asked. This display enabled us to efficiently perceive, understand and summarize the observations, experiences and attitudes of the interviewed subject regarding the research topic, and thereby draw our conclusions.

Findings

While almost every farmer we interviewed was aware of algae-based feed supplements on the market, organic farmers were more familiar with health claims made by feed supplement companies. Only two conventional farmers noted feeding 'kelp' in the past, but explained they stopped once it became too expensive. Organic farmers reported feeding algae-based feed supplements to address herd health concerns, especially reproductive issues and pink eye, but also cited rising costs of the supplements as an obstacle. Both organic and conventional farmers voiced interest in suppressing methane emissions, but only if incentives are provided. Lastly, participants said they get trusted information about feed supplements from their dairy nutritionists who assist with decisions around feed purchasing and rations.

Farmer awareness of algae supplements and their marketing claims

To understand what farmers know about algae feed supplements, we asked both open-ended questions and a series of questions about common marketing claims—to which farmers indicated if they were aware, not aware or unsure of the claim. Marketing claims may inform farmer's decision-making for incorporating them into their existing feeding regimens. Our findings of claim-awareness are reflected below:

Participants from the organic dairy farms were more aware of attribute claims of algal feed supplements than participants from the conventional dairy farms (see Table 3). Conventional farmers were more likely to say they were not aware of a given attribute claim, and organic farmers were more likely to admit they were unsure of a claim than conventional farmers. Organic farmers were most familiar with the claims that algae feeds were a source of calcium and could enhance immune function. Both conventional and organic farmers were mostly unaware of claims that algae supplements increase weight, reduce weaning stress, improve fatty acid profile of milk, increase milk fat content and reduce somatic cell counts in milk.

As for the use of algae as a feed supplement in general, every organic farmer was aware of the use of algae in cattle feed and most of them had fed algae before. Most of the conventional farmers interviewed were also aware of the existence of algae-based feed supplements, but a few were not aware of their use

Table 1. Number of milk cows on participant's dairy farms

	Organic farms in NY	Organic farms in ME	Organic farms in VT	Conventional farms in NY	Conventional farms in ME
Range in milk cow herd size	50–60	12–60	50–200	800–3800	120–1100

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Table 2. Number of participants by focus group and gender

	NY organic focus group	ME organic focus group	NY conv. focus group	ME conv. focus group	NY and VT individual interviews	Total
Male	4	7	3	5	2	22
Female	1	2	1	1	1	5
Total	5	9	4	6	3	27

Table 3. Claim awareness tally results

	Aware		Not aware		Unsure	
Attribute	*Organic*	*Conv.*	*Organic*	*Conv.*	*Organic*	*Conv.*
Increase milk yield	3		9	10	5	
Source of vitamin C	3	4	11	6	3	
Source of magnesium	6	2	5	8	6	
Source of calcium	12	4	3	6	2	
Source of zinc	6	1	8	9	3	
Enhance immune function	14	5	3	4		1
Increase weight gain	2		10	10	5	
Reduce weaning stress	2		15	10		
Improve fatty acid profile of milk	1	1	15	9	1	
Increase milk fat content		1	12	9	5	
Reduce somatic cell counts in milk	6		10	10	1	
Totals[a]	55 (29%)	18 (16%)	101 (54%)	91 (83%)	31 (17%)	1 (1%)

[a]Reflects percent of total number of org. or conv. farmers times number of claims.

at all. In the focus group of conventional farmers in New York, a farmer noted, '*I don't even know if it's available. It's never been presented to me by a nutritionist saying we should feed this because of X or Y. Never discussed in that frame.*' Very few conventional farmers we spoke to had reported feeding algae, and those that did had ceased feeding it due to cost.

