Market Potential for the Use of High-Oleic Soybeans in the Michigan Dairy Industry

Analysis of Interviews with Dairy Soybean Producers and Dairy Nutritionists

Sam Rickman, Shirel Ponnudurai, Jiayu Sun, Vincenzina Caputo, Adam Lock

FOOD CHOICE RESEARCH LAB

FEBRUARY 2025

Executive Summary

High-oleic soybeans (HOS) are an innovation in crop genetics which may have a considerable effect on the dairy industry in Michigan. Modern research finds that feeding roasted HOS to dairy cattle can lead to a positive milk production response and positive impacts on animal welfare post-calving. Our objective was to engage stakeholders on the market potential for more widespread utilization of this technology as a fatty acid option for dairy cows. We engaged stakeholders by conducting individual interviews with dairy nutritionists and dairy producers to identify the main obstacles, opportunities, and narratives around individual and industry-wide adoption of this technology. We found that nutritionists believe that feeding HOS is a way to improve feed efficiency in dairy herds, potentially leading to feed savings for farms. The extent of potential feed savings from HOS varies from farm to farm, depending on several factors including price of inputs, production response, and price of alternatives. For dairy producers interested in adopting HOS for their herds, they must decide whether it is more feasible to grow and produce it themselves or purchase it from the market. Our sample of producers and nutritionists agree that smaller dairies are more likely to be able to grow enough HOS for their own needs, while larger dairies are more likely to need to supplement what they can grow with market transactions. We find that infrastructure requirements to process HOS for feed (roasting, grinding, and storing) present additional costs and can be a considerable obstacle for dairy producer adoption. Producers can either set up their own processing facilities or utilize third party firms. The profit implications of each decision depend on various individual farm characteristics.

Table of Contents

Meet the Team

Samuel Rickman

Shirel Ponnudurai

Jiayu Sun

Vincenzina Caputo

Adam Lock

The Food Choice Research Lab at Michigan State University, led by Dr. Vincenzina Caputo, focuses on the economic and behavioral dynamics of food choices. Using a cutting-edge, multidisciplinary approach that integrates economics, marketing, behavioral economics, and sensory science, the lab aims to understand both producer and consumer decision-making. The goal is to improve models that predict decision-making processes and behavioral responses to environmental changes.

The lab's research spans several areas: trends in consumption, the impact food environments on health and sustainability choices, consumer acceptance of new food technologies, the adoption of sustainable practices by producers, and policy evaluation. The team combines qualitative methods—such as focus groups and interviews—with quantitative approaches, leveraging diverse data sources, including economic experiments, scanner data, and big data. Using advanced tools like econometrics and machine learning, the lab generates actionable insights for a broad set of stakeholders, including food producers, consumers, retailers, food companies, and policymakers.

Through its work, the lab generates science-based, data-driven evidence that directly informs decision-making across the agrifood industry and public policy. Key collaborators include the Food Industry Association (FMI), commodity groups, and government agencies, ensuring that the research is grounded in real-world challenges and addresses the evolving needs of both industry and policy.

Background and Dairy Supply Chain

Topics:

- Dairy Supply Chain
- Economic Impacts of the Dairy Industry
- Dairy Nutrition

The Dairy Sector and Supply Chain

This section provides an overview of the U.S. and Michigan dairy industry's economic impact and supply chain. The dairy supply chain alone is relatively simple, but its individual components can be quite involved. We specifically emphasise the nutrition input node of the chain due to the nature and purpose of this report.

Figure 1 shows that the United States is second behind India in global milk production. The U.S. dairy industry supports over 3.2 million jobs, which generate $49 billion in direct wages and over $794 billion in total economic impact. That is over 3% of the United States' total GDP (IDFA, 2024). The U.S. saw $6 billion in dairy exports in 2023, the highest percentage of which went to Mexico. California is the top dairy-producing state in the U.S. As the fourth largest farm commodity in terms of cash receipts, the dairy industry is an important part of the United States' overall agricultural production.

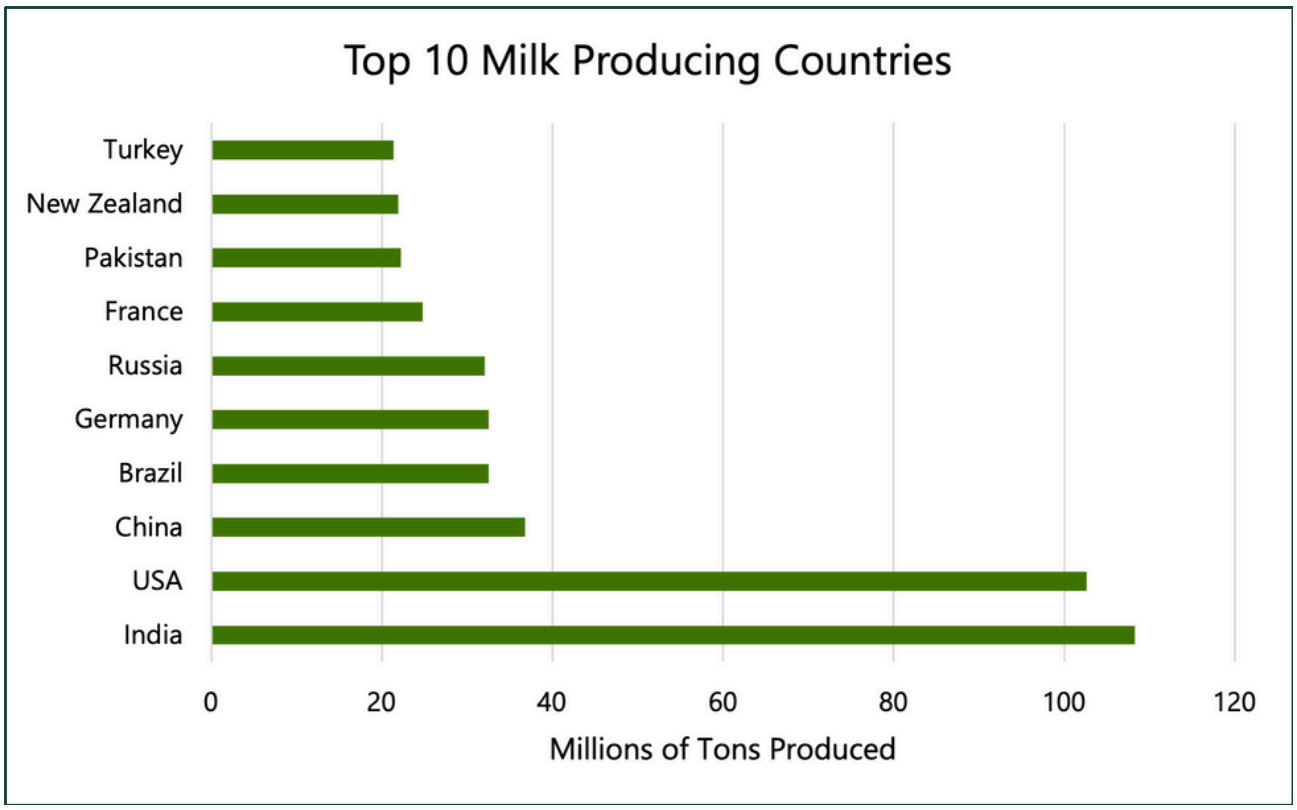


Figure 1: Milk production by country; Source: Dias Sousa, A, 2023

As shown in Figure 2, numbers of U.S. licensed dairy operations have been steadily declining since 2003; there are less than 30,000 dairy farms remaining. However, farms have been increasing in average size, and milk production is rising steadily. Milk production in the United States is primarily managed by individual families operating dairy farms, with a significant number of these farmers being affiliated with producer-owned cooperatives (USDA ERS, 2024).

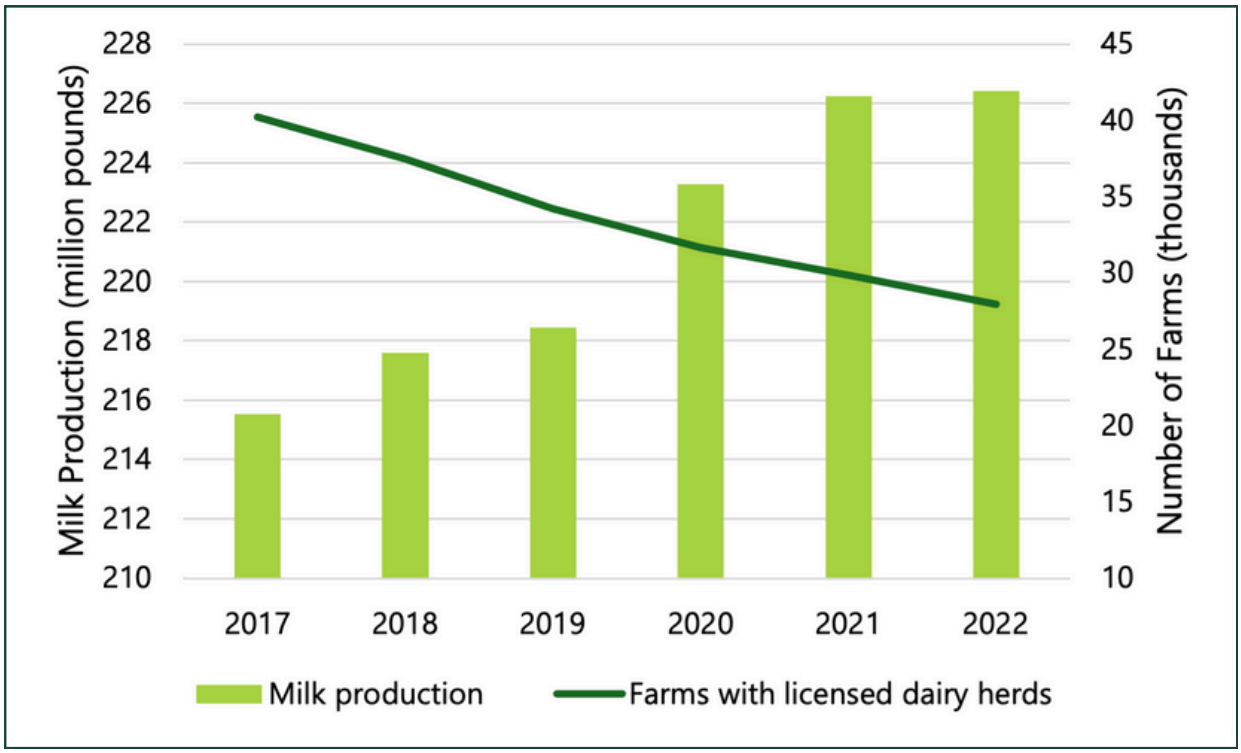


Figure 2: 2017-2022 US milk production and number of dairy farms; Source: USDA ERS, 2024

Michigan Dairy Industry

The Michigan dairy industry is a large part of the local economy, contributing over $15B to the state's GDP. Michigan is the sixth highest producing dairy state, producing over 11 billion pounds of milk annually. There are approximately 2,800 dairy farmers in Michigan, but the industry directly and indirectly provides almost 40,000 jobs for Michiganders (United Dairy Industry of Michigan, 2024). Michigan is the highest producer of milk per cow in the United States, with the average Michigan dairy cow producing 27,564 pounds of milk per year compared to a national average of 24,117 pounds of milk per cow in 2023 (USDA ERS, 2024b).

