Growing Soybean Demand: Vision for Missouri as a Net Soybean Importer

Commissioned by the Missouri Soybean Merchandising Council

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This report summarizes new soybean market opportunities in Missouri. It highlights potential growth in overall Missouri soybean demand among Missouri manufacturers of feed, industrial products and food products.

Three separate papers examined these manufacturing sectors in-depth and provided the background information needed to develop this report. Market opportunities described in these papers could help grow the amount of soy oil and meal demanded by Missouri buyers downstream in the value chain and, therefore, support additional crush capacity within the state. Additionally, Missouri historical basis provides perspective about soybean prices.

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1. Overview

The Missouri Soybean Merchandising Council (MSMC) envisions the state's soybean industry becoming a net soybean importer. Exhibit 1.1 shows Missouri's soybean supply and demand balance from 2020/21 to 2022/23. Net exports refer to Missouri's supply (production and carry-in) minus soybean volumes used in-state (crush and seed/residual use) and carry-out balances. Based on ProExporter's projections, Missouri will have 107 million bushels in net soybean exports in the 2022/23 crop year. Those exports will go to other states or international buyers.

Exhibit 1.1. Missouri soybean supply and demand (September to August crop years)*

Item	Unit	2020/21	2021/22	2022/23
Carry-in	mil. bu.	28	20	25
Area planted	thou. ac.	5,850	5,700	5,721
Area harvested	thou. ac.	5,810	5,650	5,670
Yield	bu./ac.	51	49	50
Production	mil. bu.	296	277	284
Supply	mil. bu.	324	297	316
Disappearance (use)	mil. bu.	304	272	276
Seed/residual use	mil. bu.	7	8	8
Crush	mil. bu.	161	166	168
Use in state	mil. bu.	168	174	176
Carry-out	mil. bu.	20	25	33
Net exports	**mil. bu.**	**136**	**98**	**107**

* 2021/22 data are estimates, and 2022/23 data are projections
Source: ProExporter

Five soybean crushing facilities operate within Missouri. Exhibit 1.2 lists these facilities, their locations and daily crush capacity. Three facilities operate on Missouri's western border, and two operate in east central Missouri. The U.S. crushed 66.2 million tons of soybeans in 2020, according to USDA. Missouri crushed about 4.3 million tons, which represents about 7% of the U.S. total. Neighboring states Iowa and Illinois crushed 13.5 million tons and 7.9 million tons, respectively.

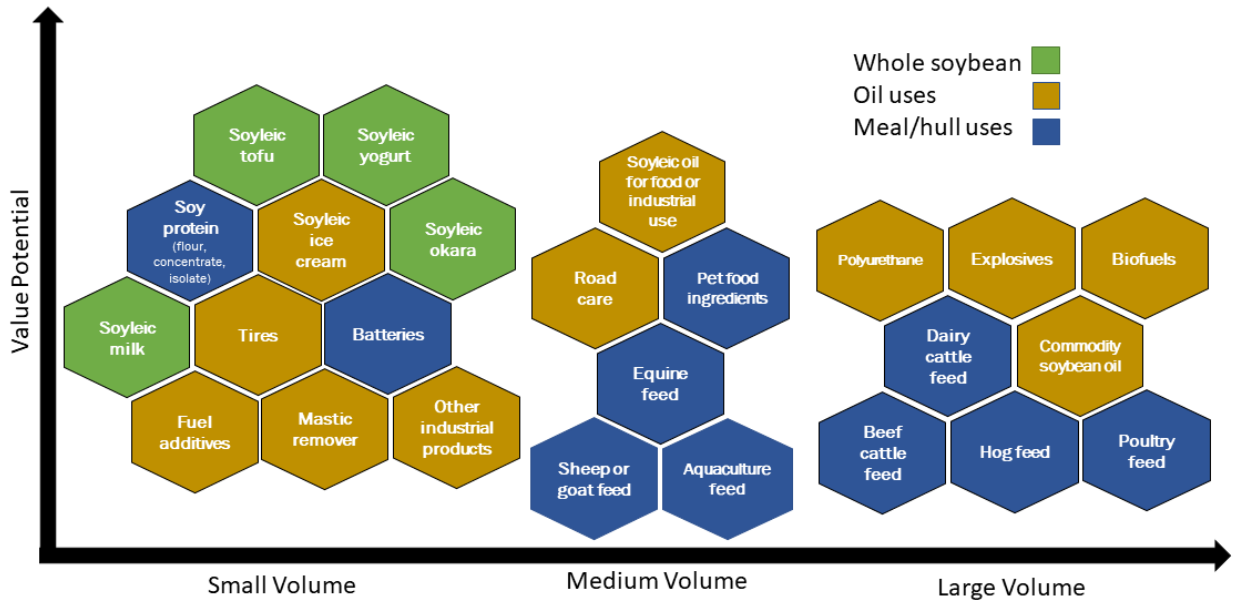
Exhibit 1.2. Missouri soybean crushing facilities by capacity

Facility	Location	Daily crush (tons/day)
Cargill	Kansas City	5,000
Ag Processing Inc.	St. Joseph	3,600
ADM	Deerfield	2,400
ADM	Mexico	1,950
Tiger Soy	Mexico	52
	Total	**13,002**

If in-state demand for soybean co-products grows, then additional Missouri soybean processing capacity may be justified. The project team evaluated potential opportunities and strategies to improve Missouri soybean demand among three Missouri manufacturing sectors: feed, industrial products and food. Three separate papers examined these sectors in-depth and provide the background information needed to develop this report. In these papers created for each sector, the team recommended strategies and tactics to pursue that would increase soybean demand. In addition, the papers listed Missouri businesses that may represent potential buyers of soybean inputs or technologies. These market opportunities could help grow the oil and meal demanded by Missouri buyers downstream in the value chain and support additional crush capacity within the state.

Exhibit 1.3 summarizes these opportunities that have potential to increase soybean demand, including among Missouri manufacturers. Some relate to Missouri Soybean Merchandising Council-funded innovations and technologies that could be further commercialized. Others represent more generic soybean component uses or applications where Missouri manufacturers have existing capabilities. The exhibit organizes these opportunities according to the estimated soybean volumes they could demand and the potential value that can be captured in the end products or markets. Note, whole soybean uses are shaded green, oil uses are shaded gold, and meal and hull uses are shaded blue.

Exhibit 1.3. Opportunities to increase Missouri soybean demand

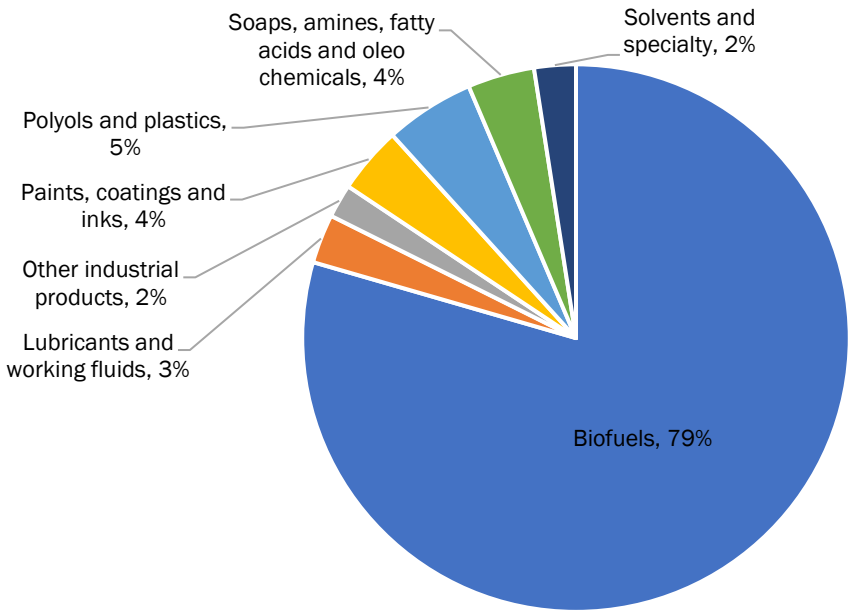


The following sections present an overview of Missouri feed, industrial products and food manufacturing sectors examined by the project team. The last section shares an analysis of soybean basis relationships in Missouri. The analysis describes price conditions and how they could evolve if changes occurred in the industry.

2. Industrial Products

Soy-based raw materials have multiple potential industrial applications, including fuels, adhesives, coatings, fibers, lubricants and plastics. Soybean oil use in industrial products is well-documented and growing. In the past 20 years, biofuel producers used more soybean oil for industrial purposes than other industrial products manufacturers. Of the approximately 5 million metric tons of U.S. soybean oil used to make industrial products in 2020, 79% found use in biofuels. See Exhibit 2.1. Other industrial use categories captured relatively smaller shares of total soybean oil. No data are available to indicate soybean meal or soybean hull use in industrial products.

Exhibit 2.1. Share of U.S. soybean oil industrial use by category, 2020



Source: Centrec and the United Soybean Board (marketviewdb.centrec.com)

In November 2021, the U.S. biodiesel industry's annual production capacity totaled roughly 2.389 billion gallons from 85 plants. Missouri ranked third with 243 million gallons of plant capacity. As such, Missouri's biodiesel industry has been a key soybean oil consumer within the state.

In the industrial sector, current soybean oil market drivers include the renewable diesel and sustainable aviation fuel industries. Proposed or announced renewable diesel projects would add 5 billion gallons or more in annual capacity by 2024. If those projects move forward and solely use soybean oil as a feedstock, then they could demand up to 67 million acres of soybeans. However, industry estimates suggest that annual production capacity will more likely range from 2 billion gallons to 3 billion gallons by 2025 because not all planned projects will ultimately operate. Still, many oil companies are partnering with agricultural companies to secure feedstock needed to produce renewable diesel and other types of fuel. Such new sources of soybean oil demand will create a more competitive industrial

marketplace for soybean oil and heighten the need for buyers, such as biodiesel producers, to strengthen feedstock relationships or contracts.

Based on the industrial products market research conducted for this project, Exhibit 2.2 identifies strengths, weaknesses, opportunities and threats related to expanding Missouri industrial use of Missouri-produced soybean components. Exhibit 2.3 names specific recommendations for increasing in-state use of soybean components.

Exhibit 2.2. SWOT analysis for Missouri soybean industry increasing in-state use of soybean components for industrial uses

Strengths	Weaknesses
• Based on jobs data, Missouri has a high concentration of industries that may use soy (e.g., manufacturers of storage batteries; power, distribution and specialty transformers; explosives; and unlaminated plastics film and sheet, except packaging). • Several Missouri firms have innovated products made from soy inputs (e.g., Express Chem, Soya System). • The MSMC industrial products investments can offer sustainability or renewable benefits. • Manufacturers may seek a local supply of soy components to stabilize access to inputs. • Emerging in-state investment infrastructure (e.g., venture capitalists, angel investors) offers financial support to startups.	• In some cases, soybean oil competes with other feedstocks that have a price and first-mover advantage. • Relatively small shares of soybean oil have been used for industrial purposes — the exception being biofuels. Therefore, these markets have been relatively niche but require efforts to open and sustain. • Missouri has trailed other states in installing small and large-scale batteries — those that store energy and may use soy components. • Industrial products manufacturers may not have the margins to pay premiums for inputs, despite their claims (e.g., non-GMO) attached to those inputs.
Opportunities	**Threats**
• Renewable diesel and sustainable aviation fuel innovations may increase soy oil use. • As building infrastructure investment grows, construction firms have the potential to demand more blasting agents and oxidizers. • To incentivize mining and construction companies to use explosives made from materials other than petroleum, an opportunity exists to create a procurement preference or get buy-in for alternatives. • Adoption of electric vehicles and deployment of large-scale storage batteries has expanded markets for batteries — potentially those made with soy carbon. • Light vehicle manufacturers may be targets to use electric batteries made from soy carbon and soy-based polyurethane materials. • Polyurethane manufacturers may use soy-based polyol in many products (e.g., building and construction materials, transportation and marine products, furniture and bedding).	• More industrial users (e.g., renewable diesel producers) sourcing soybean oil would increase the oil's price and affect the economics of other soy-based product manufacturing (e.g., biodiesel). • Much battery manufacturing occurs overseas and may limit U.S. input sales. • Coal mining has been a major use of some explosives. Switching to alternative energy may affect explosives demand. • U.S. consumers have shown more hesitation to adopt electric vehicles than drivers in international markets. • Use of renewable inputs may rely on policy decisions, which are difficult to foresee and may change. • Most analysts don't predict all announced renewable diesel capacity to be built. • Public and policy support of efforts such as the RFS and LCFS is needed to grow low-carbon solutions' adoption.