Why farmers feed or do not feed algal feed supplements

Farmer's decisions about whether to feed algal-based feed supplements came down to perceived benefits to herd health, cow behavior and lack of alternatives in organic farming, while the main barrier cited was cost. When asked why they choose to feed algae-based feed supplements, organic dairy farmers cited alleged health benefits and described anecdotal evidence to support these claims which included treating pink eye, improving fertility, reducing placenta retention, lowering somatic cell counts and ameliorating calf health. Several farmers in the organic Maine focus group attributed these improvements to the mineral composition of algae, one stating, '*It made perfect sense to me. Look at the label, there's 60 different elements on it. It's hard to go wrong with that*,' while another echoed, '*We've been feeding kelp for ages…We've always found we just liked the benefit of all the extra minerals it provides. I really think it's helping with a lot of things like pink eye.*'

Organic farmers in both focus groups and in individual interviews stated they often fed algae products to their milk cows for reproductive health reasons. A third farmer in the organic Maine focus group explained, '[*It*] *has a little extra iodine, it is supposed to help with cycling as far as getting cows bred. Yes, that's the biggest thing*,' while a fourth farmer in the group elaborated, '*I mean, fertility is a big issue. We had retained placenta issues. And so, we would feed that in lieu of like, selenium shots or something. Feeding that on a consistent basis seemed to reduce the amount of retained placentas that we had.*'

The cow's own behavior was also cited as reason to feed algae. An organic farmer in Vermont explained in an individual interview that, '*Sometimes they lick salt blocks all day long and sometimes they ignore them. I think that the cows have some ability, maybe more than humans do, to selectively pick what they need to balance their diet… And clearly the cows, we have learned over the years, they tend to eat those kind of things because there's something in there they need, right?*' In New York, an organic farmer in an individual interview similarly observed, '*If they crave that kelp, they'll eat a whole bag of it. If they don't want it, you couldn't force it down. I'm assuming that their system is getting balanced inside and they no longer crave it. If there's a deficiency, they would go for it.*'

A reason unique to organic farmers for selecting algae-based feedstocks is navigating the constraints of organic certification's rules and regulations. Firstly, the algae must be certified organic to be fed to organic livestock, according to the National Organic Program's livestock feed rule (7 CFR Part, 205.237) (2023). An organic farmer in New York explained, '*Before we can feed this, we have to have it approved by our certifier.*' Secondly, organic dairy farmers have fewer herd health options

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than conventional farmers. As many synthetic medications are not allowed in organic production, they tend to focus on preventative health measures—ensuring a balanced diet for their cows and providing enough micronutrients. Another organic farmer from New York stated plainly, '*We're looking for alternative methods to prevent or fix problems…we're restricted on some of the products that we can feed.*'

While conventional farmers do not have the same limitations for feed and health care inputs as organic farmers, some conventional farmers do occasionally choose to feed algae supplements. Three conventional farmers reported feeding algae historically but stopped when it became prohibitively expensive. One from the conventional Maine focus group explained, '*We thought it was a natural source of bioavailable things like selenium and things like that. You know, I can't say it didn't work, but you know when the price went up, we kind of weened them off of it.*' Another farmer in the same group agreed saying, '*We have* [*fed it*], *yeah. But when they doubled the price in one year, we didn't think it was really worth it.*' This finding indicates openness to incorporating algae into rations if algae was more affordable.

Awareness and perception of methane emissions reduction

We asked farmers, 'Have you heard that feeding algae feed supplements reduces methane emissions, and is this of interest to you?' Many were aware of recent studies that show feeding algae can reduce enteric methane emissions, although the conventional farmers expressed more skepticism than the organic farmers. Both conventional and organic farmers voiced interest in reducing methane emissions but clarified they would need to be compensated to make up for the increased cost of feeding algae supplements.

One form of compensation would be charging more for milk from algae-fed cows, employing a marketing strategy. Conventional and organic farmers mentioned increased marketing opportunities as a reason they would feed algae for methane reduction. A conventional farmer in the Maine focus group explained, '*For me, this angle, especially just for like the direct marketing, being able to say you're doing something, like obviously doing something about it* [*methane emissions*], *but also being able to…put it on the label*,' while a conventional farmer from New York noted, '*Everyone's trying to use this as like, 'oh, well maybe Walmart will buy our cheese and we can say we are good economic stewards'. I think it's all just marketing.*' An organic farmer from Maine justified marketing ecosystem services:

> 'That marketing and labeling becomes really important. How you differentiate your product from other milks on the marketplace that are being marketed as being healthier for the environment and your body and your children and all this…when you know almond milk is the most destructive thing they make. That marketing part has to be there too.'