Michigan has been the leader in terms of milk production per cow for a few reasons. Climate, water availability and optimal soil nutrients for forage crops play a large role. These natural factors allow for higher quality locally grown forage, which is healthier and more digestible for the rumen in the cows' stomachs, leading to more efficient milk production (Lester, 2023). Another contributing factor is that Michigan is a leader in research around dairy nutrition and dedicates finances specified for this area. Dairy nutrition is complex, and there needs to be enough information locally to allow farmers to make informed economic decisions.

According to recent data from the USDA ERS, Michigan has had higher than average feed costs per hundredweight sold for the past three years (see Figure 3). Michigan is slightly less profitable than the average US dairy farm, partly due to their smaller-than-average herd size. The state does have an advantage in that local farms produce a higher percentage of their own feed than the national average, leading to pre-established on-farm infrastructure for handling and storing feed products, including soybeans, corn, and forage.

	U.S. total			Michigan		
	2021	2022	2023	2021	2022	2023
Gross value of production						
Milk sold	18.44	25.18	20.39	17.24	24.15	19.65
Cattle	1.06	1.26	1.54	1.35	1.61	1.96
Other income	0.55	0.90	0.77	0.54	0.88	0.75
Total, gross value of production	20.05	27.34	22.70	19.13	26.64	22.36
Operating costs						
Purchased feed	7.99	9.92	8.79	5.77	7.16	6.34
Homegrown harvested feed	3.91	4.82	4.69	8.36	10.30	10.02
Grazed feed	0.03	0.03	0.03	0.02	0.02	0.02
Total, feed costs	11.93	14.77	13.51	14.15	17.48	16.38
Supporting information						
Milk cows (head per farm)	283	283	283	211	211	211

Figure 3: Dairy Production and Feed Costs; Source: USDA ERS, 2023

Dairy Supply Chain

The dairy supply chain is unique in that there is a quick turnaround time between harvest and arrival on grocery shelves. Dairy products typically arrive at supermarkets and grocery stores within two days of leaving the farm, though products requiring more processing, such as cheese, take longer. An overview of the U.S. dairy supply chain is presented in Figure 4.

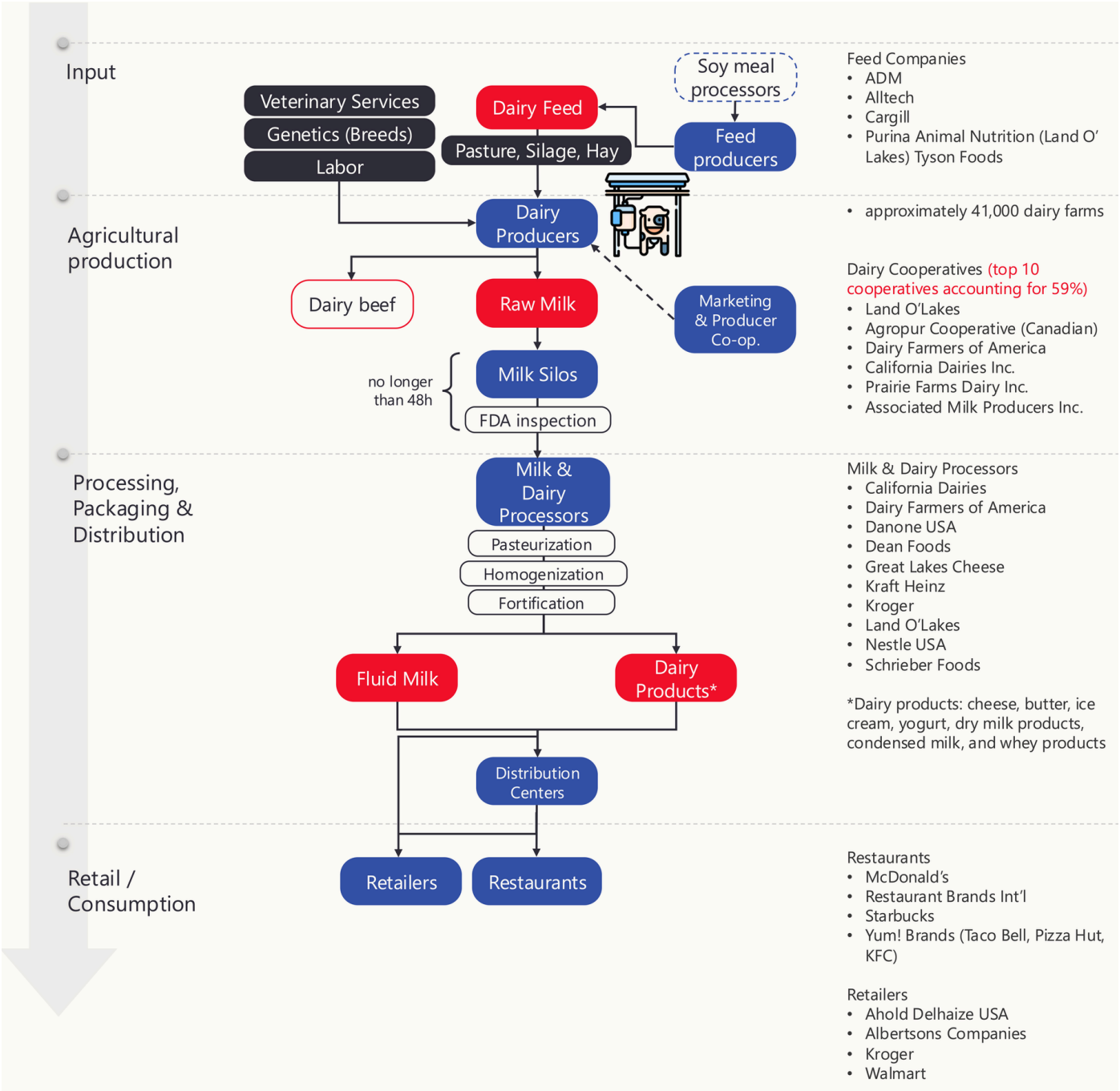


Figure 4: Dairy supply chain; Source: Ceres, 2018; Lowe & Gereffi, 2009; Smart Sense, 2018; University of Florida, 2021

1. Inputs

There are about 9.4 million dairy cows in the U.S (USDA NASS, n.d.). The Holstein, or Holstein-Friesian, is the predominant dairy breed in the United States, making up around 81% of cows on U.S. dairy farms. In recent years, Jersey (12.2%) and crossbreed (5.2%) cows have gained popularity due to their genetic predisposition to produce milk with higher contents of fat and other milk solids compared to Holstein cows (Guinan, 2020; USDA ERS, 2024).

Feed costs, on average account for approximately 50% of input costs on U.S. dairy farms (USDA ERS, 2023). Dairy herds receive meticulously planned daily rations, curated by nutritionists who possess in-depth knowledge of each farm's characteristics and nutritional requirements. It is a highly individualized topic of study, the specifics of which vary between nutritionist, farm and region. Essential pieces of a dairy cow's daily rations include energy, fiber, protein, vitamins, and minerals. The ingredients providing essential nutrients dependent on a myriad of factors, including region, farm production level, commodity prices, and time since pregnancy. The following figures (Figure 5 and Figure 6) provide a breakdown of common ingredients in a dairy diet and their nutritional values.

Feed Category	Example Ingredients	Key Nutritional Contributions	Maximum Dry Matter Intake (DMI) %
Forages	Corn Silage	Energy Fiber	<66%
	Alfalfa or Other Legumes	Fiber Crude Protein (low amount)	
	Grasses	Fiber Crude Protein (low amount)	
Concentrates	Ground Corn or Other Cereal Grains	Energy Protein (low amount)	<50%
	Soybean or Other Oilseed Meal	Protein Energy (low amount)	
Fats	Seed Oils	Energy	<6%
	Palm Oil		
	Tallow		
Other Supplements	Vitamin and Mineral Premix	NaCl, Ca, P, K, Mg, S Vitamins A, D, E	<1%

Figure 5: Common Ingredients in Dairy Cattle Diet and their nutritional contributions; Sources: The National Academies of Sciences, Engineering, Medicine, 2021; Wattiaux & Howard, n.d.