Exhibit 2.3. Recommendations to increase soybean demand in industrial products

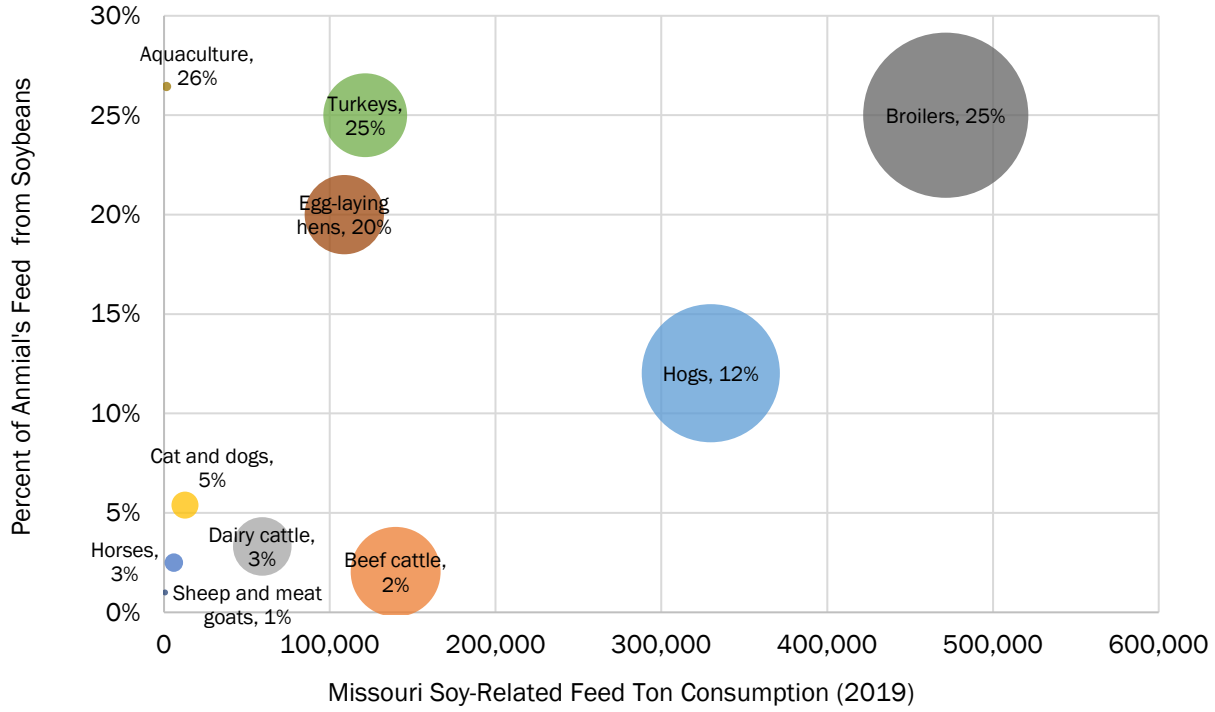
Category	Recommendations
Goal	• Elevate Missouri-produced soy component use in industrial products manufactured by Missouri facilities.
Strategy	• For each MSMC-commercialized technology, prioritize one market to understand and ultimately reach.
Tactics	• Weigh the market opportunity with other factors (e.g., policy environment, competition) to choose the opportunities that fit best with available resources. • Demonstrate the soy-based product's performance improvements, and document those findings in promotional materials.
Strategy	• Establish a boots-on-the-ground effort to convert Missouri industrial products manufacturers into soy component users.
Tactics	• Identify an industry liaison who can champion using soy components in key applications where MSMC has made investments. • Reach Missouri manufacturers that may demand soy components as inputs to assess their interest in choosing a Missouri-produced soy component. • Engage with industry associations that have members who make decisions about industrial products or components to source and use.
Strategy	• Support other Missouri industrial products manufacturers using soy components.
Tactics	• Connect these manufacturers with supply chain assistance to source Missouri-produced soy components. • Encourage manufacturers to participate in the Buy Missouri program, which requires that at least 51% of a product's content originates from Missouri (buymissouri.net).

3. Animal Production

Animal agriculture represents the largest customer for U.S. soybean meal. Approximately 98% of U.S. soybean meal is used to feed animals. In Missouri, feed uses demand 79% of all soy coproducts (oil, meal, hulls) by volume. In total, 58% of soybean coproducts consumed in Missouri goes into poultry. Hog production, which consumes 27% of soybean coproducts used for feed, ranks second behind broiler production for soy-based feed demand. Beef ranks third. Dairy, horse, sheep, meat goat and pet markets consume the rest.

Exhibit 3.1 details soy-related feed consumption in Missouri. For each species, it estimates the percent of the diet that is soy-related. Rations for Missouri's monogastric animal industries — namely, poultry and hogs — depend significantly on soybean meal. Missouri's beef cattle herd is not a major soybean meal user, but it is a large soy hull consumer.

Exhibit 3.1. Missouri soy-related animal feed consumption by species



Source: Data derived from Decision Innovation Solutions (decision-innovation.com/market-analytics/animal-food-consumption/) and other industry experts.

To quantify the opportunity for Missouri soybeans to satisfy in-state feed demand, Exhibit 3.2 estimates the soybean meal and hulls demanded by different animal species raised by operations of varying sizes. According to these estimates, raising chickens for meat production or egg production can greatly increase Missouri soy feed ingredient demand due to these diets' high soy inclusion rates and the number of animals needed for a complex or processing plant. However, other animal species could significantly change soybean

coproduct demand if large single operations or stacked multiple units within the state adopt soy components or use more soy inputs for their animals' rations.

Exhibit 3.2. Estimated soybean demand from potential animal industry growth

Sector	Operation or complex size	Annual soybean meal and hull demand (tons)	Bushels needed	Acres needed*
Broilers	50 million birds/complex	75,000	3,225,806	64,516
Egg-laying hens	2 million birds/complex	17,000	731,183	14,624
Dairy cattle	3,500 cows/operation	3,686	153,200	3,064
Breeding hogs	1,200 sows/operation	326	14,022	280
Market hogs	2,480 head/operation, 2 turns	290	12,473	249
Turkeys	10,000 birds/building, 2 turns	140	6,022	120
Beef stockers	1,000 head backgrounded, 2 turns	105	4,364	87
Beef fed cattle	1,000 head capacity, 2 turns	100	4,167	83
Aquaculture	60-acre pond, catfish production	85	3,656	73

*Assumes 50 bushels per acre yield.

Based on research conducted for this project, Exhibit 3.3 identifies strengths, weaknesses, opportunities, and threats related to the Missouri soybean industry's opportunity to expand soybean use within Missouri animal agriculture industries. Specific recommendations for increasing in-state use of soybean components can be found in Exhibit 3.4.

Exhibit 3.3. SWOT analysis of Missouri's future animal agriculture growth

Strengths	Weaknesses
• Farms are likely to position new sow units in remote, biosecure locations instead of hog production-dense areas in the Corn Belt. • Chicken consumption continues to grow, and Missouri is just north of a dense broiler production cluster in Arkansas. • Expanding Missouri's beef slaughter capacity will lead to finishing more cattle in the state. • Growth in free-range layer facilities will likely occur at the same latitude where these facilities have already emerged in Missouri.	• State permitting and local planning and zoning restrictions affect the potential for new CAFO facilities to start up and operate. • For businesses that run large confinement dairies or open feedlots, Missouri's climate is not as attractive as the climate in other states. • Access to immigrant labor affects where processors decide to locate and where new production complexes have the most opportunity.
Opportunities	**Threats**
• Consumers' emerging health and animal welfare preferences open the potential for producing more eggs with specialty characteristics. • The commodity egg industry will rebuild layer housing to adhere to cage-free rules, which a segment of consumers has demanded. • Poultry and pork meat exports from the U.S. will become more competitive with meat produced in other countries. This will be due to soybean meal prices declining as the soybean meal supply increases — a side effect of trying to meet demand for renewable diesel, which may use soybean oil as a feedstock.	• Broiler and layer facility location decisions depend on choices made by a few critical corporate decision-makers. • Consumer acceptance of plant-based substitutes may hinder sales growth potential for animal products. • Animal producers in competing states have access to less expensive soybean meal because of their proximity to new crush plants. • New animal production capacity tends to locate near existing industry clusters.

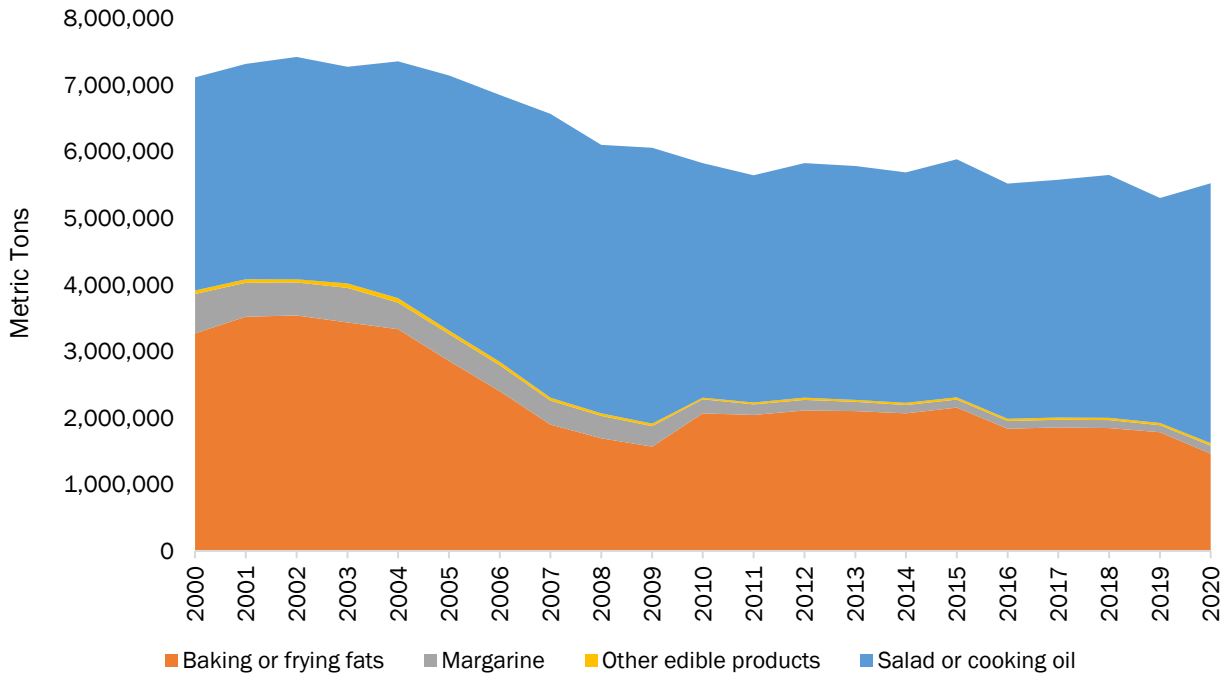
Exhibit 3.4. Recommendations to increase soybean demand by animal sector

Sector	Category	Recommendations
Poultry	Goals	• Attract new broiler, egg-laying hen and turkey complexes into Missouri. • Strengthen soybean coproduct use in existing Missouri broiler, layer and turkey diets. • Develop demand for SOYLEIC non-GMO soybean meal.
	Tactics	• Identify an industry liaison experienced in the Missouri poultry industry. • Connect with key poultry stakeholders and nutritionists from leading Missouri companies and other leading U.S. businesses. • Identify areas of Missouri that accept poultry production, have farmers willing to be contract-producers and offer the labor force necessary for poultry processing.
	Contacts	• The Poultry Federation • Missouri Poultry Yearbook from Missouri Department of Agriculture • Top U.S. poultry companies from Watt Global Media • U.S. Meat Export Federation
Hogs	Goals	• Add sow inventory and farms in Missouri. • Finish more Missouri-born pigs within state.
	Tactics	• Identify areas in Missouri suitable for swine production. • Work with existing swine integrators to locate feeding barns in Missouri.
	Contacts	• Smithfield Foods, JBS and Pipestone have sow operations in Missouri. • Missouri Pork Association
Beef cattle	Goals	• Encourage additional beef stocker/backgrounding production in Missouri. • Encourage additional beef cattle finishing in Missouri.
	Tactics	• Connect with larger Missouri backgrounding and feedlot operators. • Support intentional crossbreeding of beef on dairy for dairy grazing herds.
	Contacts	• Veterinarians, semen companies, regional livestock markets and universities
Dairy cattle	Goals	• Attract new large-scale confinement dairies to Missouri. • Develop demand for SOYLEIC non-GMO soybean meal.
	Tactics	• Partner with Missouri Department of Agriculture and Missouri Dairy Growth Council to facilitate large dairies starting or moving to Missouri. • Connect with feed mills and nutritionists. • Connect with Mid-South Dairy Records for top-producing Missouri cow herds.
	Contacts	• Organic/non-GMO contact: NEMO Feed • Mid-South Dairy Records • Kurt Olsen, Missouri Department of Agriculture
Aquaculture	Goals	• Add soybean coproducts to Missouri aquaculture diets.
	Tactics	• Develop new aquaculture enterprise budgets, and increase educational programming around aquaculture in Missouri. • Connect with existing Missouri aquaculture businesses about soybean coproduct usage in their operations.
	Contacts	• Missouri Aquaculture Directory • Missouri Aquaculture Association • MU Aquaculture/Fisheries Extension and Lincoln University Extension

4. Food Products

Making soy foods from whole soybeans consumes a relatively small share of the world's soybeans. Just 6% of the soybeans produced globally are used to make whole soybean products such as tofu and soy milk. Other food products containing soy ingredients feature oil or meal. Exhibit 4.1 details U.S. soybean oil consumption by food use category from 2000 to 2020. Consumption for food use totaled 6.35 million metric tons in 2020. During the mid- to late 2000s, soybean oil demand for baking and frying uses dropped, and the industry saw an uptick in the oil's use as a salad or cooking oil.