Alternatively, compensation could come from subsidizing the cost of algae supplements or paying farmers for feeding it. Conventional farmers agreed in focus groups that algal feed supplements would either need to be cheaper before they would be willing to feed them, or they would need to be incentivized. However, there was hesitation among farmers about incentive programs. A few elucidated that previous attempts to incentivize environmentally friendly management practices failed because the programs that paid farmers to do so ended. One farmer in Maine explained, '*It was like cover crops. You know, everybody was doing it when we were getting paid 20 bucks an acre and then when that program went away, people didn't really focus on getting it done. Even though there's a benefit, it just…there's an expense.*'

When asked about models like carbon offset programs, farmers expressed concern about bureaucracy and not being reimbursed quickly enough. A conventional farmer in New York told us, '*There's multiple different ones and they're somewhat complex and kinda hard to navigate…it's gotta be faster and simpler. So, the one that we're involved with now, we get an annual review…which was in June, and I just got it* [*the reimbursement*] *in March. So, the offset that was produced from June of 2020 to June of 2021 was approved in June 2021 for March of 2022. So that's too slow.*'

Farmers also expressed concern that incentivizing feeding algae would ignore other climate-friendly practices they already employ. While both conventional and organic farmers voiced frustration with pointing the finger at dairy farms for greenhouse gas emissions, many organic farmers felt that their pasture-based systems are not to blame. Organic regulations require ruminant livestock obtain a minimum of 30% of their dry matter intake from pasture during the grazing season which must be at least 120 days long (7 CFR 205.237). Additionally, some organic farmers add a separate grass-fed certification, which specifies more stringent pasture standards and prohibits grain from rations. Three of the farmers in the organic New York focus group reported obtaining this extra certification. Organic and grass-fed certified farms report feeding algae-based feed supplements in addition to grazing, so the two practices are not exclusive. In fact, the Certified Grass-Fed standards list 'kelp' as one of only seven supplements approved for use without restrictions, and note it serves a rumen health function (Organic Plus Trust, Inc, 2023).

An organic and grass-fed certified dairy farmer in New York expressed frustration regarding carbon offset programs targeted to dairy farms, stating '*we're obviously not perfect farmers but we don't really create some of the problems that you see somebody with a different operation creating. We're talking about carbon credits…well, how about us? We're all grass, sequestering carbon.*' A farmer in the Maine organic focus group similarly observed:

> 'I feel like there's more effective ways that we can reduce methane than going after cows and trying to make them the most efficient machines. Especially when most of us are grazing our cows anyway, we're not in a feed lot. You know, we have those carbons sinks, we're collecting our manure. We're highly regulated and managed both by the state as well as our certifiers. So, it's like, we do more than our part already.'

Conventional farmers stated they would need financial assistance to start feeding algae supplements and the organic farmers stated that such incentive programs should account for climate-friendly practices the farmer already employs. Our findings are consistent with previous research showing most farmers require incentives for providing additional ecosystem services (Ma *et al.*, 2012; Smith and Sullivan, 2014). It's critical that future research on feeding algae to reduce methane emissions include the decision-making processes and needs of the farmers who will implement that technology.

Farmer's preferred and trusted source of feed supplement advice

Lastly, a crucial finding in our focus group and individual interviews is that both conventional and organic farmers trust and

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rely on their dairy nutritionists to source appropriate feeds and provide information about new or alternate feed sources. While a few organic farmers we spoke with use their nutritionists as a resource for accessing information about new feeds, some conventional farmers stated they trust their nutritionists to such an extent that the farmer may not know every sub-ingredient in their total mixed rations, which are formulated by the nutritionists. One conventional farmer in Maine acknowledged dried algae may have once been included in their cow's rations, but that they would not have been aware of it. Farmers in all focus groups and interviews indicated they trust their nutritionists first and foremost, and then will turn to extension specialists, veterinarians and other farmers for information about feed supplements.