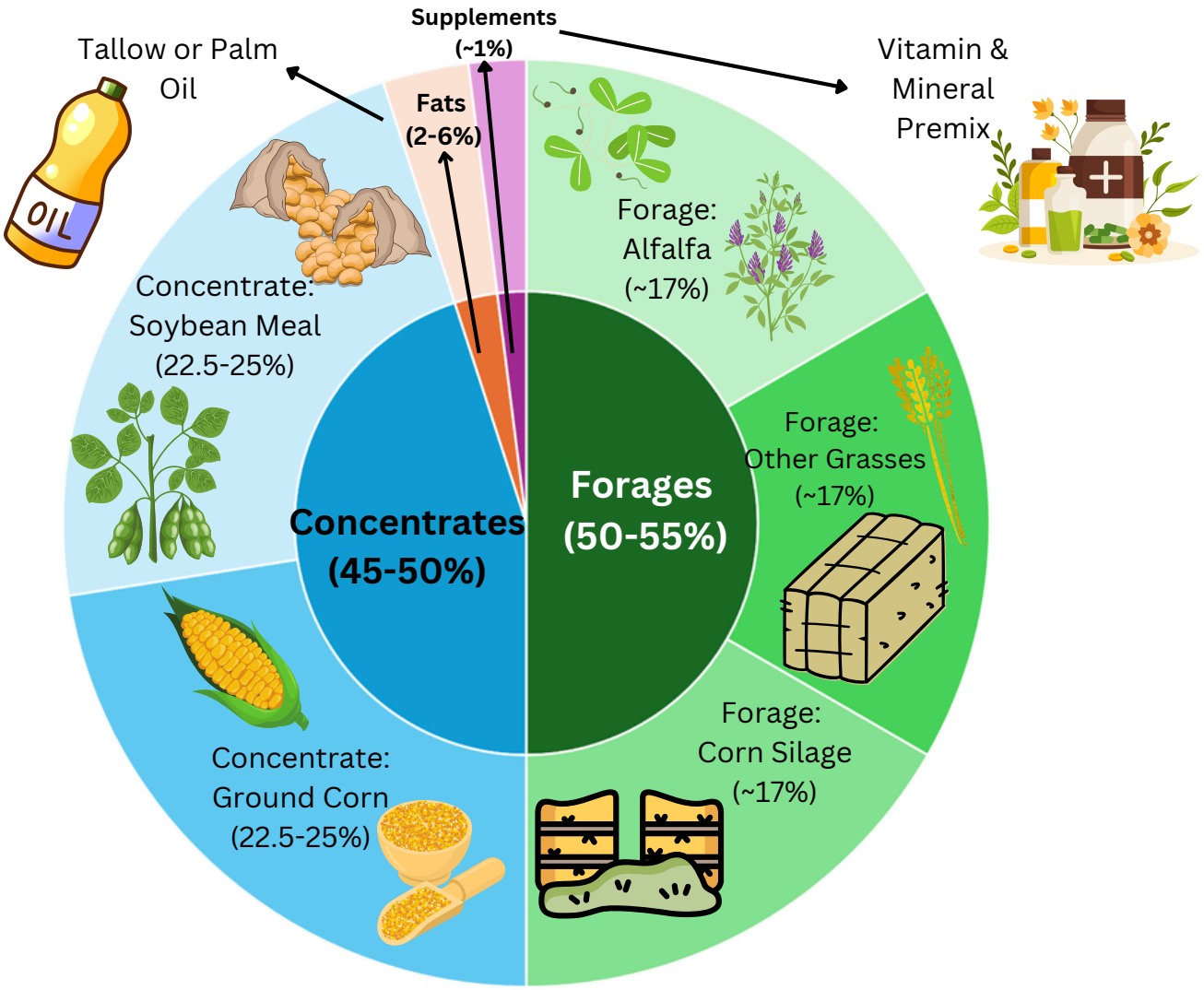


Figure 6: Example Dairy Diet; Source: The National Academies of Sciences, Engineering, Medicine, 2021; Wattiaux & Howard, n.d.

Dairy farmers in Michigan often have the capacity to grow crops on their farms, which they use to feed their cattle. Crop acreage decisions often depend on the market price for commodities. A recent trend of declining corn prices, as shown in Figure 7, can lead farmers to consider growing higher priced crops and purchasing their corn from the market. The top priority for farms is often to grow forages first. Once they have grown enough forage to meet the needs of their herds, farmers use additional acreage to produce concentrated feeds like ground corn and soybeans. They will either feed the corn or soybeans on their own farm if they have the requisite processing capabilities or sell it to market and use that revenue to purchase feed products. The infrastructure requirements for growing corn and soybeans are compatible, allowing farmers to decide which one to grow based on market conditions and crop rotations.

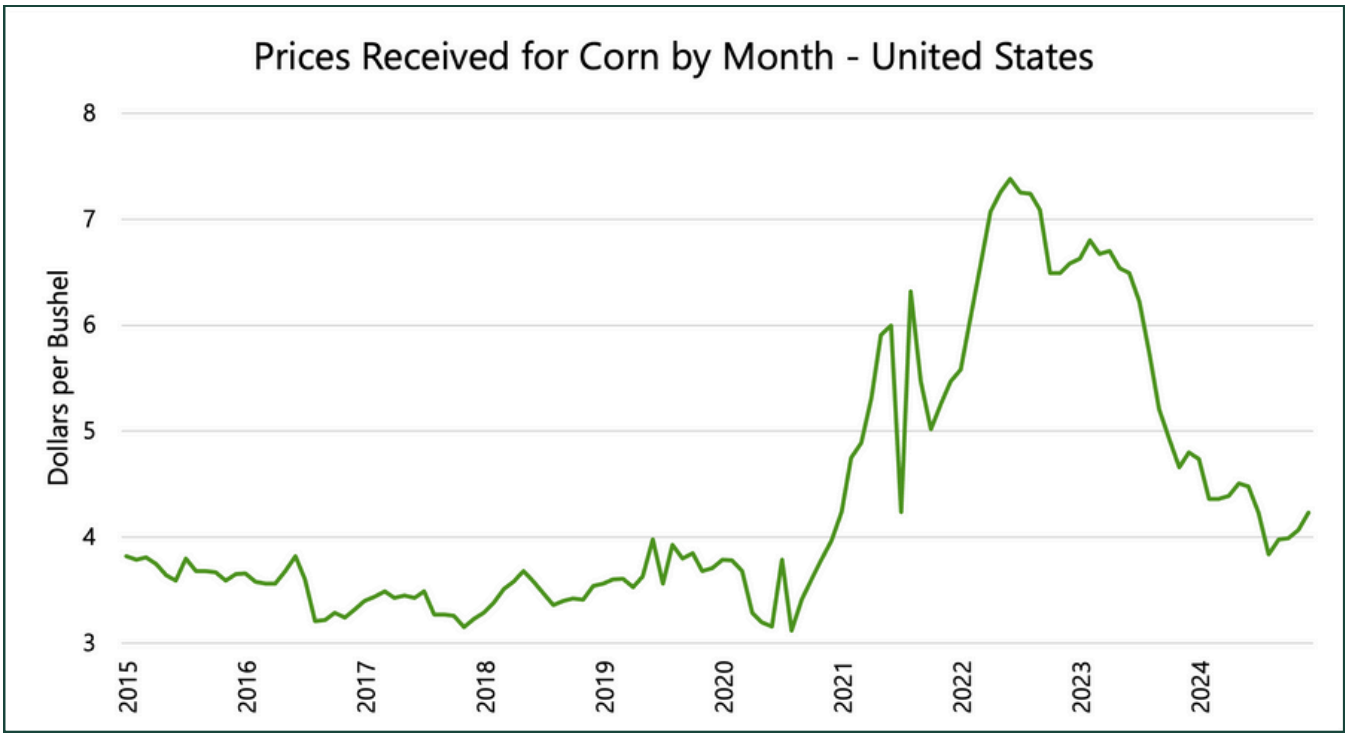
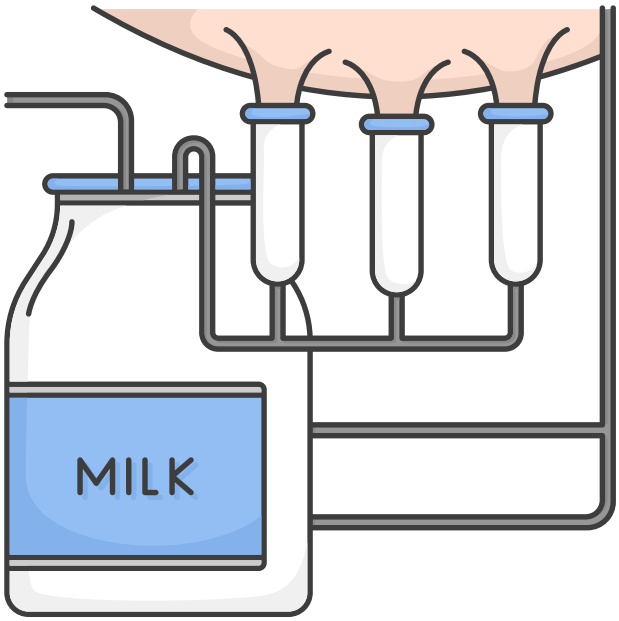


Figure 7: Corn Prices per Month; Source: USDA NASS, 2024

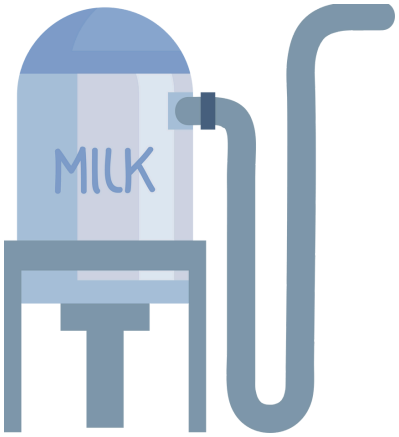
2. Agricultural Production

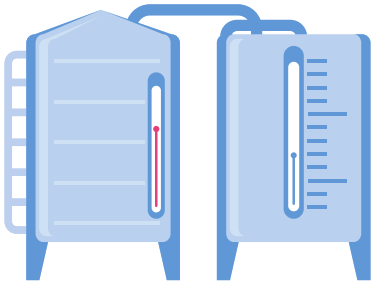
Harvesting the milk begins with milking, which has been made easier with the advent of automatic milking systems, or AMS. The milk is then transported through pipes to cooling storage silos. Milk is maintained at a temperature of 39 degrees Fahrenheit or lower in these silos for no more than 48 hours, allowing it to await inspection by FDA agents to ensure the safety of the milk for consumption. While most of the milk successfully passes inspection, any that falls short of the required standards is rejected.



Every year, over 3 million dairy cows are processed for the U.S. beef supply chain, with the annual rate of cow culling on dairy farms ranging from 30% to 35% (Moreira et al., 2021). The sale of these culled dairy cows for beef constitutes a substantial portion, accounting for 5-15% of the gross income for dairy enterprises (Lowe & Gereffi, 2009).

3. Processing, Packaging, and Distribution





Samples of milk are taken from farm vats prior to collection, and then from the bulk milk tanker upon arrival at the factory. Samples from the bulk milk tanker are tested for antibiotics and temperature before the milk enters the factory processing area. Farm milk samples are tested for milkfat, protein, bulk milk cell count and bacteria count. If milk does not meet quality standards it is rejected and isolated from the supply chain. Most farmers are paid based on the quality and fat composition of their milk. If the milk meets standards, it is transported to a processing plant or the product manufacturer, where the fluid milk is made into different dairy products and packaged for distribution. With almost no exceptions in the United States, any milk transported interstate must be pasteurized, and most often is also homogenized and fortified.

If the farmer is a member of a cooperative, the cooperative collects their members' milk and facilitates its transportation to processing and manufacturing facilities. Some of these cooperatives exhibit substantial vertical integration by operating their own processing and manufacturing plants, while others serve local or regional areas. The Michigan Milk Producers Association (MMPA) is the largest cooperative in Michigan. In recent years, an increasing number of dairy farmers across the nation have opted to join national cooperatives (USDA ERS, 2024).