Exhibit 4.1. U.S. soybean oil food use by category, 2000 to 2020



Source: Centrec and the United Soybean Board (marketviewdb.centrec.com)

U.S. soybean cake and meal produced for edible uses is a small U.S. industry. Animal feed has been the predominant cake and meal user. Of all soybean cake and meal produced, the portion directed to edible protein products has been relatively small — just 1.1% to 1.7% from 2016 to 2020. Production for edible uses has averaged 584,597 tons in the past three years (2019 to 2021).

The Missouri Soybean Merchandising Council has invested in developing several innovations that have the potential to open or expand markets for soybeans in Missouri-produced food products. Those include high-oleic soybean oil, vitamin B12-fortified soy foods such as soy milk and tofu, nondairy ice cream made from high-oleic soybean oil and spray-dried powder to substitute for soy protein isolate. Other market opportunities with the potential to expand soy-related demand in Missouri-produced food include meat substitutes, snack bars, cheese, breakfast cereal, bread, beverages and supplements.

Based on the market research conducted for this project, Exhibit 4.2 identifies strengths, weaknesses, opportunities and threats related to expanding Missouri food manufacturers' use of Missouri-produced soybean ingredients. The recommendations in Exhibit 4.3 share ideas about how to increase in-state use of soybean components.

Exhibit 4.2. SWOT analysis for Missouri soybean industry increasing in-state use of soybean-derived food ingredients

Strengths	Weaknesses
• Several industries with the potential to use soy ingredients concentrate in Missouri, based on jobs data. Those include breakfast manufacturing; pasta, dough and flour mixes; ice cream and frozen dessert manufacturing; fats and oils refining and blending; and flour milling. • Soyleic oil allows high-oleic oil users to make non-GMO claims on packaged goods. • Soy protein derived from Soyleic soybeans has some advantages relative to commodity soy protein. Those include desirable color, blending potential and shelf life. • With widespread production, soybean ingredients represent an economical ingredient option.	• The premium associated with Soyleic non-GMO soybean oil may make the ingredient cost-prohibitive for some food companies. • Relative to other states, Missouri firms have made minimal investments in processing capacity to produce whole soy foods (e.g., soy milk, tofu). • Protein products made from soy may have consumer acceptance problems because of the ingredient's allergen risk and flavor.
Opportunities	**Threats**
• Soyleic's non-GMO attribute especially appeals to consumers purchasing food to eat at home — a category that grew during the pandemic. • Supply chain constraints caused by the pandemic led some consumers to choose products, such as tofu, they hadn't used consistently. Those buyers may be maintained in the long term. • MSMC-funded research into fortifying soy foods with vitamin B12 has the potential to make a plant-based product fortification standard — just as dairy milk is typically fortified with vitamin D. • The Show-Me Food, Beverage and Forest Products Manufacturing Initiative may recruit more processors that could use Missouri-produced soy. • The St. Louis region has been identified as a hub for plant-based food manufacturing. • Blending soy with other proteins may improve the "completeness" of those other proteins while balancing some of soy's drawbacks, such as flavor.	• Soy ingredients face competitive threats from alternative ingredients. For example, in the alternative milk category, soy milk has lost significant share to almond and oat options. • Because plant-based product manufacturers are relatively new, they may be more open to choosing novel ingredients and scaling their supply chains over time to provide enough of those novel ingredients. • Although an opportunity, plant-based foods (e.g., meat alternatives) may be perceived as highly processed compared with traditional alternatives (e.g., animal meat). Consumers interested in minimal ingredients may choose not to switch to plant-based options.

Exhibit 4.3. Recommendations to increase soybean demand by soy ingredient

Product	Category	Recommendations
Oil	Goal	• Open new in-state markets for Soyleic non-GMO, high-oleic soybean oil. • Increase sales of Missouri-grown soybean oil to Missouri food manufacturers.
	Strategies	• Educate Missouri food businesses about the advantages of Soyleic oil. • Engage an industry liaison or third-party business to champion Missouri-produced soybean oil as an ingredient option. • Introduce soybean oil to emerging food businesses.
	Tactics	• Invest in Soyleic use trials that demonstrate fry life or shelf life improvements attributed to the high-oleic trait. • Contact Missouri manufacturers in key categories that may use soybean oil. (This report lists Missouri manufacturers by product category.) • Communicate with foodservice establishments (e.g., restaurants) based in Missouri to identify potential markets for soybean oil. • Reach out to Bright Future Foods, a St. Louis food incubator that operates as a subsidiary of Post Holdings. The incubator has invested in two climate-friendly food brands: Airly Oat Clouds and EverGrain. • Build awareness of soy ingredient applications through the Missouri Food Entrepreneur Network (MO-FEN). • Support value chain stakeholders such as Tiger Soy, Moberly Natural Crush and Benson Hill as they grow and add value to Missouri-produced soybeans.
Protein	Goals	• Open new in-state markets for Soyleic soy protein. • Increase sales of Missouri-grown soy protein to Missouri food manufacturers.
	Strategies	• Educate Missouri food businesses about Soyleic soy protein's advantages. • Engage an industry liaison to build relationships with Missouri food manufacturers. • Participate in industry conversations to raise soy protein's profile as a food ingredient.
	Tactics	• Aggregate research findings that show how Soyleic protein's attributes (e.g., color, blending potential, shelf life) offer advantages. • Package those findings into promotional materials. • Contact Missouri firms that manufacture foods that list soy protein as an ingredient. (This report lists Missouri manufacturers by product category.) • Reach out to Bright Future Foods, a St. Louis food incubator that operates as a subsidiary of Post Holdings. The incubator has invested in two climate-friendly food brands: Airly Oat Clouds and EverGrain. • Build awareness of soy protein applications through the Missouri Food Entrepreneur Network (MO-FEN). • Assess whether to support the University of Minnesota's Plant Protein Innovation Center or replicate the effort with Midwest soy centers at the University of Missouri, Purdue University and Iowa State University. • Collaborate with soybean checkoff organizations in neighboring states to create a program modeled after the Plant Protein Highway formed in the Upper Midwest and Canada. • Support value chain stakeholders such as Tiger Soy, Moberly Natural Crush and Benson Hill as they grow and add value to Missouri-produced soybeans.

5. Missouri Soybean Basis

Basis involves prices of two attributes of a product. *Quality Basis* relates to the price difference between two different qualities of the same commodity; example: high oil content soybeans minus Grade 1 standard soybeans. *Spatial Basis* is the difference in prices of the same product at two different locations; example: Grade 1 yellow soybeans in Cape Girardeau, Missouri minus St. Joseph, Missouri. The core economic story for a price difference over space is transportation cost. If spatial basis exceeds cost to transport a product between two locations, the product will be moved from lower to higher price locations. *Temporal Basis* is the difference in price between the same product at two different points in time; example cash soybean price, St. Louis, Missouri (futures contract delivery point) minus July 2022 Chicago futures price. Temporal basis is economically expressed as the cost of storage. If temporal basis exceeds storage cost, an incentive exists to store the product. Storage costs include (a) physical storage cost, (b) interest opportunity cost, and (c) insurance (for physical destruction of product). Transportation arbitrage and storage costs are two primary ways grain elevators generate revenue from trading grain.

Basis tends to follow historical and seasonal patterns in Missouri. The market economy of the United States allows grain to flow through an interconnected transportation system to the highest buyers, meaning basis is influenced by transportation cost, ocean shipping spreads, ending stocks, and interest rates regardless of destination. Basis can be a signal of demand strength but is primarily a tool end users and merchandisers use to control the flow of grain in and out of the market. In cases where futures markets are not providing the signal for soybean producers to sell, grain merchandisers might be required to increase basis to encourage the flow of grain into a receiving location. The opposite is true if futures prices are rising on high global demand or short supplies. Therefore, it is incorrect to say strong demand increases basis. Proximity to end users does impact the magnitude basis values change regarding variations in transportation costs. Areas with multiple demand sources like Southeast Missouri, where export markets compete with domestic users for soybeans, tend to have stronger basis values but also increased volatility.

Exhibit 5.1 illustrates the seasonality of Missouri basis for Mexico, Missouri. Basis has tended to weaken rapidly late summer into the fall. Historically, soybean basis has strengthened considerably from early October through December. Although specific to one geographical region of the state, most basis values follow the same spot basis seasonal pattern except those serving international export demand. Large soybean export demand early in the marketing year increases the need for grain flow in areas serving export markets. Chicago futures prices are usually weakest at harvest compared to the rest of the year due to the new crop hitting the market. For end users and grain merchandisers needing soybeans to fill export contracts, the decline in futures prices sends the wrong signal to producers holding grain. Figure 5.2 illustrates how stable basis is throughout the year for western regions of Missouri that primarily serve livestock meal demand compared to the seasonal nature of the Mississippi River export market. The U.S. exports most of its annual soybean exports between October and March. Basis swings in export markets are difficult for domestic end users who buy soybeans throughout the year to navigate.

Figure 5.1. Three-year and five-year average soybean basis for Mexico, Missouri*

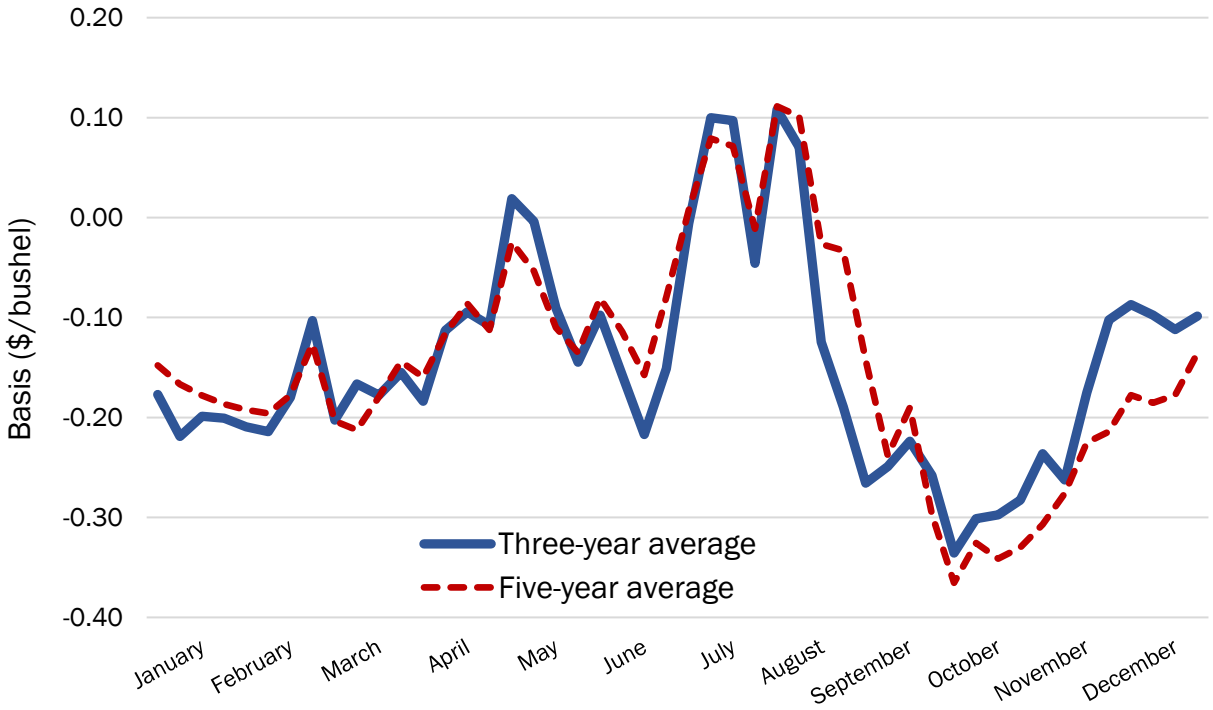
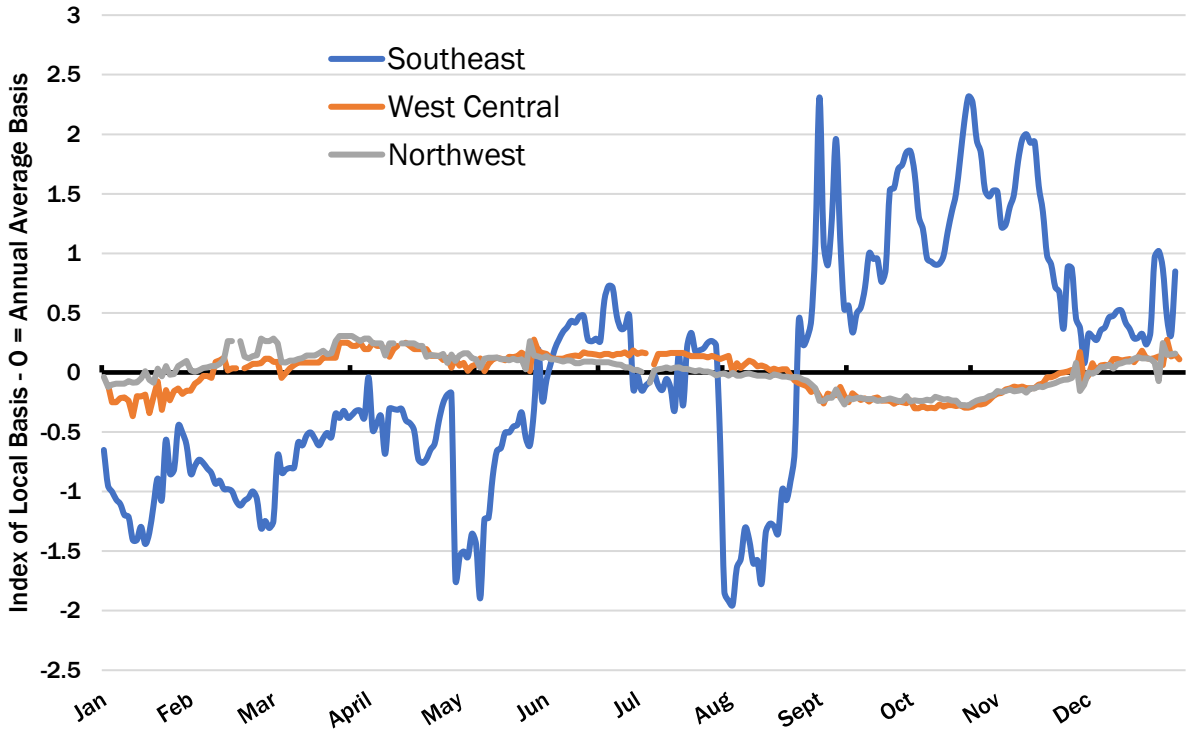


Figure 5.2. Three-year index* of Missouri basis intensity by geographical region



* Five-year average represents 2016 to 2021; three-year average represents 2018 to 2021

Exhibits 5.3 and 5.4 illustrate Missouri soybean spatial basis (Missouri location minus New Orleans, LA) on July 20, 2020, and October 20, 2020, respectively. These dates were selected because they represent two different points in the marketing year (July and October) and two different marketing years 2019/20 and 2020/21. Even with these differences, similar patterns emerge. Missouri basis is highly connected to a transportation network that serves all soybean end users. As long as international buyers demand U.S. soybeans, the Mississippi river market will have the stronger basis bids compared to the rest of the state due to lower transportation costs. However, this international demand is currently seasonal, leading to relatively large swings in basis prices.