The relationship between farmers and nutritionists merits further study, as the decision behind feeding algae on a given dairy farm may be more collaborative than individual. Future research on algae feeds will include surveys and interviews of dairy nutritionists and dairy professionals.

Conclusion

To date, there has been a limited amount of research examining dairy farmer's perceptions of algae-based feed supplements, and their motivations for using or not using them—especially in emerging conversations about incorporating algae into dairy feed to suppress enteric methane emissions. In this paper, we address this gap by analyzing focus group and individual interview data. Results from our interviews indicate farmers are aware of the existence of algae-based feed supplements, but organic farmers are more likely than conventional farmers to purchase and feed them. Their motivations are primarily driven by balancing herd health with supplement costs, and efforts to feed algae to reduce methane emissions would necessitate incentive programs to make it worth the high input cost. Some pasture-based organic farmers worried incentives would ignore their existing contributions to carbon sequestration.

We view the results from these interviews as preliminary findings that present ideas for continued study. Future research on feeding algae feed supplements to livestock for enteric methane emission reduction ought to include the perspectives of farmers, not only to incorporate their questions and concerns into the research design, but to ensure there is openness to adopting new feeding technologies. Additionally, attention should be paid to the relationship between livestock farmers and their animal nutritionists, who help them make feed ration decisions and recommend products. Forthcoming research examines dairy nutritionist's perceptions of algae feed supplements using survey data and individual interviews.

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Conflict of interest. None.

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Appendix:

Questions as basis for interview guide for organic and conventional dairy farmers

1. Describe, briefly, how you came to farm in this region and how your farm has changed over time, regarding farm size, milking system, and cattle feeding regimes.
2. Have you used algae-based feed supplements in your operation? If you haven't used algae-based feed supplements, have you heard of dairy farmers using them?
3. For what reasons do you use algae-based feed supplements or believe others use them?
4. If you do not use algae-feed supplements, why not?
5. I have compiled a list of potential benefits of algae-feed supplements. I will read the potential benefit and please indicate if you are aware of it, not aware, or unsure.

Attribute	Aware	Not aware	Unsure
Increase milk yield			
Source of vitamin C			
Source of magnesium			
Source of calcium			
Source of zinc			
Enhance immune function			
Increase weight gain			
Reduce weaning stress			
Improve fatty acid profile of milk			
Increase milk fat content			
Reduce somatic cell counts in milk			

6. Do you believe it's difficult to access algae-based feed supplements? Why?
7. It's often said that organic dairy farmers use algae-based feed supplements more than conventional dairy farmers- do you agree and if so, why do you think that is?
8. Do you believe algae-based feed supplements have potential negative effects? What are the negative effects (on dairy production or cow health, others)?
9. Have you heard that feeding algae supplements can reduce methane emissions from cattle? Is this something in which you are interested?
10. Have you heard of C offset (OR INSET) programs or other types of programs to incentivize farmers to reduce GHG emissions? Is this something in which you are interested?
11. Does your milk buyer have sustainability goals? What are they and how are they implemented?
12. Has your milk buyer-imposed caps on production? Has this changed your feeding regimes or the type of cow you milk? More emphasis on component pricing? Please explain.
13. Have you heard of on-farm micro-algae production? Would you consider installing a micro-alga growing system on your farm?
14. Do you have an anaerobic digester on your farm? Would you consider linking it with a micro-algae system (using effluent from the AD as growth medium for the algae? (Closed system with effluent to grow algae to feed to cows and cow waste fed into AD).
15. Who or what are your most trusted/valued info sources for cow nutrition?
16. Are there other people to whom we should speak about this topic? OV nutritionist Dr. Silvia Abel-Caines.
17. Is there any other information you wish to provide, or questions you need answering before adopting algae-based feed supplements?

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