4. Retail and Consumption

Packaged milk and dairy products are delivered from the plant to a distribution center or directly to the retailers. Cooperatives also provide marketing support for the final product.

Consumption of fluid milk has decreased over the last 50 years, with Americans consuming 128 pounds of fluid milk per person in 2023, compared to 130 and 134 pounds in 2022 and 2021 respectively (USDA ERS, 2024). Many factors explain this

decline, including changes in taste and preferences throughout generations, and an increasing availability of plant-based milk alternatives. Although this trend is expected to continue, fluid milk remains an important staple and dairy farmers should assess new methods of processing and marketing in order to generate demand (Stuart & Kuchler, 2022). In contrast, domestic consumption of cheese has been increasing over the last few decades. 16.8 pounds of American-made cheese was consumed per person in 2023, an increase from 16.3 and 16.2 pounds in 2022 and 2021 respectively (USDA ERS, 2024).

Supply Chain Innovation: High-Oleic Soybean Feed

High-oleic soybeans (HOS) are a modern innovation that are believed to have a positive impact on milk- and butter-fat yield when fed to dairy cattle. A combination of feed savings and yield increases has led dairy economists to estimate a potential profit gain of $0.29/cow per day (Nicholson et al., 2024). More aggressive estimates, albeit from seed companies themselves, suggest dairy farms can make up to $1 extra profit per cow per day (Krull, 2023). Regardless, the Michigan dairy industry is showing increased interest in HOS due to the economic upside and pre-established soybean infrastructure in the state.

Natural Implications

A 1980 review by Palmquist and Jenkins demonstrated that increased milk fat yields in dairy cattle requires supplemental fat to support lactation. Supplemental fat can be fed in several ways, including oilseeds, animal fat, and plant oils, all of which have unique fatty acid (FA) profiles. More recent research indicates the importance of the FA profile itself. There is a growing body of literature which suggests that higher levels of oleic acid in dairy rations can lead to increased milk production (de Souza et al., 2019; Western et al., 2020; Burch et al., 2021).

Enter high-oleic soybeans into the picture. Michigan is a large producer of soybeans, and has extensive infrastructure devoted to the cultivation of this commodity crop. It is relatively simple infrastructurally for farmers to switch from commodity soybeans to HOS, or other identity-preserved (IP) types like non-GMO, and food grade. High-oleic soybeans are distinguished from commodity soybeans in that they have a higher percentage of oleic acid (monounsaturated fatty acid) relative to linoleic acid (polyunsaturated fatty acid). Commodity soybeans contain ~23% oleic acid and ~62% linoleic acid, while HOS contain ~78% oleic acid and ~13% linoleic acid, depending on the brand (see Figure 8).

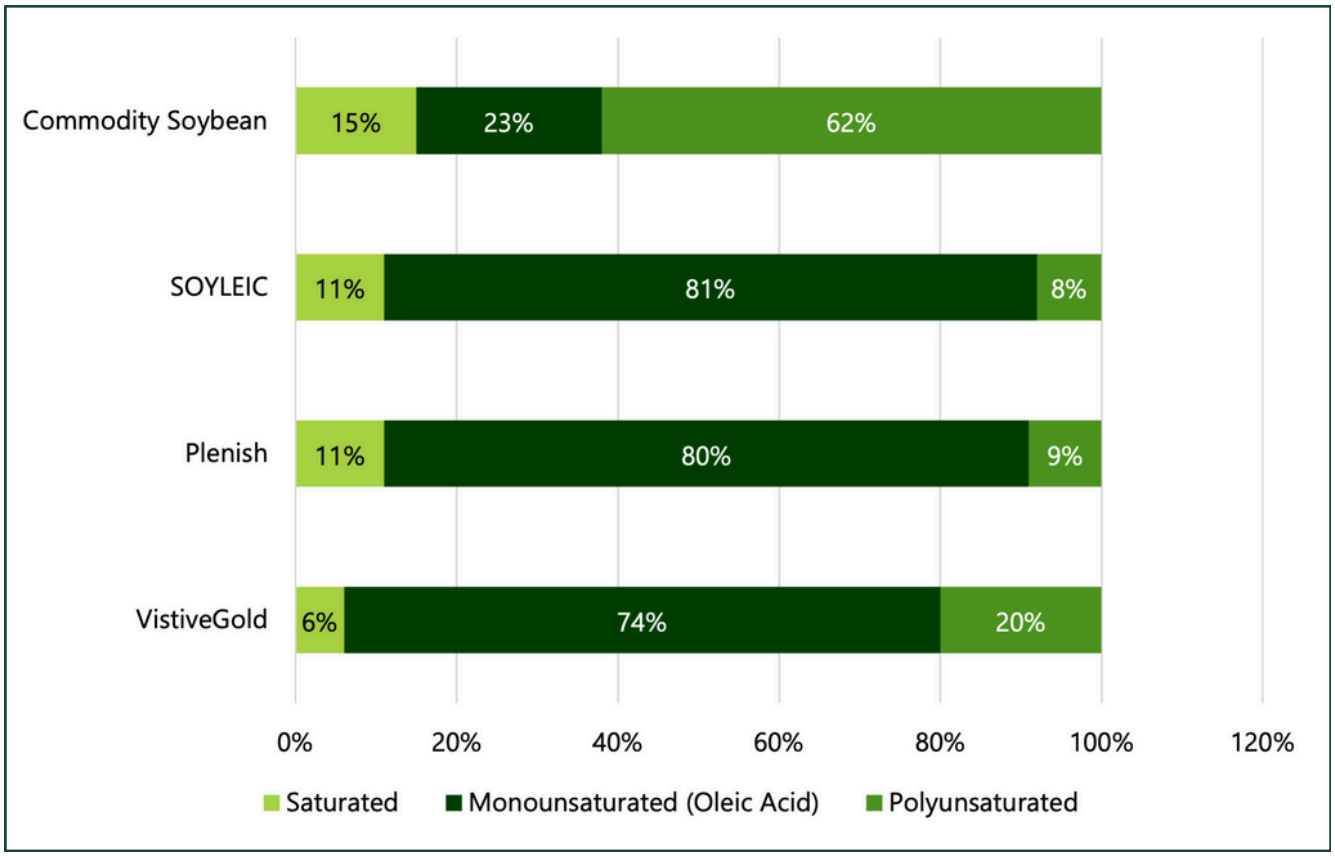


Figure 8: Fatty acid profile of commodity and high oleic soybean varieties; Source: Soybean Export Council, 2024

When fed to dairy cattle, the high levels of linoleic acid in commodity soybeans are known to increase risk of milk fat depression, a phenomenon in which the rumen in the cow is unable to efficiently digest specific FAs in its diet, causing decreased levels of milk fat production (Bauman et al., 2011; Dorea et al., 2017). This fact has led dairies to not widely utilize whole roasted commodity soybeans as a FA source; the soybean meal used in dairy cattle rations is typically a by-product of oil extraction and does not contain nearly as much fat. Instead, farmers utilize more effective FA options, such as palmitic acids (largely from palm oils), stearic acids (often from animal fats), or other sources of oleic acids (usually from various oilseeds) (Burch et al., 2022). Some of these FA sources can also lead to milk fat depression, are one of the most expensive components of dairy cow rations, and often need to be imported from the other side of the world. Contrarily, HOS can be widely produced locally and economically, adding to the economic potential from its beneficial FA profile.

This was a clear opportunity, though there needed to be more research about the effectiveness of increasing HOS in dairy cow rations. The research was taken on by Bales and Lock. They found evidence that increased HOS rations led to positive milk production responses, and that it did not affect the body reserves (Bales and Lock, 2024). In their experiment, they focused on the effect of roasted and ground soybeans, building off established research which concluded that roasted soybeans increased lactation performance (Grummer et al., 1994). Bales and Lock recommend feeding between four and nine pounds of HOS per day to see an increase in components. This conclusion contributed to a buzz about HOS utilization in the Michigan dairy feed industry, and some trail-blazing dairy farmers have made extensive efforts to test it on their own farms. There has been very limited research which engages local dairymen and nutritionists about their perceptions of HOS and the general market landscape and potential for widespread implementation of this rising technology.

Individual Interviews with Dairy Nutritionists and Dairy Producers

Description:

- Semi-structured interviews
- 12 farmers on 8 soybean farms
- Analysis and Discussion

There is a growing body of research about the nutritional effect of feeding HOS to dairy cattle, so this study aims to determine how Michigan dairies decide whether to take the necessary steps to feed it to their herds. Dairies often employ nutritionists who advise farmers on the nutrition and finances of feeding their herd. Determining the economic feasibility of feeding HOS to one's herd involves detailed analysis, which depends on the individual dairies' traits, priorities, and risk tolerance. The following section is the result of our conversations with nutritionists and dairy producers, and all opinions expressed are a result of observed trends in the interviews.

Questions and Procedures

We conducted semi-structured interviews with 10 primary decision makers from 12 dairy farms3, as well as nine dairy nutritionists. These interviews took place on MSU's campus or virtually. We developed questions following a literature review, discussions among the research team, a preliminary interview with a dairy farmer, and meetings with local stakeholders. We adjusted questions as the interviews progressed to ensure that we focused on relevant topics.

Following Caputo et al. (2023), we organized questions into themes, recorded the meetings, created transcripts, and analyzed trends in the data by coding responses from the transcripts. We synthesized the observed trends according to the themes from the interview questions.

For nutritionists, questions were organized into the three themes: (i) nutritionist profiles and overview of responsibilities, (ii) on-farm nutritional and economic considerations with feeding HOS, and (iii) opinions on market obstacles and opportunities with feeding HOS. Table 1 encapsulates thematic areas and the relevant questions asked to dairy nutritionists.

Thematic Areas	Relevant Questions
Nutritionist Profiles and Overview of Responsibilities	• Give an overview to your current organization and your role within the organization. • Do you recommend feed products directly to dairies?

On-farm Nutritional and Economic Considerations with Feeding HOS	• What is your familiarity with HOS feed?
	  ◦ Where did this familiarity come from?
	• Do you currently feed HOS on any of your dairies?
	• What is the impact of HOS on dairy cattle?
	  ◦ Are Michigan dairy producers generally aware of this impact?
	• What dietary components can be replaced by HOS, and what is the economic effect of this?
	• Generally what goes into formulating conclusions on potential benefits and drawbacks of certain products?

Opinions on Market Obstacles and Opportunities with HOS	• Have you heard any general narratives about feeding HOS in the nutrition community? • How has the market and conversation of feeding HOS changed in recent years? • How do you expect the market to change in the future? • What would catalyze, or hinder widespread adoption of HOS feed? • What is the typical adoption timeline for emerging feed technologies?