Exhibit 5.3. Missouri soybean spatial basis, July 20, 2020

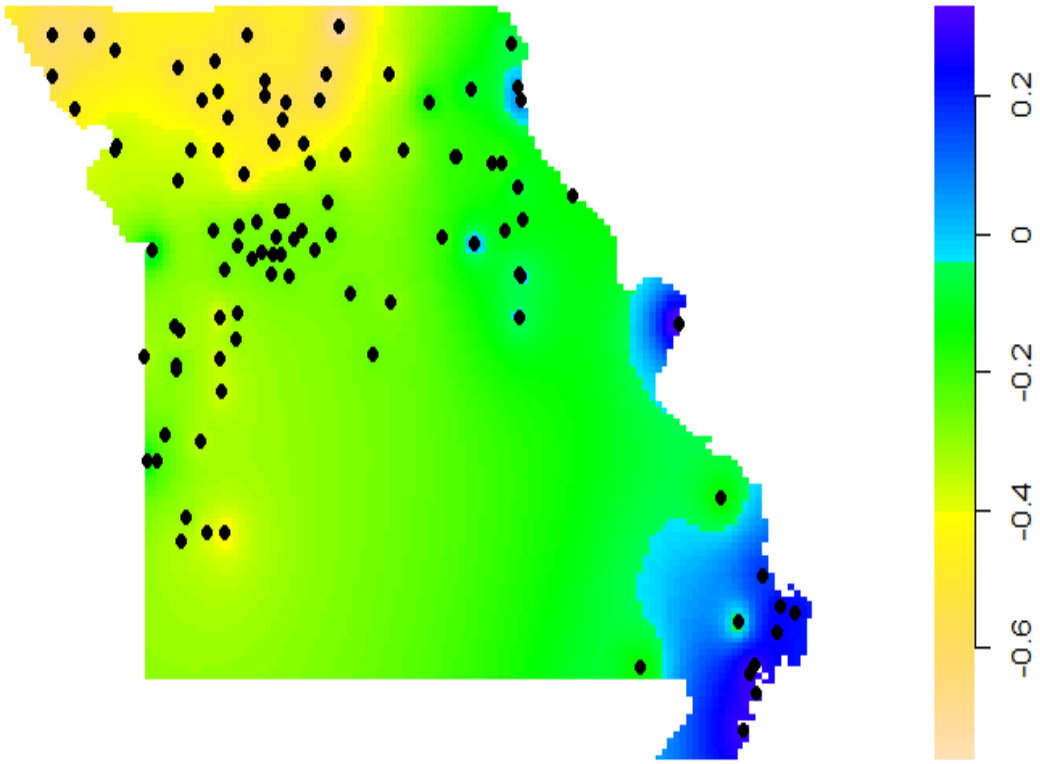
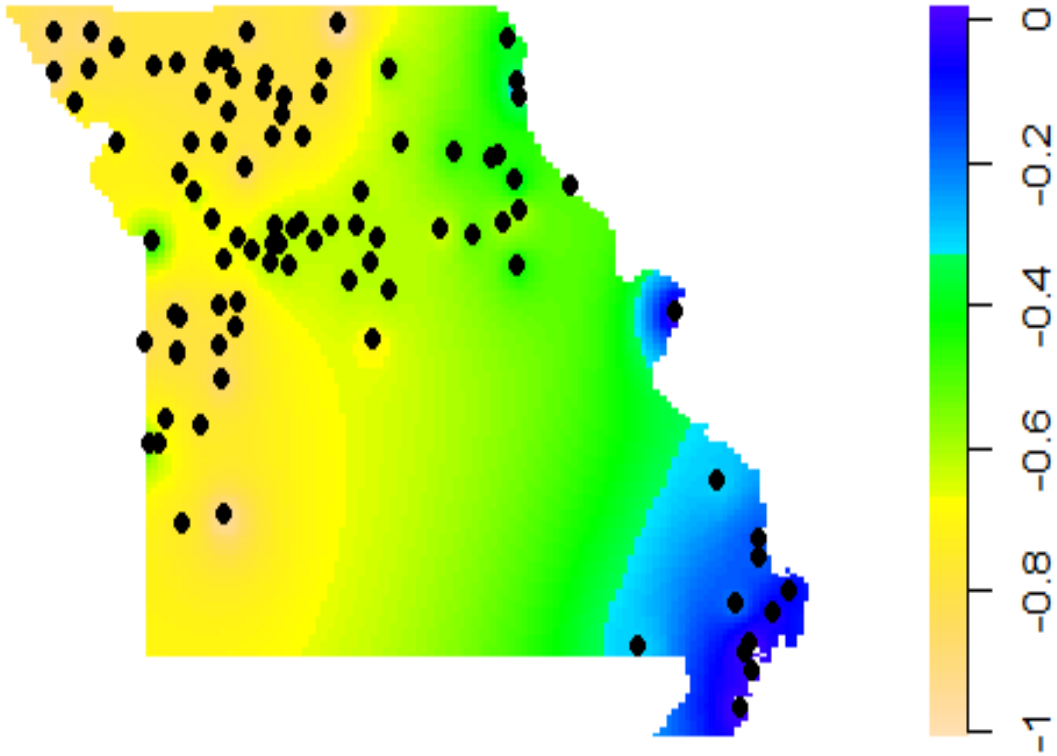


Exhibit 5.4. Missouri soybean spatial basis, October 20, 2020



In summary, basis is a tool used by end users and merchandisers to control the flow of grain in a local market. There are multiple variables that impact basis values in any one location including quantity of storage, transportation costs, interest rates and local supply. Basis across Missouri has been relatively stable over time. As global and local demand for soybeans has increased, regional production has increased as well and returned local basis to its long run average.

Growing Missouri Soybean Demand: Animal Production

Commissioned by the Missouri Soybean Merchandising Council

Funding provided by the Missouri Agricultural and Small Business Development Authority

March 2022

Missouri Soybeans

Extension
University of Missouri

MASBDA
Missouri Agricultural and Small Business Development Authority

Growing Missouri Soybean Demand: Animal Production

This report explains animal demand for soybean products in Missouri, and it explores future growth opportunities to supply those products to Missouri's animal agriculture industries.

Livestock operations, particularly poultry and hog operations, serve as the major soybean product consumers in the state. Information presented in this report examines the comprehensive Missouri animal protein industries that use soybean products. Details include how each industry is currently positioned and may progress in the future. Finally, the report suggests how each industry might be induced to use more soybean products.

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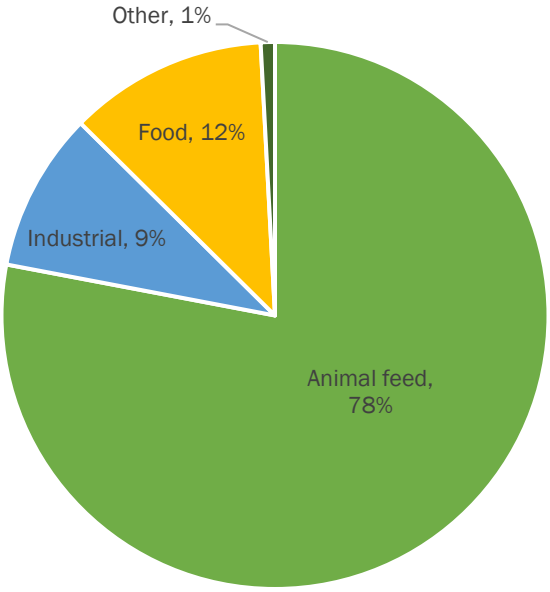
1. Summary

In the U.S. overall, animal agriculture represents the largest customer for soybean meal. Approximately 98% of U.S. soybean meal is used to feed animals. Of total U.S. soy-based product tonnage consumed by animals, soybean meal captures the largest volume (86%). Following it are soy hulls (11%), soybean seeds (2%) and soybean oil (1%).

Missouri exports 45% of the soybeans it grows to other states or countries as raw beans. The remaining 55% of the state's soybean crop is crushed or used inside Missouri. A review of Missouri animal sectors that currently consume soybean coproducts informs how to potentially increase soybean demand in the future.

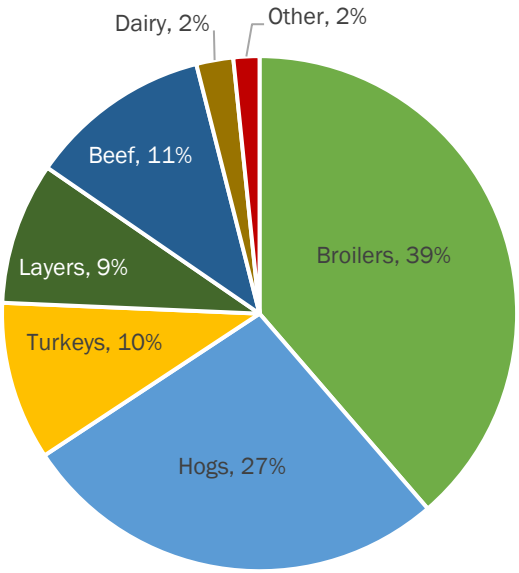
Animals consume soy-related feedstuffs including soybean meal, soy hulls, whole soybeans and soybean oil. As depicted in Exhibit 1.1, animal feed dominates Missouri soybean coproduct consumption by volume. In Missouri, feed uses demand 78% of soy coproducts. Therefore, animals fed in-state drive soybean product volume demand.

Exhibit 1.1. Share of Missouri soybean and soybean coproduct use volume by sector



Poultry consumes more soy-related animal feed in Missouri than other species. See Exhibit 1.2. Broilers consume 39%, turkeys consume 10% and layers consume 9% of soybean coproducts used for feed in the state. In total, 58% of soybean coproducts consumed in Missouri goes into poultry. Hog production, which consumes 27% of soybean coproducts used for feed, ranks second behind broiler production for soy-based feed demand. Beef ranks third. Dairy, horse, sheep, meat goat and pet markets consume the rest.