Table 1: Thematic areas and associated questions for interviews with dairy nutritionists

For producers, questions were organized as follows: (i) producer profiles and current operations, (ii) decision-making around using HOS feed on your dairy, and (iii) current state and future of the industry. Table 2 shows questions asked to dairy producers. Both full questionnaires can be found in the appendix.

Thematic Areas	Relevant Questions
Producer Profiles and Current Operations	• Provide a brief overview of your current production setup? • Give a brief overview of your current feed program. • What type(s) of crops do you grow on-farm? • What percentage of your own crops do you feed to your cattle? • What factors go into your decision of what products you feed your herd?
Considerations with Using HOS Feed on Your Dairy	• What is your familiarity with HOS feed? • Do you currently use HOS feed? • Why or why not? • What would motivate you to use HOS feed in the future? • What are some obstacles for switching? • What is the learning curve for using HOS feed? • How would your feed program change with the introduction of HOS feed? • What are the main productivity and/or financial concerns with switching to HOS feed? • What materials do you need to have on your farm to be able to handle HOS feed?
Current State and Future of the Industry	• How does your company assess the success of a new feed product? • What conditions are ideal for changing your feed program? • What do you perceive as the biggest challenges to expanding HOS feed utilization in the industry as a whole? • What are the greatest opportunities related to HOS feed use in the dairy industry?

Table 2: Thematic areas and associated questions for interviews with dairy producers

Dairy Nutritionist Interview Results

Operational Overview of Nutritionists Sample

The nutritionists interviewed for this study varied in their core responsibilities and scope of work. 7/9 nutritionists work as third party consultants, directly advising local dairies on developing diets for their herds. One nutritionist oversees feed program design for a group that owns five dairies. The final interviewee identified as a dairy specialist, who works with dairy farmers, nutritionists, and crop growers to identify opportunities and trends in the feed market. This final interviewee has been conducting market research about the feasibility of HOS for several years now. Only three of the nutritionists we spoke with currently feed HOS to their herds. One can do this because producers they work with grow HOS on their farms. The other two belong to firms which also have feed mills as part of their operation, and contracted some soybean growers to grow HOS for use in their feed products. 8/9 of the interviewees explicitly indicated that they provide financial consulting services to dairy farms as well. We tailored questions to each nutritionist to allow them to share their specific expertise.

On-Farm Nutritional and Economic Considerations with HOS

Nutritional Considerations

Our first objective was to understand how nutritionist perception of feeding HOS compares to the literature. We aimed to compare consistencies and differences between their perception on exactly how these beans affect cow health and milk yield, and what the economic implications are of these effects. We observed trends indicating that there are two main nutritional effects of feeding HOS: (i) fat components and animal health, and (ii) nutrient efficiency.

Difference in Fat Component Yield and Animal Health

Nutritionists were generally cautious while speaking about milk- and butter-fat component increases. For example, one nutritionist said, "*Many people are referring to high-oleic soy products as 'milk fat enhancing.' And I think that's really a misconception. They are not milk fat depressing*." This sample of nutritionists unanimously agreed that the high-oleic FA profile of HOS supports efficient conversion of feed into milk production and helps promote strong cow health throughout pregnancy, but the extent of which the fat components increase depends on what they were previously feeding. If producers are already feeding an effective fatty acid profile, they should not see a significant increase in components. In that case, it is still possible to see an increase in feeding efficiency.

Nutrient Efficiency

The participants largely echoed what we found in literature review - that whole roasted HOS can be a source of protein and accessible FAs, which leads to high feed efficiency. They indicated that HOS can be an efficient alternative to feeding relatively expensive calcium salts, palm fats, and protein-based meal, depending on the prices of each. One participant said, "*Good nutritionists feed nutrients, not products, and the benefit of HOS is that it is a single product that covers multiple nutrient needs of the cattle*." The long-term economic opportunity with feeding HOS is due to feed savings not component increases.

> *"Good nutritionists feed nutrients, not products, and the benefit of HOS is that it is a single product that covers multiple nutrient needs of the cattle."*

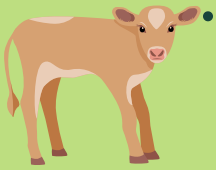
Economic Considerations

Whether HOS feed adoption leads to extra profit on a farm depends on various factors, most notably including logistical implications of acquiring enough HOS feed, and market prices of alternative FA and protein sources. Savings potential will vary for each farm, and our sample of nutritionists estimated a range of $0.00-$1.80 savings per cow per day (see Figure 9). The dairies on the higher end of that range are the ones who can produce and process their own HOS, and who were spending more on FA supplements. Research about the different benefits of specific fatty acids for dairy cattle is relatively new; we observe a gap in the literature about nutritionist preference for different fatty acids based on price, location, and logistics.

Nutritional and Economic Considerations with Feeding HOS

Nutritional Considerations

- Increased Feed Efficiency
  - The same amount of dry matter intake can yield more energy-corrected milk.



- Supports better animal health when compared to traditional soybeans
  - Especially through pregnancy and calving

- Can lead to increased components (i.e. milkfat and butterfat yield)
  - This depends on previous diet and caloric intake

Economic Considerations

- Up to $1.80 per cow per day savings observed
  - Highest level of savings observed on farms that can produce HOS themselves

- Economic benefit highly variable
  - Depends on feed availability, price of alternative energy sources, and herd production levels

- Nutritionists observe high retention rates among farmers who've adopted HOS

Figure 9: Summary of the main considerations of dairy nutritionists

The HOS market in Michigan is new, and most HOS acreage isn't going to the dairy feed industry. One nutritionist said, "*although there has been a large increase in the number of HOS growers in Michigan, most of those growers already have an end user established*." Nutritionists unanimously stated they would feed HOS if they could, but many indicated they cannot find it at an affordable price. This fact limits the early growth of the market and gives an early edge to those farms who can produce it themselves. One nutritionist put it concisely: "*HOS will only be widely adopted when the price is right for purchasing*." On the other hand, another said, "*Every dairy farmer I know who has experimented with HOS made a permanent switch to include it in their rations*."

Nutritionist Opinions on Industry Opportunities

Nutritionists notice that interest in HOS has steadily grown among their dairies, and many expect that trend to continue. Early adopters will likely continue to build infrastructure and experience cost savings, though broader adoption is contingent on the development of local infrastructure. One nutritionist suggested vertical integration as an opportunity: "*If you want the whole bean market to grow, you need third parties to enter the market. You need feed companies to sign contracts with growers to start buying, storing, and processing HOS to use for feed. This will, of course, affect the profit margins of all parties involved.*"

One interviewee asked the question: "*Why can't we just purchase the high-oleic soybean oil, and supplement the diet that way if we cannot yet purchase whole roasted beans?*" One nutritionist said they were forced to do that to round out their rations after they were unable to acquire the last few months' worth of HOS feed. They indicated that this turned out to be a profitable option for their farm, and they would do it again if necessary. The market for HOS oil is more established than that of whole roasted beans, which could make it easier for producers to acquire nutrients. This product would not contain protein, and fees associated with the soy oil supply chain would eat into profit margins, but it could still be a viable source of FAs. The economic potential and nutritional impact of dairy cows feeding on HOS oil is generally unexplored in the literature.

Finally, our sample indicated that two large marketing opportunities are around environmental and economic sustainability. Increased environmental sustainability of feeding HOS stems from a reduction in importing fats, supporting local agriculture, and reducing transportation emissions. Economic sustainability of feeding HOS may come from closed loop systems, shorter supply chains, and reduced feed costs, creating more resilience to shocks and market fluctuations. However, this potential will only be fully realized if market infrastructure and processing capabilities are augmented (see Figure 10). These opportunities were echoed in our interviews with dairy producers.

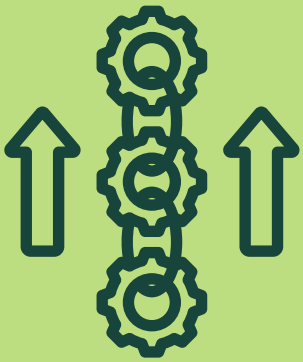
Temporary Adaptation

Purchase HOS Oil

Utilize the more established HOS oil supply chain as a dietary supplement

Supply Chain Adjustment

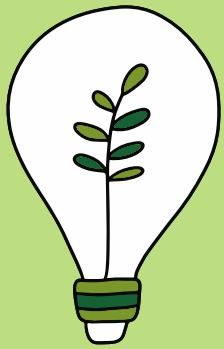
Vertical Integration



Feed mills to source seeds and provide premiums for soybean growers to produce HOS.

Marketing Opportunity

Sustainability Story



Market HOS-fed milk as a locally sourced, environmentally sustainable product

Figure 10: Main industry opportunities as described by dairy nutritionists

Dairy Producer Interview Results

Producer Profiles

The following section summarizes our interviews with dairy producers. Primary decision makers from 12 dairy farms participated in this study. Farms 6 and 10 represent 2 farms each, because they each encompass two separate farms with one owner. We did not include producer names, production level, or individual finances, to retain producer anonymity.

Farm sizes ranged from 480 to 3,000 milking cows, with an average of 1,188 per farm. While only 30% of the farms currently feed HOS, 80% are growing them in the 2024 season and plan to feed them once harvested and processed. 40% have or are building capacity to roast beans on their farms, with 70% having capacity to store beans on their farm. That information is summarized in Table 3.

Producer	Number of Milking Cows	Feeds HOS at Time of Interview?	Grows HOS at Time of Interview?	Soybean Roasting and Grinding Capacity On-farm?	Soybean Storage Capacity on Farm?
1	650	Yes	No	No	No
2	550	No	Yes	Yes	Yes
3	1,000	No	Yes	Yes	Yes
4	550	No	No	No	No
5	480	Yes	Yes	Yes	Yes
6	3,000	No	Yes	No	Yes
7	2,000	No	Yes	No	Yes
8	1,150	No	Yes	No	Yes
9	1,000	Yes	Yes	No	Yes
10	1,500	No	Yes	Yes	Yes

Table 3: Producer Profiles

Most farmers who currently or plan to feed HOS this year have the capacity to store at least a years' worth of ground and roasted beans on their farms, except for producer 1. This producer was able to purchase ground and roasted beans, via contract, from a local feed company. The company brings them a month's worth of beans at a time, and they use a small commodity barn to store it. Producers 2, 3, and 10 are listed as growing, roasting, and storing HOS while not feeding them because 2024 is the first year they adopted this technology. They were not feeding HOS at the time of the interview, but they have full setups in place to process their harvest for feed once it has been harvested. Figure 11 illustrates all interviewees' feed setup relative to HOS.

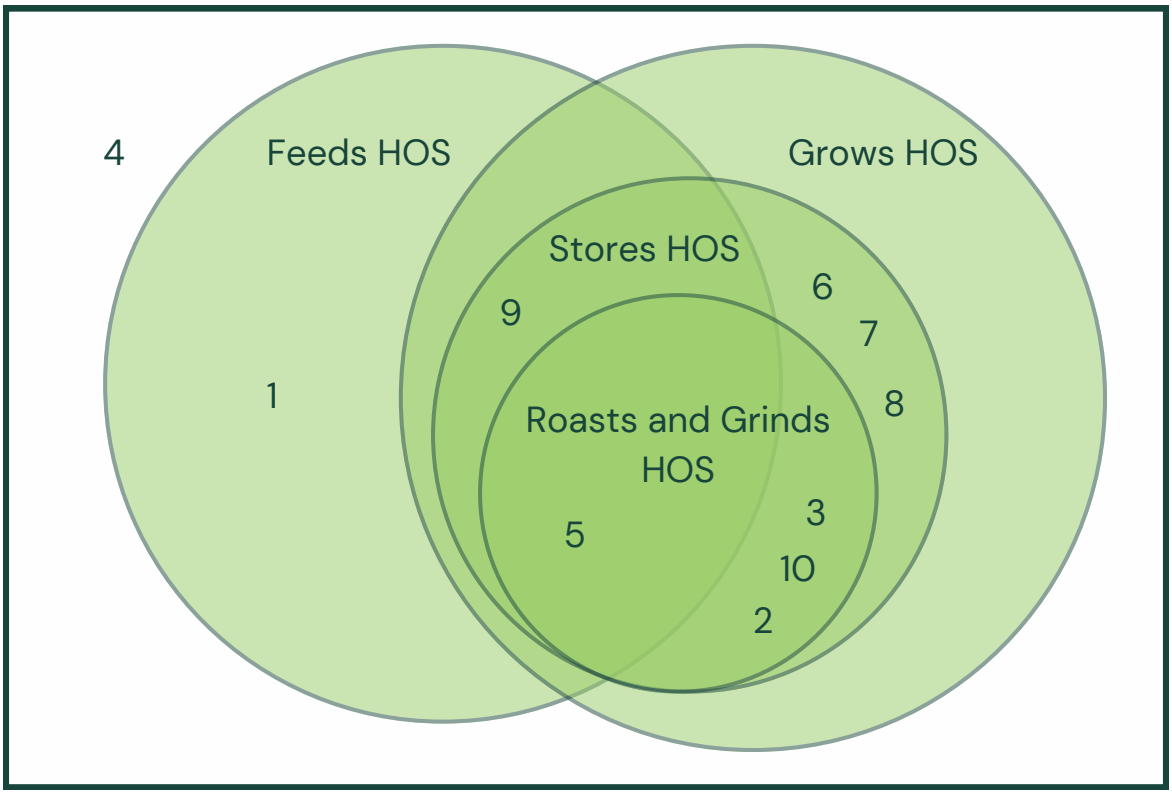


Figure 11: Current producer HOS operations.

Considerations Around Using HOS Feed on Dairies

The first behavioral question we asked farmers was why they did or didn't feed HOS. The producers unanimously stated that they have reviewed modern literature on the nutritional and economic benefits, but another trend we noticed was how many farmers were influenced by other dairy producers in the area who had already adopted HOS. There are a handful of farms on the West side of the state who have been feeding HOS for a year or more, and four of the producers who are introducing high-oleic soybean feed on their farms in 2024 indicated that they were influenced by farmers in their area who already feed it. More empirical research is necessary to explore the impact of word-of-mouth learning's effect on farmer adoption rates, but it appears to be having at least a minor effect on farmer adoption of HOS in Michigan.

We also noticed a clear trend around the factors producers need to consider while deciding whether to invest in the necessary requirements to feed HOS. We created a flow chart of dairy farmers' considerations around utilizing high-oleic soybean feed on their own farm. Whether adoption is financially beneficial to an individual farm depends on farm-specific factors, and we summarize these factors below in Figure 12.

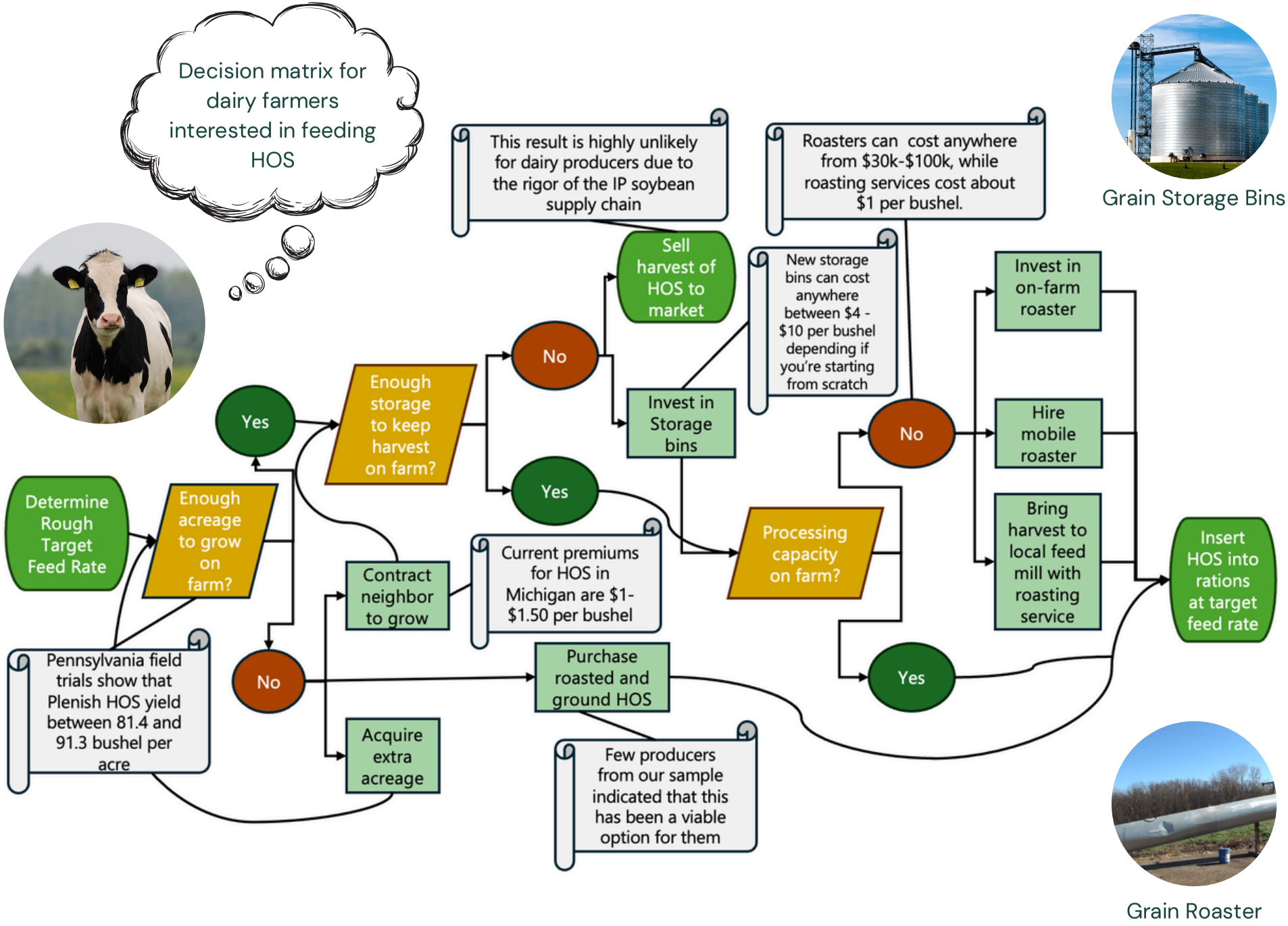


Figure 12: Flow chart of choices made by dairy farmers regarding HOS feed

Target Feed Rate

The initial consideration for producers is how they are going to obtain a supply of HOS that is sufficient for the nutritional needs of their herd. There is a degree of trial and error that goes into adjusting rations to find the optimal feeding rate for a herd, but modern literature suggests a minimum of 4lbs per cow per day is necessary to observe the nutritional benefit (Bales and Lock, 2024). From there, they must determine their feed rate based on the economics of obtaining HOS feed and consulting nutritional experts about how to adjust the other components of their rations. The producers we spoke to were generally aware of modern feed rate recommendations and indicated that they are aiming for a range of 4-9lbs per cow per day.

Acreage

Producers must determine whether they have enough acreage to grow enough HOS for their needs, or if they must seek other sources. From our sample, the smaller dairies (650 cows or less) indicated that they have the acreage to grow enough HOS for their needs. Dairy farmers usually try to take care of their forage and silage needs first, and then decide if they want to grow additional crops for the market or additional crops to feed their herds. However, they may determine that they would convert some acres of forage/silage to soybean cultivation, depending on market prices of other crops and their current crop rotations. Low 2024 prices of corn led one participant to say, "*...with corn being in the $4 to $4.25 range, we think we can buy our corn for very close to the cost of production*." They went on to say that this led them to convert almost all their corn acres to soy so that they could feed HOS in the following year. If a farm cannot grow enough HOS with their own acreage, they have the following options:

Contract a Soybean Grower

The first is to contract a soybean farmer to grow beans for them. One of our 1,000+ herd producers already committed to this strategy and indicated favorable financial returns. They offered their neighbors a $1 premium on top of the market price for commodity soybeans, and contracted enough to satisfy the needs of their herd for a year. They also decided to grow a small number of acres of HOS for the 2024 season, thus increasing and diversifying their supply. This producer stressed the benefit of building this relationship with their neighbor, and described how it has been a win-win for both parties. Upon financial review, they found that their input cost decreased, even despite the need to pay a premium and contract a mobile roaster (see processing section for more details on mobile roasting). They said:

> *"I look at this thing like we figured it out with corn. We don't all buy our corn from the elevator. We buy our corn from our neighbors. Why? Because it's better for us and it's better for them. The whole thing is just easier when it doesn't go on a truck and go into town and then come back out here. I'm not gonna get any of that benefit or any of that advantage if it's been on a truck three times."*

Producers 6 and 7 also explicitly mentioned a desire to build relationships with their neighbors, thus obtaining affordable soybeans with minimal transportation costs and building the local economy.