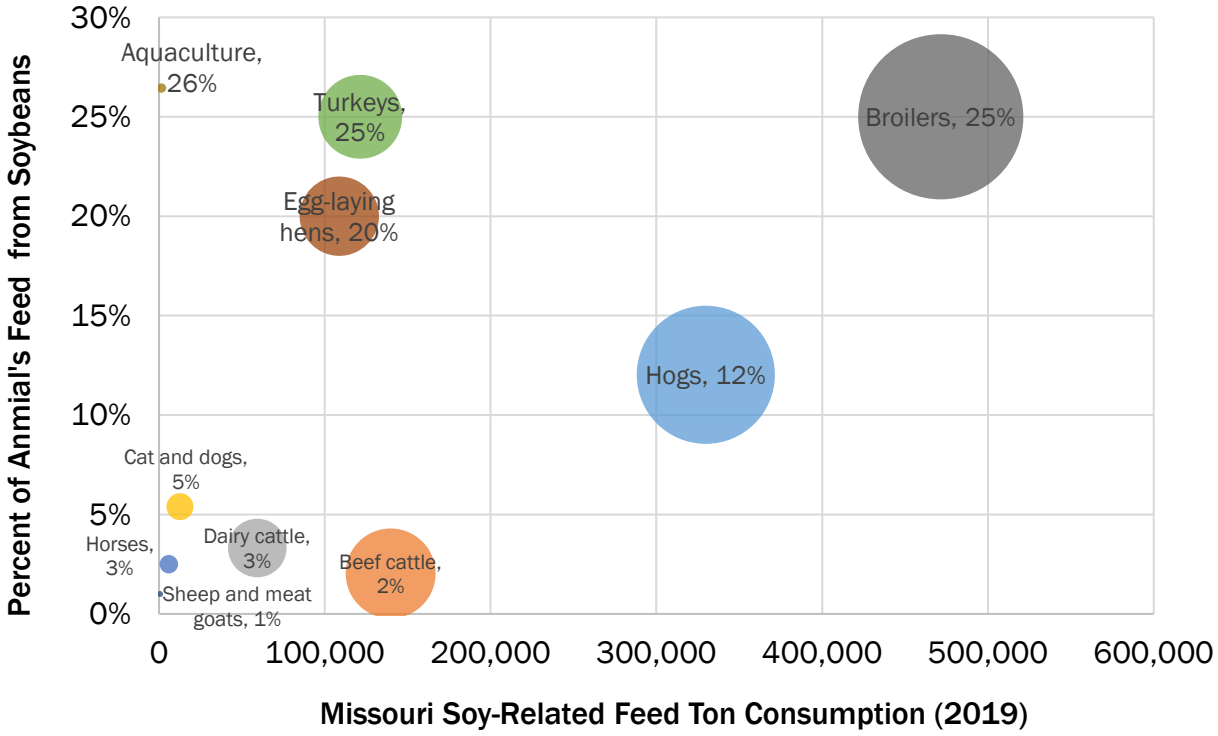
Exhibit 1.2. Missouri soybean animal feed usage by sector



Source: Decision Innovation Solutions (decision-innovation.com/market-analytics/animal-food-consumption/)

Exhibit 1.3 details soy-related feed consumption in Missouri, and for each species, it approximates the percent of the diet that is soy-related.

Exhibit 1.3. Missouri soy-related animal feed consumption by species



Source: Data derived from Decision Innovation Solutions (decision-innovation.com/market-analytics/animal-food-consumption/) and other industry experts.

Soybean meal provides a high-protein, high-quality protein feed for animals. Younger growing animals and lactating animals require the highest protein levels in their diets. Feed rations for these animals typically have a high soybean meal inclusion rate.

The following discussion highlights the extent of Missouri animal production and the implications for soybean feed demand. Rations for Missouri's monogastric animal industries — namely, ***poultry*** and ***hogs*** — depend significantly on soybean meal, which is lower in fiber than many cheaper intermediate-level proteins. Soybean meal is also higher in amino acids normally not found in the high-corn diets fed to monogastric animals.

The broiler and hog industries are the two largest consumers of Missouri's soy-related feed ingredient tonnage. Annual demand from both industries exceeds 300,000 tons. For broilers, egg-laying hens and turkeys, soybean meal makes up more than 20% of their diets.

Missouri's ***beef cattle*** herd is not a major soybean meal user, but it is a large soy feedstuff consumer. The state's beef industry uses more than 139,000 tons of soy ingredients. Beef cattle consume more soy hulls than other soy-related feedstuffs. Soy hulls and soybean meal make up 2% of Missouri's cow-calf herd diet, which depends primarily on pasture and hay. Stocker cattle and finishing calves typically consume low-cost soy hulls in rations.

Soybean feedstuffs make up 3% of total feed and harvested forage that ***dairy*** cattle consume. The dairy sector demands soybean meal for protein and soy hulls for highly digestible soluble fiber. Because Missouri's dairy herd is less than 4% of the size of its beef cattle herd and slowly shrinking, dairy's overall impact on soy ingredient use is small.

Aquaculture is an emerging industry to demand soy-based feed ingredients. In general, soybean meal represents approximately 26% of food fish or fingerling diets. Fish require higher crude protein than most commercially produced livestock. Missouri has a small aquaculture industry compared with aquaculture industries in other U.S. states.

Other animal species also consume soy coproducts on a smaller scale. Rations for ***sheep***, ***meat goats*** and ***horses*** have small soy-related inclusion rates. No more than 5% of purchased feed provided to these animals is soy-based. In Missouri, these species do not present a significant opportunity to greatly increase soy product demand.

Missouri is a leading U.S. state in ***pet food*** production. The state has 15 pet food facilities that procure more than 1 million tons of pet food ingredients annually. Soy-related ingredients represent about 6% of the pet food volume produced. Soybean meal, soy flour and soybean hulls make up about 94% of the soy-related products used in pet food. Missouri facilities that make cat or dog food could add Missouri soy-related ingredients to their formulas or increase their use of such ingredients.

Exhibit 1.4 summarizes the opportunities for increasing soy-related demand within Missouri animal production. For each animal sector, the table describes how these sectors operate and potential paths to increase use of Missouri-grown soybeans to feed animals.

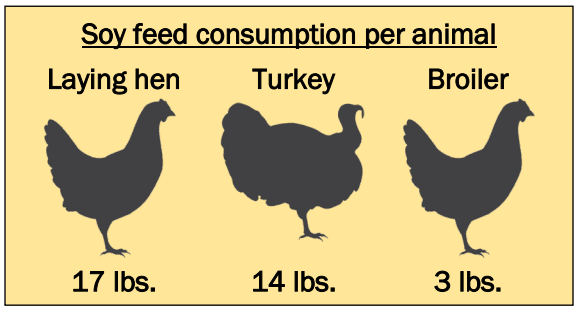
Exhibit 1.4. Opportunities to expand soy-related demand within Missouri agriculture

Sector	Discussion
Broilers	Industry growth depends on business plans of major integrated companies. Georges, Simmons Foods and Tyson Foods currently offer contracts to Missouri growers. New broiler complexes typically are sized for around 50 million birds annually. Complexes include feed mill, hatchery, contract growers and processing facility. Each complex would require about 200 contract broiler houses. Modern buildings house approximately 30,000 birds that have six- to seven-week production cycles. Farmer-contractors tend to have three buildings per location.
Egg-laying hens *(Commodity eggs, large scale)*	Industry growth depends on business plans of commodity egg companies currently operating in Missouri or attracting a new entrant. Rose Acre Farms and Cal Maine currently operate in Missouri. The complete egg-laying complex is typically company-owned, and integrated contract production isn't needed. A 2 million-bird complex is conventional size.
Egg-laying hens *(Specialty eggs, contract production)*	Industry growth depends on business plans of specialty egg producers already contracting with growers in Missouri or new entrants. Existing specialty egg companies with grower contracts in the state include Opal Foods, Vital Farms and Mid-States Specialty Eggs. Specialty eggs include those with claims such as pasture-raised, free-range, organic, non-GMO and high-omega-3. Growth in new units to produce cage-free or free-range eggs opens opportunities in Missouri due to the state's moderate weather and small farms.
Turkeys	A stagnant industry which could change with increased turkey meat exports. Growth depends on existing integrated companies, Butterball or Cargill Protein, or attracting a new integrator. Modern buildings house approximately 10,000 birds that have 14- to 20-week production cycles. Three buildings per location is common.
Hogs for breeding	Smithfield Foods, JBS and Pipestone influence the Missouri breeding hog sector's potential growth. New sow farms commonly add 1,200 sows. Biosecurity concerns that result from concentrated hog production lend support to future growth plans for Missouri's breeding hog herd.
Market hogs	More than half of Missouri-born pigs are not raised to slaughter weight within the state. A typical building for wean-to-finish hogs will hold 1,240 hogs, and sites typically have two or more buildings.
Beef stockers	The biggest growth opportunity for soy in Missouri's cow-calf industry could be more pasture-based or dry lot backgrounding, which would typically involve raising steers or heifers up to 800 pounds.
Beef fed cattle	Slaughter capacity growth from Missouri processors creates opportunities for beef cattle finishers. Existing farmers could develop dry lot or covered finishing facilities ranging from 100- to 1,000-head capacity. Missouri currently finishes less than 15% of calves born in the state.
Dairy cattle	Missouri's 69,000 dairy cows consume soy coproducts, but they represent a relatively small piece of total in-state soybean demand. The industry is contracting slowly. Growth in the form of large-scale startup farms, relocations from other U.S. states and Missouri dairy producers incrementally scaling operations would be needed to revamp Missouri's dairy industry and increase its soy product demand.
Aquaculture	Missouri has a small aquaculture industry — about 26 farms — but has potential for growth through scaling operations or attracting new entrants. Aquaculture production systems include pond culture, flow-through or recirculation. The minimum pond size for food fish production is considered 5 acres.

2. Poultry

Industry perspective

In 2019, Missouri's poultry and egg production sector generated $1.2 billion in farm revenue. Of this total, broiler chickens accounted for 56% ($700 million); turkeys, 27% ($341 million); eggs, 17% ($219 million); and farm chickens, 0.1% ($1.1 million).



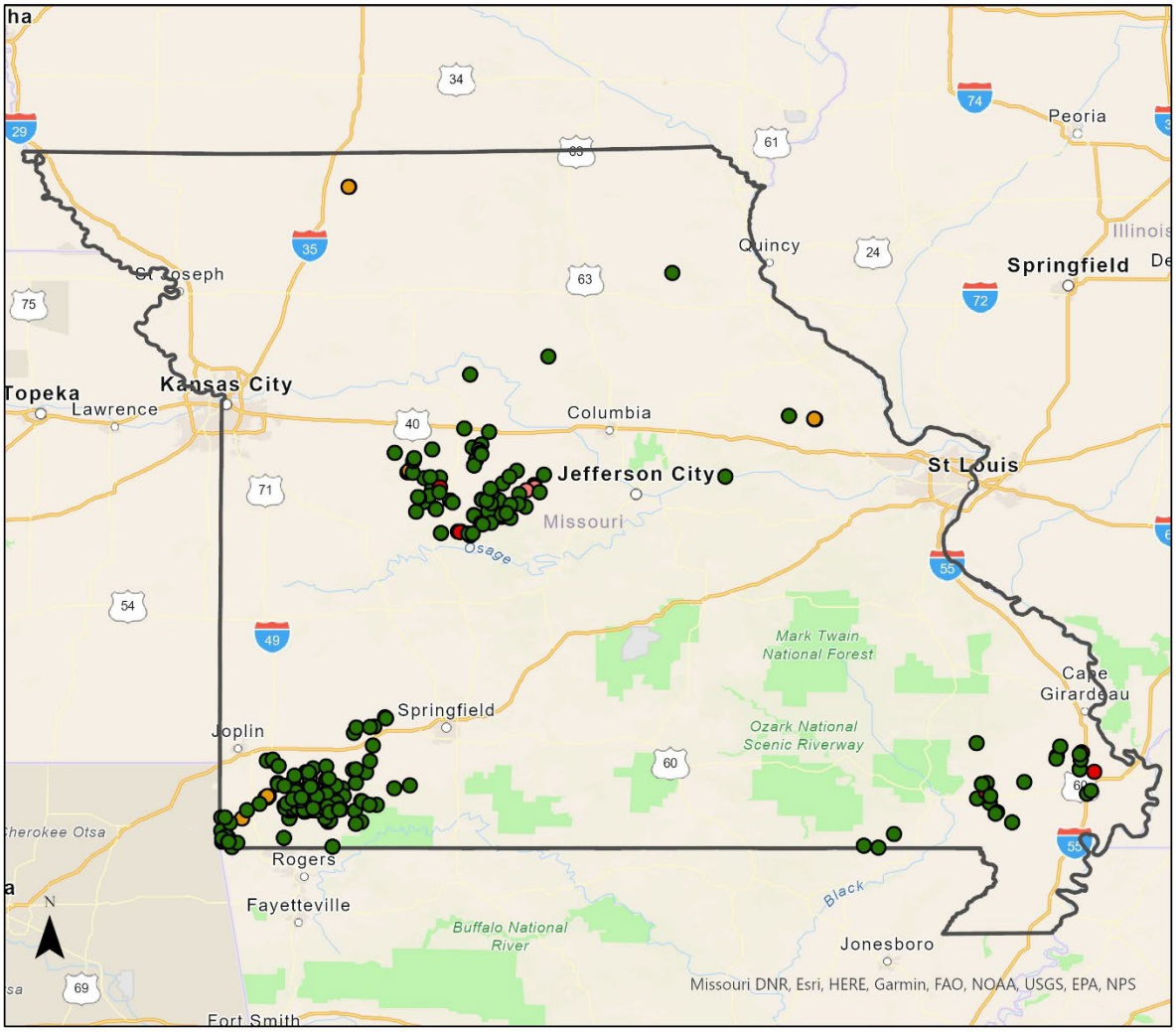
In 2020, approximately 290 million broilers were raised in Missouri, which ranks eighth in the U.S. for broiler production. For turkeys, 16.5 million were raised in Missouri, which ranks fifth in the U.S. for turkey production. Missouri has four turkey plants, but only Butterball and Cargill Protein slaughter turkeys. Six broiler chicken processing plants are located in southwest, southeast and central Missouri. Exhibit 2.1 lists broiler and turkey companies and their plant locations. Exhibit 2.2 shows locations of permitted poultry operations in Missouri.

Exhibit 2.1. Broiler and turkey companies in Missouri and plant locations

Type	Company	Location of Missouri Processing Plants
Broiler	George's Inc.	Cassville (1)
Broiler	Simmons Foods	Southwest City (1)
Broiler	Tyson Foods	Sedalia (1), Dexter (1), Noel (1), Monett (1)
Turkey	Butterball	Carthage (1)
Turkey	Cargill Protein	California (1)
Turkey	Tyson Foods	St. Joseph (1), Kansas City (1)

Source: WATT Poultry USA 2021 (batchgeo.com/map/wattpoultrytopcompanies2021)

Exhibit 2.2. Poultry concentrated animal feeding operations (CAFOs) in Missouri



Broiler, Fryer and Roaster Chickens CAFO Type

- General CAFO IB
- General CAFO IC

Chicken Eggs CAFO Type

- General CAFO IB
- Site-Specific CAFO (IA)

Type	Chicken laying hens, pullets and broilers with a wet handling system	Checken laying hens without a wet handling system	Chicken broilers and pullets without a wet handling system
Class IA	210,000	574,000	875,000
Class IB	90,000 to 209,999	246,000 to 573,999	375,000 to 874,999
Class IC	30,000 to 89,999	82,000 to 245,999	125,000 to 374,999

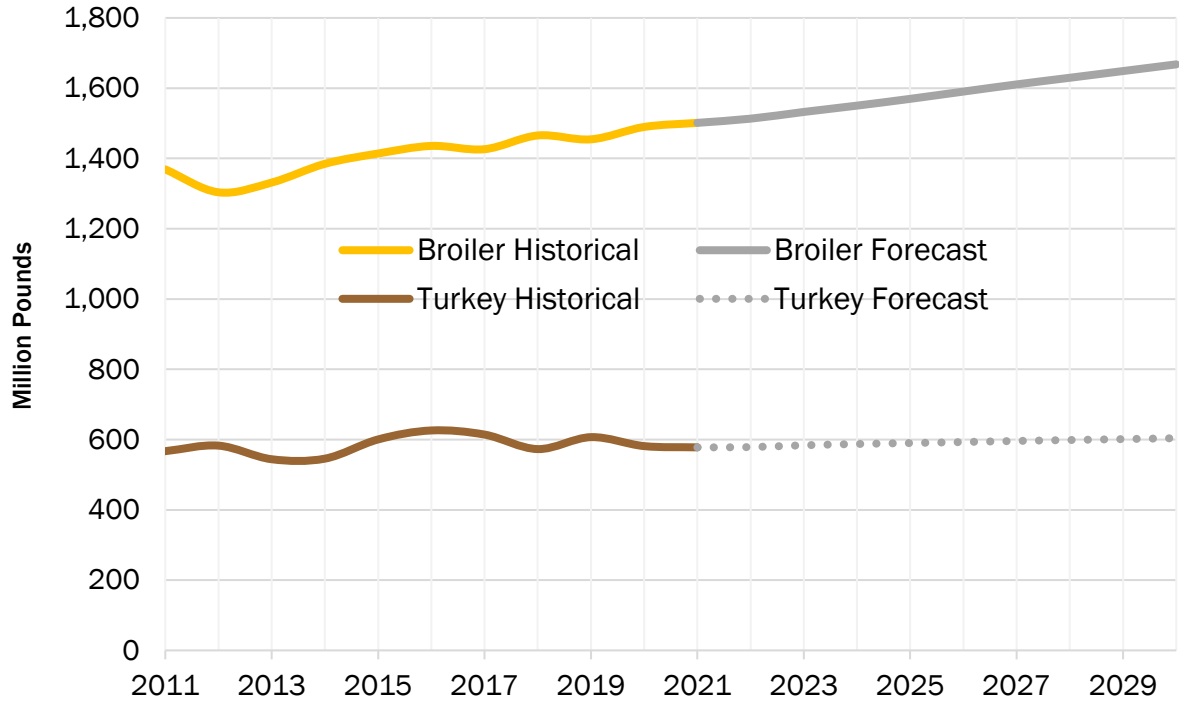
Heartland GIS

Created March 23, 2022

Source: Missouri Department of Natural Resources (modnr.maps.arcgis.com/apps/webappviewer/index.html?id=cf630b020a17452fb30994cb4b36f003)

Exhibit 2.3 charts historical broiler and turkey production numbers from USDA and a future forecast for these industries from the MU Food and Agricultural Policy Research Institute (FAPRI). Broiler production is forecast to grow approximately 1% per year through 2030. In 2030, the state's broiler production is expected to total 1.667 billion pounds. Turkey production is also expected to grow after 2021 but only by about 0.5% per year.

Exhibit 2.3. Missouri historical and projected broiler and turkey production

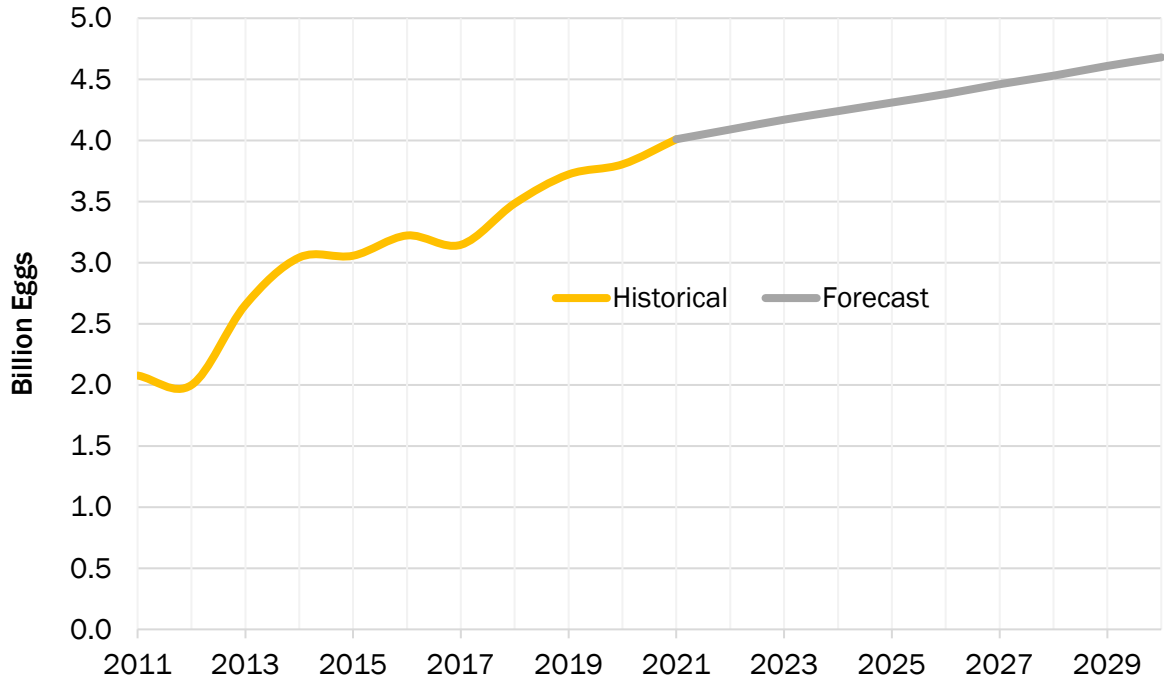


Source: USDA, National Agricultural Statistics Service (nass.usda.gov) and MU Food and Agricultural Policy Research Institute (fapri.missouri.edu)

Exhibit 2.4 summarizes historical and forecasted Missouri egg production from layer hens. The number of eggs produced in Missouri has grown strongly since 2012. Approximately 3.8 billion eggs were produced in 2020. Egg production is expected to grow by about 1.5% per year through 2030. Chicken layer inventory for Missouri was 13,463,000 birds on Dec. 1, 2020, which was 10.7% higher than inventory in the previous year.

Missouri also has a large base of certified organic egg producers. It ranked No. 2 in the U.S. in 2019 with 112 farms and 1,885,643 birds in layer inventory. Cage-free state legislation in California and Massachusetts will also provide some market disruptions as producers look to comply with these regulations (wattagnet.com/articles/43602-expect-2022-cage-free-mandates-to-disrupt-us-egg-market).

Exhibit 2.4. Missouri egg production



Source: USDA, National Agricultural Statistics Service (nass.usda.gov) and MU Food and Agricultural Policy Research Institute (fapri.missouri.edu)

Egg companies operating in Missouri include Opal Foods, Rose Acre Farms, Vital Farms, Mid-States Specialty Eggs and Cal-Maine.

- *Opal Foods* has a corporate office in Neosho, Missouri, and layer farms in Missouri, Iowa and Colorado. In 2020, Opal Farms had 8.4 million laying hens. It specializes in all-natural, cage-free, organic and all-natural eggs with omega-3s.
- *Rose Acre Farms* is the No. 2 egg producer in the U.S. It has Missouri farms in Knob Noster and Troy.
- *Vital Farms* has growers in Missouri who specialize in pasture-raised egg production. The business also operates an egg processing facility in Springfield, Missouri.
- *Mid-States Specialty Eggs* is a certified producer of free-range, cage-free, pasture-raised, organic and non-GMO eggs. The company has a flock of 5.7 million layers in Missouri and Arkansas.
- *Cal-Maine* recently invested $18.5 million into a new egg product facility (MeadowCreek) to be located in Neosho, Missouri. (wattagnet.com/articles/43701-cal-maine-approves-investment-in-egg-product-manufacturer).

Soy-related feed consumption

Annual Missouri feed consumption

- 471,539 tons of soybean meal

Feed is typically purchased and controlled by the integrated poultry company. Sample formulations for the broiler life cycle (starter, grower, finisher) are presented in Exhibit 2.5. The first formulation is based on traditional feeds. The second formulation is based on all-vegetable ingredients.

Exhibit 2.5. Example traditional and all-vegetable feed formulations for broilers, 2020

Ingredients	Traditional feed formulation			All-vegetable feed formulation		
	Starter Feed	Grower Feed	Finisher Feed	Starter Feed	Grower Feed	Finisher Feed
	Pounds per 1,000					
Corn, ground	590	615	640	570	595	620
Soybean meal, 44% CP	300	275	250	300	275	250
Corn DDGS	0	0	0	50	50	50
Poultry by-product meal, 60% CP	50	50	50	0	0	0
Soybean oil	15	20	25	25	30	35
Supplements, amino acids, vitamins and other additives	45	40	35	55	50	45
Total	1,000	1,000	1,000	1,000	1,000	1,000

Source: WATT Global Media (feedstrategy.com/animal-feed-formulations)

Exhibit 2.6 shows an example of a laying hen diet.

Exhibit 2.6. Example laying flock diet

Ingredients	Pounds	Percent of total
Corn	1,248.08	62.3%
Soybean meal, 48% CP	418.31	20.9%
Limestone	185.06	9.2%
Corn DDGS	100.20	5.0%
Dical phosphate	24.47	1.2%
Soybean oil	13.47	0.7%
Vitamin premix	5.00	0.2%
Salt	6.24	0.3%
Methionine	3.35	0.2%
Total	2,004.18	100.0%

Source: University of Missouri

Chicken companies interested in using climate and carbon claims in marketing materials may change chicken diet composition. Such dietary changes could threaten the broiler industry's soybean meal demand in the long term. Carbon-reduction chicken is one effort seen in the marketplace that involves changing a broiler's diet.

<u>Opportunities for high-oleic soybean meal and oil</u>

Dr. Bryon Wiegand with the University of Missouri conducted research (2017-20) on high-oleic soybean oil and meal inclusion in broilers and layers. Including high-oleic soybean oil and meal in broiler diets had no impact on broiler feed efficiency when compared with a diet containing traditional commodity soybean oil and meal. The high-oleic soybean meal and oil in broilers' diet did shift the fatty acid profile in boneless, skinless breast and thigh meat. This shift offers potential to improve broiler meat's nutritional content and shelf-life.

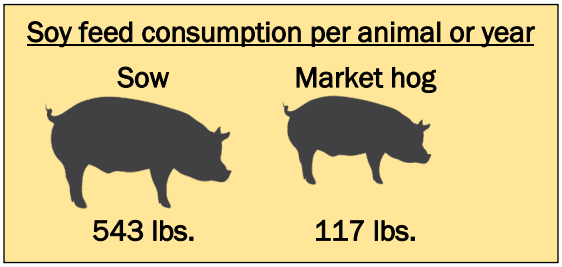
Laying hens were studied to understand how high-oleic soybean oil affects hen performance, egg quality and egg yolk fatty acid composition. Results showed high-oleic soybean oil altered the fatty acid composition of egg yolks and reduced feed intake (7%) without having a significant effect on egg quality parameters. The egg laying rate dropped by 2% in hens fed high-oleic feed. The results suggest that including high-oleic soybean oil will shift the proportion of fatty acids in egg yolk tissues and, therefore, lead to higher levels of monounsaturated fatty acids and lower amounts of saturated fatty acids in egg yolks. Reduced feed intake by hens fed high-oleic soybean oil compared with commodity soybean oil gives producers an option to lower feed costs when feeding high-oleic soybean oil.

Benson Hill, a St. Louis-based food tech company, has collaborated with Rose Acre Farms to develop a supply chain of high-protein, high-oleic, low antinutrient soybeans. They intend to develop a processing facility near grower-partners in Indiana. Local soybean contract growers will gain price premiums for identity-preserved, non-GMO soybeans (goodegg.com/news/2020/12/10/benson-hill-collaborates-with-rose-acre-farms-to-expand-soybean-processing-capacity-and-build-out-supply-chain-infrastructure).