Purchase Finished HOS Feed From the Market

Only one of our producers currently purchases ground and roasted HOS from the market. They were able to purchase them because a local feed mill approached them with a "decent price." They decided to experiment with HOS feed before committing financially to the associated infrastructure requirements of growing it themselves. As briefly mentioned in the producer profiles, they store the roasted beans in a small commodity barn one month at a time. This producer indicated that this method has not yet led to any increase in profitability of their farm, though it did lead to increased feed efficiency. They also indicated that they were approached by an Ohio feed mill with roasted and ground HOS for $50 less per ton than they currently are

getting. They said that this price would almost certainly lead to an increase in profitability for their dairy. No other producer we interviewed indicated that they believe this is the best option for them right now, due to a perceived lack of market availability. Half of the producers noted they would purchase a ground and roasted HOS if it were available to them, though 8/10 indicated they believe this option would eat away at the profit margins of HOS feed.

Purchase New Acreage

The final option is to add acreage to their farms by purchasing or leasing new land. None of our interviewed producers have taken this step, though several mentioned that it is a consideration.

Storage Capacity

Dairy producers must then determine if they possess enough storage space to keep the HOS on-farm until it is time to feed. If they do not own enough storage, they must either build grain bins or sell their harvest to the market. Per the latter, they would need to navigate the rigor of the Identity-Preserved (IP) soybean market, which is a considerable deterrent to soybean farmers growing IP beans generally (Knudson, 2022). Dairy farmers would likely opt to grow a different crop instead of HOS if this were their only option. Per the former, building grain bins is a financial investment for a farm. 8/10 of our interviewees decided that this investment was feasible for them, projecting a return on investment of 3 years minimum, 5 years maximum. Those producers feel that storage investment is low risk because it builds equity, and the bins can be used for corn and other grains if feeding HOS is not feasible. One producer made the point that they will be able to sell corn and beans at whatever time of year now that they have extra storage, saying, "*With our new storage we can take them to the market when the market wants them. The fluctuations in the markets move up and down throughout the year, and we'll be able to sell them at the optimal time.*"

Processing for HOS Feeding

As highlighted previously, soybeans need to be roasted and ground to provide maximum nutritional benefit to dairy cattle. This proves to be one of the largest obstacles for dairy farms to utilize HOS. Producers generally have three options to process their supply of HOS: (i) purchasing their own roaster, (ii) utilizing mobile roasters, or (iii) utilizing a local feed mill.

i. Purchasing a Roaster

Grain roasters can cost anywhere between $10,000 for a used model and $100,000 for a new high capacity model. There are also costs associated with running the machine, including maintenance, gas or electricity, and labor. Along with being a pecuniary investment, operating a roaster can present a steep learning curve for producers. It is possible to over- or under-roast soybeans, eroding feed efficiency for cattle thus wasting resources. When asked about the learning curve of feeding HOS on their farms, 70% of participants indicated that roasting the beans is their biggest concern. Figure 13 presents a list of the main pros and cons of installing a roaster on-farm as indicated by the interviewees:

+ Pros	− Cons
1. Manageable ROI timeline	1. Considerable initial investment
2. Cost-effective way to process HOS	2. Operating costs and labor
3. Creates closed-loop system	3. Margin for error associated with roasting
4. Builds equity	

Figure 13: Pros and cons of purchasing a grain roaster

Four of our interviewees decided that the benefits of owning their own roaster are worth the initial investment and operating costs. One producer has been roasting their own beans for four years, and they say the added profits have already been higher than the cost of their roaster. Most of this financial upside comes from creating a closed loop system, increasing efficiency by eliminating the costs incurred through logistics, i.e. transport and processing.

ii. Utilize Mobile Roasters

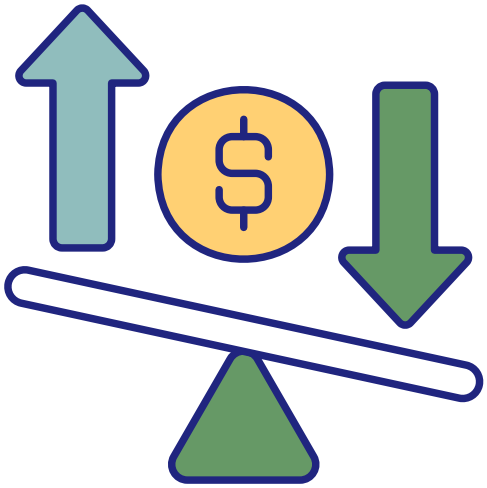
Another option is to utilize mobile roasters, where it costs about $1 per bushel to roast soybeans on average. The farmer who purchases HOS from their neighbor uses this strategy because they wnted to get someone who “knows what they’re doing,” thus minimizing the margin for error with roasting the beans. Their mobile roaster has been doing it for 30+ years and has a high level of expertise. This producer indicated that their farm is more profitable than it was prior to utilizing HOS feed, even though they purchase the beans at a premium and pay for a mobile roasting service. They did express that they plan to purchase their own roaster in the future, as they feel that this strategy will lead to the largest profit margin for their farm.

iii. Bring Raw Beans to Feed Mills for Roasting Service

Finally, some feed mills have the capacity to roast beans for customers. Interviewees indicated that this is an option, though no one we interviewed currently practices this. The need to truck the beans to and from the feed mill presents extra costs along with a notable time commitment, which eats away at the profit margins.

Industry Opportunities for Higher Impact

We asked producers to outline how they ascertain whether new feed products increase their farm profits, and how long it would take to definitively know whether HOS adoption is worth financial investment. They stated, unanimously, that the change in total feed cost over total revenue is how they determine the success of a new feed product. Some said they should have a sound conclusion within a few weeks of feeding, while others indicated it can take longer. A trend we noticed between interviewing nutritionists and producers is that the long-term profitability of using HOS is partially dependent on market prices of other feed products. 90% of sampled producers feel that HOS is or will be a good option for them because fat is generally the most expensive part of their rations by volume, and they believe local production of soybeans is more affordable than purchasing FA supplements. For example, the price of palmitic acid has been high recently and has cut significantly into dairy farmer margins (Dairy Global, 2022). Producers did not have widespread agreement on how much palmitic acid they would remove from their rations upon introducing HOS. However, the nine producers who already have or are planning to adopt HOS unanimously stated that they believe a decreased need to purchase fatty acid supplements will make their farms more resilient to market fluctuations and supply chain shocks.



Like the trend observed with nutritionists, producers spoke about the growth of HOS feed as an opportunity for sustainability. In terms of economic sustainability, the smaller-scale producers feel that gaining more control over the prices of their inputs will allow them to stay in business for longer, resisting modern trends of a declining number of dairies and an increase in average dairy size. For example, the producer who has been feeding HOS for four years said "*They say the 250 to 500 cow herds is not as profitable as a bigger herd. And I'm thinking [feeding HOS] is*

something to keep them in business. They don't need so much of a land base to do this as compared to bigger dairies that would require massive land bases to grow enough high-oleic beans." This identified opportunity is consistent with data observed from the USDA, where Michigan dairies are slightly smaller on average, and grow a higher percentage of their own feed (USDA ERS, 2023).

Some of the larger dairies feel that utilizing a local crop which is often imported from abroad is a way to bolster the local economy. For example, one large producer said "The sustainability side of this is huge. We may no longer need to purchase products from overseas and can support the local economy. I think that is one of the most important pieces in my mind about this." HOS provides an opportunity for almost all components of Michigan dairy herd diets to be produced within a relatively small radius of their farms, decreasing transport-based emissions. Increased efficiency of feeding has environmental upside as well, as less inputs are required for the same or more output. A summary of industry opportunities are summarized in Figure 14. Finally, it is possible that increased animal welfare associated with HOS can have a positive environmental impact, though there is a need for further research on this subject.

Closed Loop System

An input farmers can produce on-farm

Diversifies operations, decreasing vulnerability to market fluctuations and supply chain shocks.

Shortened Supply Chain

Strengthen local economy & decrease carbon emissions

Palm oils travel ~9,000 miles to Michigan dairy farms. HOS would be produced in-state.

Small Dairy Profitability

Resist trends of declining numbers of dairies

Smaller dairies identify HOS as an opportunity to compete with larger dairy dominance.

Figure 14: Industry opportunities from dairy producers' perspectives

Key Findings and Final Remarks

The advent of HOS feed is clearly a large opportunity for the Michigan dairy industry. Through our interviews with nutritionists and producers, we find that most of the current economic upside comes from feed savings associated with increased feed efficiency, lower transportation costs, and more control over inputs. Profitability of adoption depends on a myriad of factors that vary farm to farm. We conclude that the need to roast the soybeans prior to feeding is one of the largest deterrents for HOS adoption on dairies. Farmers must either buy their own roaster (which presents a steep learning curve and sizable initial investment) or enlist someone else to roast their HOS (which eats into the profit margin). The current market landscape favors using most HOS for cooking oil, which has limited investment in infrastructure to convert HOS into dairy feed. Ground and roasted HOS is available on the market in some capacity, but the one producer we spoke to who was able to do this indicated that this strategy has not increased their profit yet. Many producers and nutritionists indicated that they have not seen this product on the market yet. Producers and nutritionists alike acknowledged economic and environmental sustainability advantages posed by this product. The emphasis on locally produced and environmentally sustainable feed and dairy products may be a significant marketing opportunity for the soy and dairy industry. There is a need for further research about nutritionist and dairy producer preferences for the specific fatty acid breakdown of various feed alternatives, as this is consequential for building the market and profitability of each feed alternative.

Appendix

Dairy Interview Questions: The interview with dairy farmers includes 5 sections, as described below.

Section 1: Introduction

1. Can you please provide a brief overview of your current production setup? For example, your:
    a. Herd size
    b. Crops (if any)
    c. Number of employees
2. Give a brief overview of your current feed program.
3. What factors go into deciding what varieties of soybeans (or other crops) you feed your cattle each year?
    a. How often do you adjust?
4. Do you use crops that you grow yourself to feed your cattle?
    a. Is there any processing needed to make these crops usable for your cattle?

Section 2: Perceived obstacles and benefits to using HOS in dairy feed

1. Are you familiar with High-Oleic Soybean feed?
    a. If so, what information do you know about it?
    b. Are there any stories (what is being said) in your community about using HOS for your cattle?
2. Do you currently use HOS feed?
    a. If so:
        i. What percentage of your soybean feed is HOS?
        ii. When did you first convert to (partial) HOS feed?
        iii. What motivated this transition?
        iv. What advice would you give to producers who are just starting to make the transition to HOS?
    b. If not:
        i. What are some of the obstacles for switching?
            1. Lower availability of feed?
            2. Unconvincing benefit to your cattle?
3. How will your feed program change?
4. Are you planning to convert more of your feed program to HOS?
    a. What would motivate you to switch to HOS?
5. Are there any additional financial or productivity concerns that you have about HOS feed compared to other products?
6. Could you talk about the learning curve associated with using HOS feed?