3. Hogs

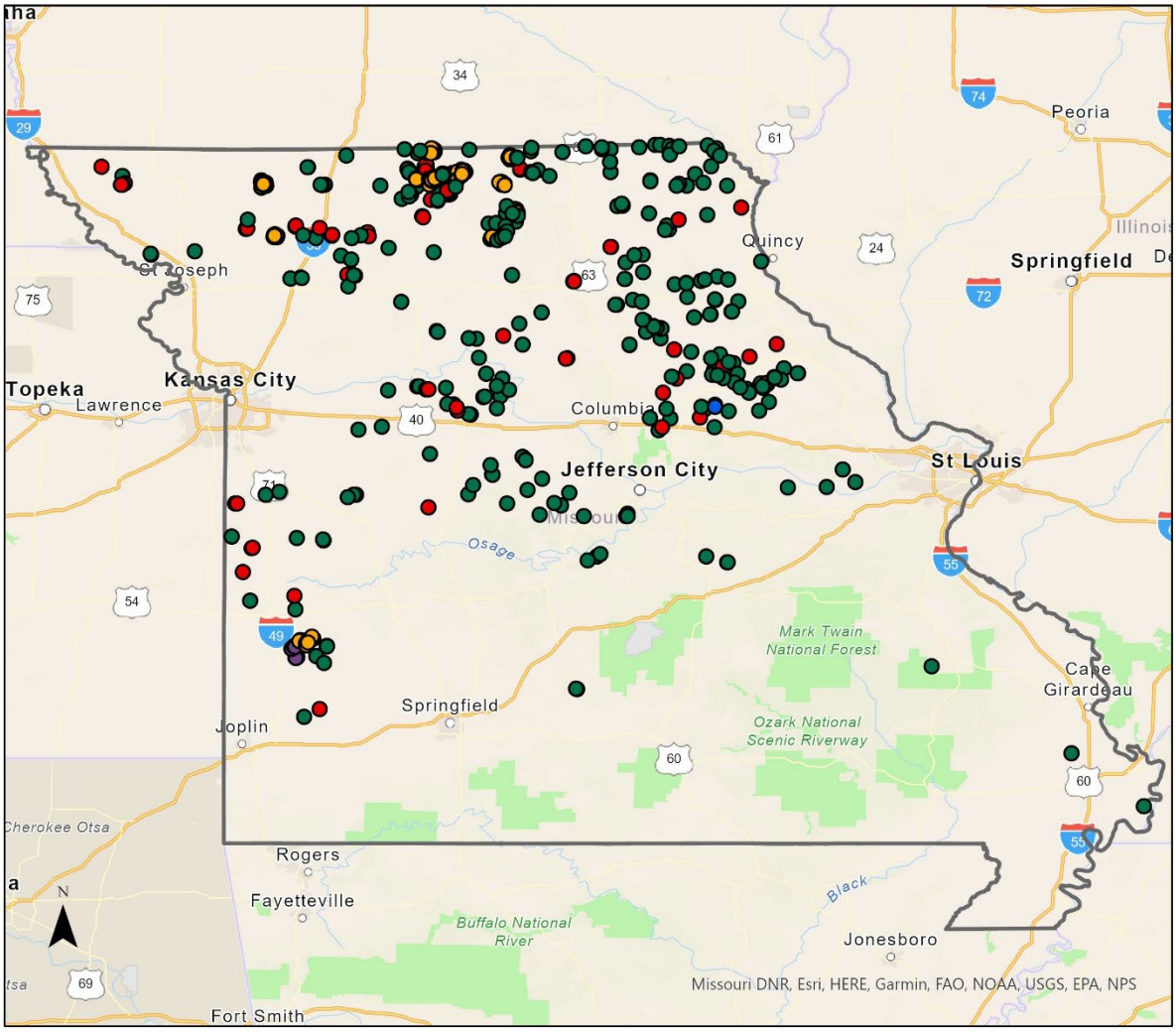
Industry perspective

Missouri is a major hog producer. It ranks within the top 10 of U.S. states for hog inventory, commercial hog slaughter and hog farms. From 2011 to 2020, annual revenue from hog production in Missouri averaged $928 million.



Swine operations are typically segmented by the production cycles they manage. Farrow-to-finish, farrow-to-wean and wean-to-finish are common production systems in Missouri. A farrow-to-finish enterprise maintains breeding and farrowing pigs. Such operations feed pigs until market weight, which is about 280 pounds. Farrow-to-wean farms produce pigs, which are sold at weaning when they weigh roughly 15 pounds. Some Missouri farms feed weaned pigs to 40 pounds to 50 pounds before those pigs move to another farm for finishing. Locations of permitted animal feeding operations in Missouri can be found in Exhibit 3.1.

Exhibit 3.1. Swine concentrated animal feeding operations (CAFOs) in Missouri



Swine CAFO Type

- General CAFO IB
- General CAFO IC
- General CAFO NP
- Site-Specific CAFO (IA)
- Site-Specific CAFO (IB)

Type	Under 55 Pounds	Over 55 Pounds
Class IA	70,000	17,500
Class IB	30,000 to 69,999	7,500 to 17,499
Class IC	10,000 to 29,999	2,500 to 7,499

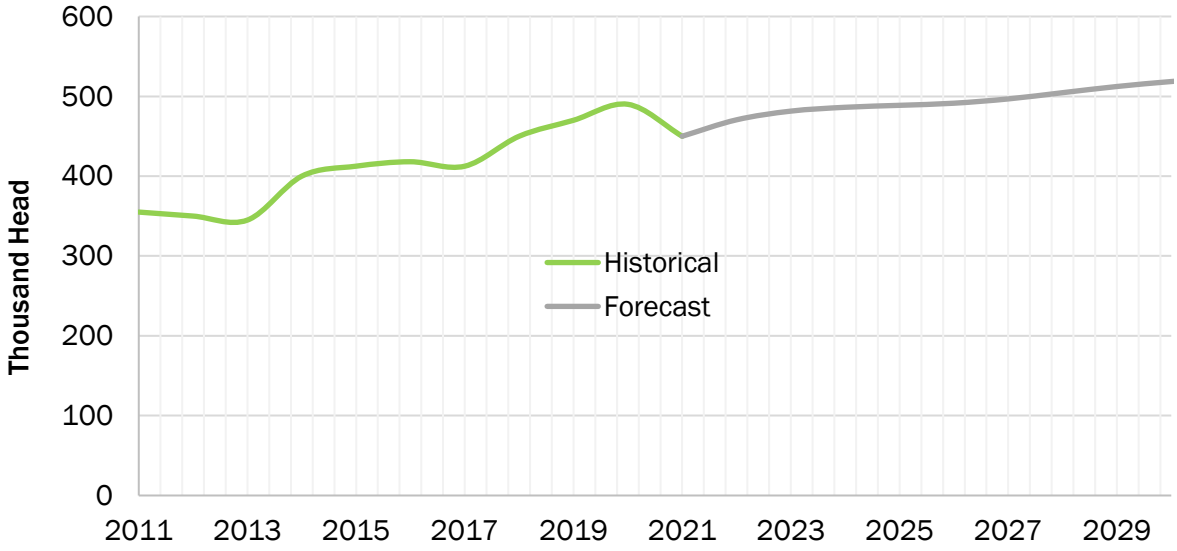
Heartland GIS

Created March 23, 2022

Source: Missouri Department of Natural Resources (modnr.maps.arcgis.com/apps/webappviewer/index.html?id=cf630b020a17452fb30994cb4b36f003)

Missouri's breeding herd peaked on Dec. 1, 2019, at 490,000 sows before it started decreasing — at least in some part due to COVID-19. See Exhibit 3.2. Missouri is forecast to increase its hog breeding herd through 2030. Missouri's hog breeding herd produces between 10 to 11 million pigs annually. More than 6 million pigs weighing 15 pounds to 50 pounds were sold from Missouri in 2020. Most Missouri pigs are transported to and fed in Iowa, Illinois or Kansas. More than half of Missouri-born pigs are not raised to slaughter weight within the state.

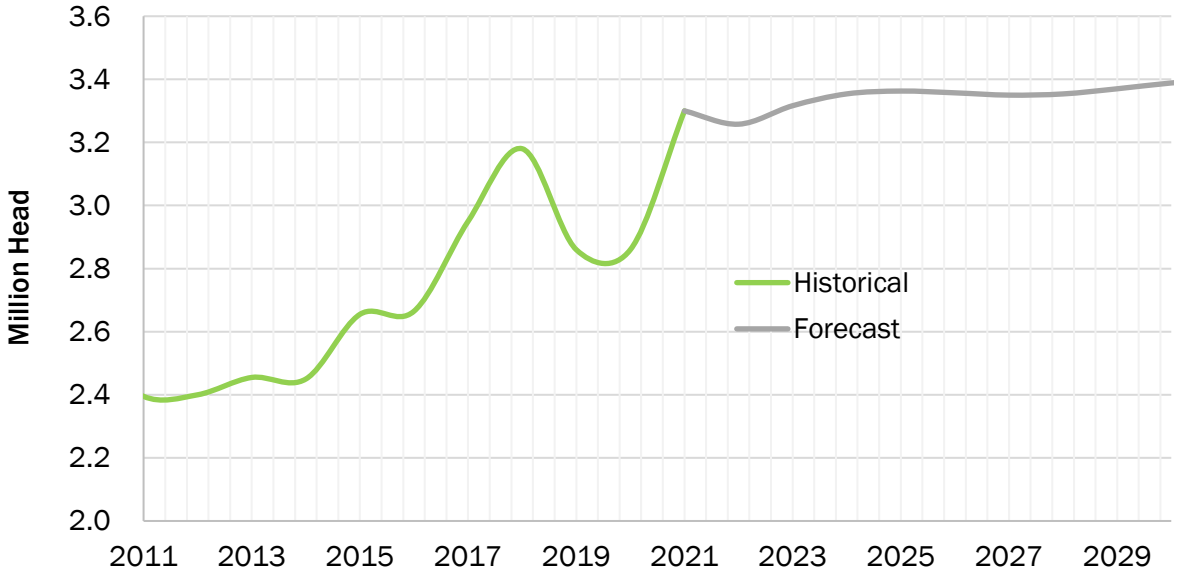
Exhibit 3.2. Missouri breeding hog inventory, Dec. 1, preceding year



Source: USDA, National Agricultural Statistics Service (nass.usda.gov) and MU Food and Agricultural Policy Research Institute (fapri.missouri.edu)

The number of Missouri market hogs fed to slaughter weight has grown since 2011. Market hog inventory reached almost 3.3 million head in 2020. See Exhibit 3.3. FAPRI forecasts Missouri's market hog inventory to remain just less than 3.4 million head through 2030. Retaining more hogs in Missouri could significantly impact demand for the volume of soy coproducts processed and used in the state.

Exhibit 3.3. Missouri market hog inventory Dec. 1, preceding year



Source: USDA, National Agricultural Statistics Service (nass.usda.gov) and MU Food and Agricultural Policy Research Institute (fapri.missouri.edu)

The most recent U.S. Census of Agriculture recorded 2,687 farms with hogs in Missouri. About half of Missouri hog inventory is classified as farrow-to-finish production. Some of the largest U.S. hog producers, including Smithfield Foods, JBS and Pipestone, have sow farms in Missouri. Market hogs often are grown under production contracts. Increasing the number of weaned pigs fed to market weight would likely stem from integrators choosing to locate feeding barns in Missouri.

Soy-related feed consumption

Soybean meal is used as a protein source for hogs. Exhibit 3.4 provides examples of swine rations. The annual feed needed in a farrow-to-wean enterprise totals 2,987 pounds per sow. Of that total feed weight, 543 pounds (18%) is soybean meal. The ration of a single finishing feeder pig contains 117 pounds of soybean meal. Soy hulls can also be included in finishing pig diets, but current recommendations limit hulls inclusion to less than 10% of the diet.

Annual Missouri feed consumption

- 325,383 tons of soybean meal
- 4,430 tons of soy hulls

Exhibit 3.4. Swine confinement production rations

Feed	Farrow-to-wean (lb./sow/year)	Percent of ration	Finishing weaned pigs (lb./pig)	Percent of ration
Corn	2331.7	78%	512.8	78%
Soybean meal	542.5	18%	117	18%
Other	200	4%	11	4%
Total	2,987.3	100.0%	653.82	100.0%

Source: Kansas State University Extension (agmanager.info/farm-mgmt-guides/livestock-budgets)

Opportunities to increase soybean meal consumption

To grow soybean meal consumption among pig producers, one strategy is to raise more pigs. To increase the size of the pig crop, Missouri would need to add sows. The size of the weaned pig population heavily depends on pig flow through gestation facilities. Sow farms are likely to expand in increments of 600 sows. Commonly, sow farms expand by adding 1,200 sows at a time. Sow farms have continuous feed demand as the number of sows and piglets are fairly constant throughout the year. Exhibit 3.5 shows the feed consumed by the weaned pig production sector.

Exhibit 3.5. Swine expansion opportunities

Feed	Farrow-to-wean		Finishing weaned pigs	
	(tons/1,200-sow farm/year)	1% increase	(tons/1,240-hog facility/year)	1% increase
Number of facilities	1	4	1	20
Corn	1,399	5,596	636	12,718
Soybean meal	326	1,302	145	2,901
Other	68	271	30	595
Total	1,792	7,169	811	16,215

Assuming a pre-pandemic sow inventory of 475,000 sows in Missouri, adding 4,750 sows in Missouri would increase the breeding herd size by 1% and require about four new 1,200-sow facilities. Soybean meal use could rise by 1,300 tons per year.