Section 3: Technologies and market conditions

1. What type(s) of soybean meal do you feed your cattle?
    a. Why? What are the pros and cons?
2. Are you aware of any other feed types?
    a. What are the pros and cons of using other varieties?
3. What conditions are ideal for altering your feed program?

Section 4: Business relationships

1. Who do you purchase soybean feed from?
2. Is high-oleic soybean feed available from your feed dealer?
    a. Do you anticipate it becoming more widely available?
3. Has/would a switch to HOS feed affected your consumer base?
4. What percentage of your dairy products do you sell under contracts, and how long have you had these relationships with your buyers?
5. Is it difficult to finance the new purchase of materials necessary to roast HOS on your own farm?

Section 5: Supply chain

1. How would you describe the dairy supply chain?
    a. With who do you interact the most (least)?
    b. What is your role in the supply chain?

Section 6: Future of the industry

1. What do you perceive as the biggest challenges to HOS feed utilisation in the industry?
2. How does your company measure to feed product's success?
    a. How long does it take to know if a feed product will be a permanent staple of your rations?

Closing remarks

1. Is there anything else that we should know about:
    a. Your feed decision-making process?
    b. Dairy production in general?
2. Do you have any questions or final comments?
3. Do you have any additional contacts within your industry that we can reach out to for this study?
    a. Other dairy producers
    b. Your nutritionist

References

- Bales, A. M., Cinzari, M. E., & Lock, A. L. (2024). Increasing palmitic acid and reducing stearic acid content of supplemental fatty acid blends improves production performance of mid-lactation dairy cows. Journal of Dairy Science.
- Bales, A. M., & Lock, A. L. (2024). Effects of increasing dietary inclusion of high oleic acid soybeans on milk production of high-producing dairy cows. Journal of Dairy Science. https://www.sciencedirect.com/science/article/pii/S0022030224008646#bib24
- Bauman, D., Harvatine, K., & Lock, A. (2011). Nutrigenomics, Rumen-Derived Bioactive Fatty Acids, and the Regulation of Milk Fat Synthesis. Annual Review of Nutrition. https://www.annualreviews.org/content/journals/10.1146/annurev.nutr.012809.104648
- Burch, A. M., Contreras, A., Abou-Rjeileh, U., & Lock, A. (2022). Harnessing fatty acids for transition cow management. Michigan State University Extension. https://www.canr.msu.edu/news/harnessing-fatty-acids-for-transition-cow-management
- Burch, A. M., Pineda, A., & Lock, A. L. (2021). Effect of palmitic acid-enriched supplements containing stearic or oleic acid on nutrient digestibility and milk production of low- and high-producing dairy cows. https://www.sciencedirect.com/science/article/pii/S002203022100566X?via%3Dihub
- Dairy: An Investor Brief on Impacts that Drive Business Risks. (2018). Ceres. https://www.ceres.org/resources/reports/dairy-an-investor-brief-on-impacts-that-drive-business-risks
- de Souza, J., St-Pierre, N. R., & Lock, A. L. (2019). Altering the ratio of dietary C16:0 and cis-9 C18:1 interacts with production level in dairy cows: Effects on production responses and energy partitioning. Journal of Dairy Science. https://www.sciencedirect.com/science/article/pii/S0022030219307787?via%3Dihub
- Dias Sousa, A. V. (2023). Top Countries Shaping the Global Dairy Industry. https://ruminants.ceva.pro/dairy-industry
- Dorea, J. R. R., & Armentano, L. E. (2017). Effects of common dietary fatty acids on milk yield and concentrations of fat and fatty acids in dairy cattle. Animal Production Science. https://www.publish.csiro.au/an/AN17335
- Economic Analysis of High-Oleic Soybeans in Dairy Rations. (n.d.). https://www.sciencedirect.com/science/article/pii/S002203022400002X
- Farm Milk Production. (2023). USDA ERS. https://www.ers.usda.gov/topics/animal-products/dairy/background/#Jump2
- From Farm to Fork: The Dairy Supply Chain. (2018). Smart Sense. https://blog.smartsense.co/farm-to-fork-dairy-supply-chain
- Grummer, R., Luck, M., & Barmore, J. (1994). Lactational Performance of Dairy Cows Fed Raw Soybeans, with or Without Animal By-product Proteins, or Roasted Soybeans. Journal of Dairy Science. https://www.sciencedirect.com/science/article/pii/S0022030294770740?via%3Dihub
- Guinan, F. (2020). Changes in the Breed Composition of U.S. Dairy Herds. Council on Dairy Cattle Breeding.
- High palmitic acid prices cut into dairy farmer margins. (2022). Dairy Global. https://www.dairyglobal.net/health-and-nutrition/nutrition/high-palmitic-acid-prices-cut-into-dairy-farmer-margins/
- Knudson, B. (2022). The Market Potential for IP and Non-GMO Soybeans. Michigan Soybean Committee. https://www.michigansoybean.org/uploads/1/3/7/2/137244386/final_market_potential_for_ip_soy__knudson_.pdf
- Krull, A., & Kilger, S. (2023). The potential of Plenish High Oleic soybeans in dairy feed [Interview]. https://www.feedandgrain.com/expert-insights/podcasts/podcast/15659161/the-potential-of-plenish-high-oleic-soybeans-in-dairy-feed-podcast
- Lester, K. (2023). Happy cows are healthy cows: Why Michigan's cows produce the most milk. Capital News Service. https://news.jrn.msu.edu/2023/10/happy-cows-are-healthy-cows-why-michigans-cows-produce-the-most-milk/
- Lowe, M., & Gereffi, G. (2009). A Value Chain Analysis of the U.S. Beef and Dairy Industries. Environmental Defense Fund. https://www.researchgate.net/publication/294579508_A_Value_Chain_Analysis_of_the_US_Beef_and_Dairy_Industries
- Michigan Dairy Facts. (2024). United Dairy Industry of Michigan. https://www.milkmeansmore.org/milk-local/michigan-dairy-facts/#:~:text=Michigan's%20dairy%20industry%20generates%20nearly%2040%2C000%20jobs%2C%20directly%20and%20indirectly.
- Milk. (2022). BetterHealth Channel. https://www.betterhealth.vic.gov.au/health/healthyliving/milk
- Milk Cost of Production Estimates. (2024). [Dataset]. USDA ERS. https://www.ers.usda.gov/data-products/milk-cost-of-production-estimates/
- Moreira, L., Guilherme, J. M. R., & Schaefer, D. (2021). Beef production from cull dairy cows: A review from culling to consumption. Journal of Animal Science. https://academic.oup.com/jas/article/99/7/skab192/6298574
- Nicholson, C., Stephenson, M., Armentano, L., & Harvatine, K. (2024). Economic Analysis of High-Oleic Soybeans in Dairy Rations. Science Direct. https://www.sciencedirect.com/science/article/pii/S002203022400002X

References

- NUTRIENT REQUIREMENTS OF DAIRY CATTLE (8th ed.). (2021). The National Academies of Science, Engineering, Medicine.
- Overview on Dairy. (2024). USDA ERS. https://www.ers.usda.gov/topics/animal-products/dairy/
- Palmquist, D. L., & Jenkins, T. C. (1980). Fat in Lactation Rations. Journal of Dairy Science. https://www.sciencedirect.com/science/article/pii/S0022030280828815?via%3Dihub
- Prices Received For Corn by Month—United States. (2024). USDA NASS. https://www.nass.usda.gov/Charts_and_Maps/Agricultural_Prices/pricecn.php
- Stewart, H., & Kuchler, F. (2022). Fluid Milk Consumption Continues Downward Trend, Proving Difficult to Reverse. https://www.ers.usda.gov/amber-waves/2022/june/fluid-milk-consumption-continues-downward-trend-proving-difficult-to-reverse/
- Terán, A., & Cessna, J. (2021). Farm Milk Components and Their Use Among Dairy Products Have Shifted Over Time. USDA. https://www.ers.usda.gov/amber-waves/2021/august/farm-milk-components-and-their-use-among-dairy-products-have-shifted-over-time/
- The Economic Impact of Dairy Products. (2024). International Dairy Foods Association. https://www.idfa.org/dairydelivers#:~:text=The%20Economic%20Impact%20of%20Dairy%20Products&text=In%20fact%2C%20America's%20dairy%20industry,are%20shaping%20the%20dairy%20industry.
- United States Cattle Inventory down 3%. (2023). USDA NASS. https://www.nass.usda.gov/Newsroom/archive/2023/07-21-2023.php
- Untangling the knots in the supply chain. (2021). University of Florida. https://news.ufl.edu/2021/12/from-florida-episode-15/
- U.S. High Oleic Soybeans & High Oleic Soybean Oil Sourcing Guide. (2024). U.S. Soybean Export Council. https://ussec.org/u-s-high-oleic-soybeans-high-oleic-soybean-oil-sourcing-guide/
- USDA ERS. (2024a). Dairy Data [Dataset]. https://www.ers.usda.gov/data-products/dairy-data/dairy-data/
- USDA ERS. (2024b). Milk cows and production by State and region [Dataset].
- Wattiaux, M., & Howard, T. (n.d.). Feeds for Dairy Cows. Babcock Institute for International Dairy Research and Development. https://nydairyadmin.cce.cornell.edu/uploads/doc_97.pdf
- Western, M., de Souza, J., & Lock, A. (2020). Milk production responses to altering the dietary ratio of palmitic and oleic acids varies with production level in dairy cows. Journal of Dairy Science. https://www.sciencedirect.com/science/article/pii/S0022030220308365?via%3Dihub

Acknowledgements

Special thanks to the Michigan Alliance for Animal Agriculture (MAAA) for providing the resources and tools to conduct this research effectively. The M-AAA is a partnership between the animal agriculture industry, the Michigan Department of Agriculture, and Michigan State University. Their initiatives are instrumental in making research like this possible.

M-AAA
Michigan Alliance for Animal Agriculture

To cite this report (APA 7th edition):

Rickman, S., Ponnudurai, S., Sun, J., Lock, A. & Caputo, V. (2025). Market Potential for the Use of High-Oleic Soybeans in the Michigan Dairy Industry. Report No. 2, Food Choice Research Lab, Michigan State University.

Contact: vcaputo@msu.edu