Missouri also has a thriving market hog feeding sector. Just less than half of the pigs born in Missouri are fed to market weight in Missouri. Typically, weaned pigs that weigh about 15 pounds are fed until they're market hogs that weigh 280 pounds. Market hog feed demand is also fairly constant. At any one time, more than 3 million hogs are on feed in Missouri.

A typical building for wean-to-finish hogs will hold 1,240 animals. Each barn is filled and emptied twice per year. Often, two buildings will be constructed at the same location, but this analysis estimates feed usage of a single 1,240-head finishing barn. Exhibit 3.5 shows the tons of feed consumed by 1,240 pigs being raised to 280 pounds.

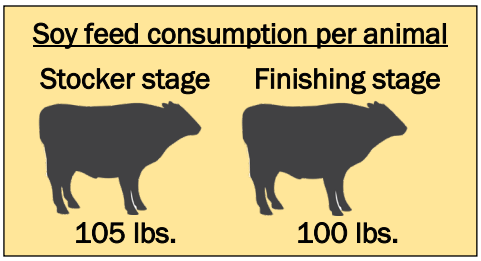
Increasing the number of hogs finished in Missouri from today's roughly 5 million by 1% would increase the number of hogs finished by 50,000. This would require 20 more barns with a capacity of 1,240 pigs per barn. Annual soybean use would rise by 2,900 tons.

Opportunities for high-oleic soybean oil

Dr. Bryon Wiegand with the University of Missouri conducted research (2017-20) on high-oleic soybean oil inclusion in market pig rations. The research concluded that the high-oleic oil yielded no significant differences in pig growth and performance and pork carcass composition and quality. These results suggest that traditional dietary oils can be replaced by novel high-oleic soybean oil to shift the proportion of fatty acids in tissues without causing deleterious effects on finishing pig performance, carcass composition and fresh pork quality.

4. Beef cattle

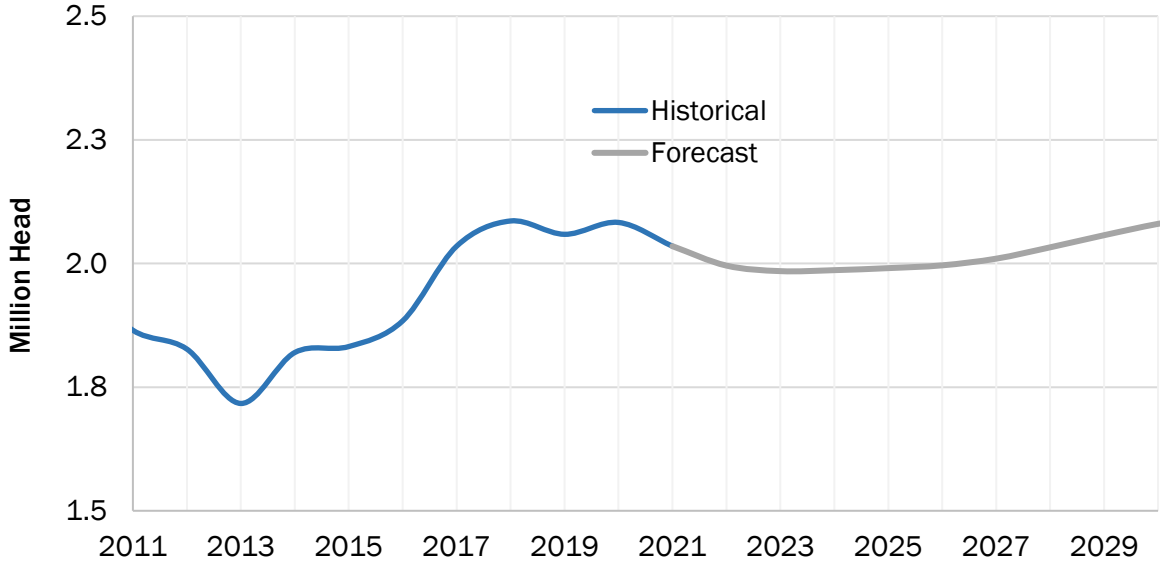
<u>Industry perspective</u>



Missouri beef operations raise cattle in different models: cow-calf production, stocker production and fed cattle production. Missouri has a large beef cow inventory, and it is a leader in U.S. beef calf production. On Jan. 1, 2021, cow-calf operations held 82% of Missouri's total beef cattle inventory. Stockers held 12% of beef cattle, and operations with cattle on feed held about 3% of beef cattle. Dairy cattle — both cows and replacements — made up the remainder of reported cattle reported (about 3%).

Exhibit 4.1 details Missouri's beef cow inventory history and forecast through 2030. Inventory levels are expected to rise and fall with the national 10-year beef inventory cycle. Missouri's beef cattle inventory is forecast to change by less than 10%. The herd is expected to hover near 2 million head over time. Note, drought-induced changes in pasture carrying capacity can unpredictably impact the beef herd's size.

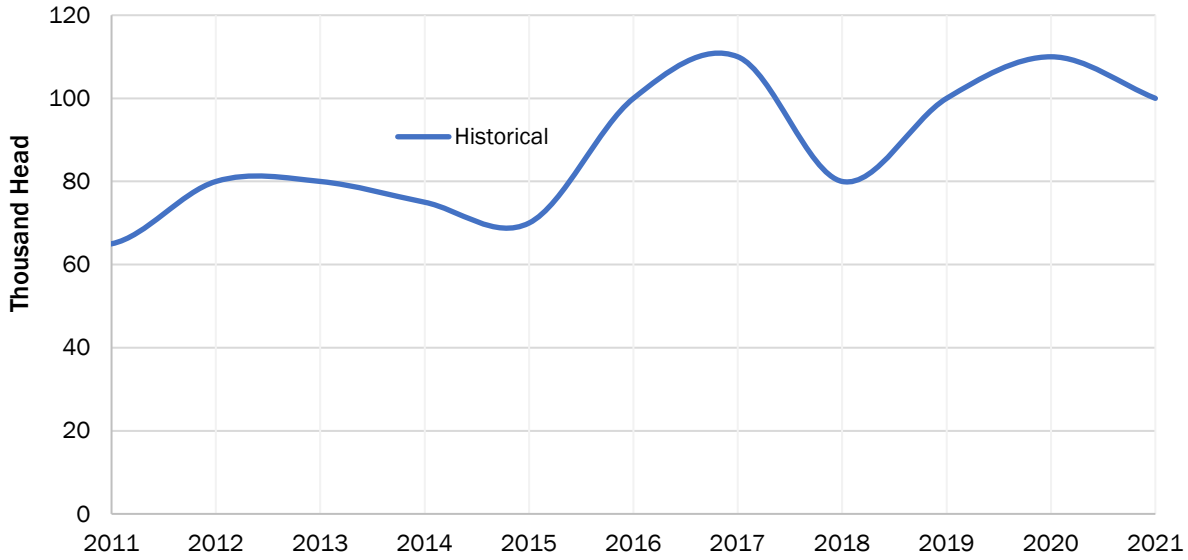
Exhibit 4.1. Missouri beef inventory



Source: USDA, National Agricultural Statistics Service (nass.usda.gov) and MU Food and Agricultural Policy Research Institute (fapri.missouri.edu)

Missouri is a major feeder calf exporter. The state sends 80% of its calves to be finished in other Midwestern states. Missouri has a small cattle feedlot industry. Exhibit 4.2 shows the trend in Missouri's Jan. 1 cattle on feed inventory from 2011 to 2021. Between 2015 and 2021, Missouri's cattle on feed inventory fluctuated more than the long-term trend would suggest. On Jan. 1, 2021, Missouri's cattle on feed inventory totaled 100,000 head. During the past 25 years, Missouri averaged approximately 83,000 cattle on feed per year.

Exhibit 4.2. Missouri cattle on feed inventory



Source: USDA, National Agricultural Statistics Service (nass.usda.gov)

Soy-related feed consumption

Annual Missouri feed consumption
- 118,644 tons of soy hulls
- 21,057 tons of soybean meal

Soy hulls are typically used in rations for Missouri growing calves. The hulls serve as an energy source that offers fiber suitable for ruminant diets, and they provide more protein than grains. See Exhibit 4.3. For stocker cattle, a common supplement blends one-third soy hulls, one-third corn gluten and one-third corn. In a pasture backgrounding operation, 525 pounds of protein supplement is fed from a 590-pound starting weight to an 815-pound sale weight. Less supplement (107 pounds) would be fed in a winter dry lot backgrounding situation. Winter dry lot rations use more corn.

Exhibit 4.3. Missouri steer growing ration per head

Feed	Winter beef backgrounding budget (lb.)	Percent of total	Pasture backgrounding budget (lb.)	Percent of total
Mixed hay	1,221	57.7%	0	0.0%
Corn	754	35.7%	0	0.0%
Protein supplement (1/3 soy hulls, 1/3 corn gluten and 1/3 corn)	107	5.1%	525	94.4%
Salt/minerals	27	1.3%	27	4.9%
Limestone	6	0.3%	4	0.7%
Total	2,115	100.0%	556	100.0%

Source: University of Missouri Extension (extension.missouri.edu/publications/g681)

Missouri finishing rations include soybean meal. See Exhibit 4.4. In finishing rations, only 2.3% of the feed comes from soybean meal for a five-month feeding period — the time it takes to grow a 750-pound steer into a 1,300-pound market weight. Corn and distiller grains represent the largest portion — approximately 86% — of the total finishing ration.

Soybean meal provides protein and amino acids to an all-corn and corn coproduct diet, which otherwise would be deficient in protein and amino acids. For ruminants, soybean meal traditionally has been a superior but more expensive protein than corn coproducts. Increased U.S. crush capacity stemming from renewable diesel demand could alter the relative valuation of soybean meal versus corn. Thus, soybean meal's inclusion rates in finishing rations could increase.

Exhibit 4.4. Missouri yearling beef steer finishing ration per head

Feed	Lb.	Percent of total
Corn	2,240	51.3%
Distiller grains	1,500	34.3%
Soybean meal	100	2.3%
Salt and additives	30	0.7%
Grass hay	500	11.4%
Total	4,370	100.0%

Source: University of Missouri Extension (extension.missouri.edu/publications/g683)

5. Dairy cattle

<u>Industry perspective</u>

Like in many traditional dairy states, Missouri has had a steady decline in dairy cow inventory during the past two decades. In contrast, U.S. dairy cow numbers grew during this period. Such growth has occurred in states where new large confinement dairy farms are built. These dairies typically each contain more than 1,000 head. Growth in cow numbers has occurred in clusters — predominately in western and Great Plains states.

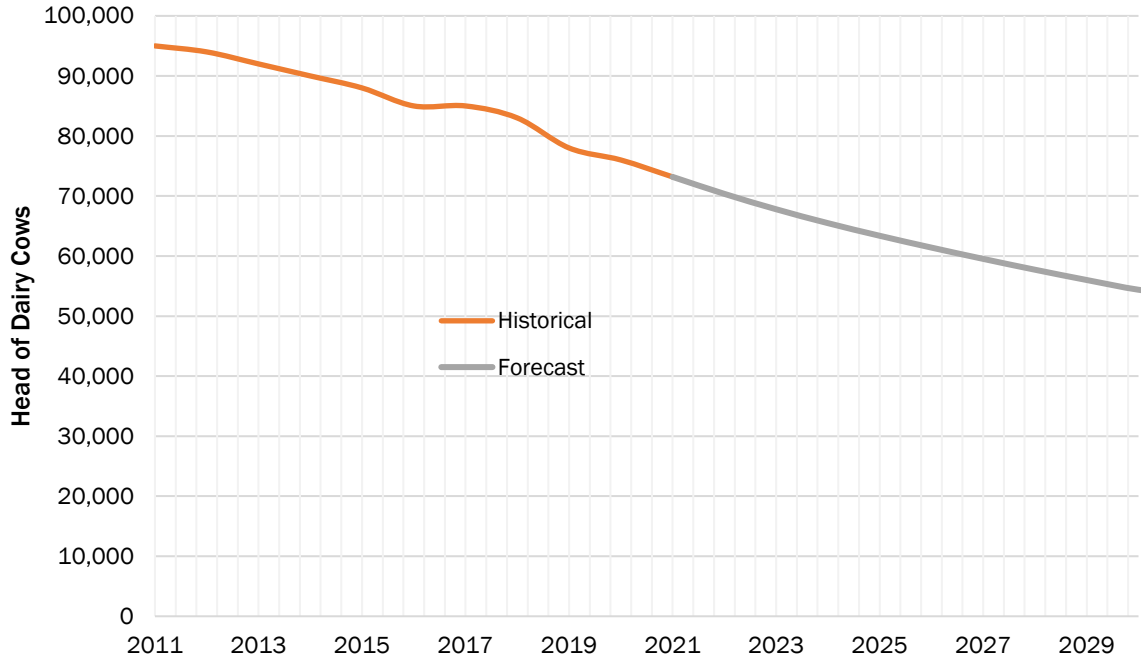
<u>Soy feed consumption</u>

Dairy cow/year

2,106 lbs.

Exhibit 5.1 presents Missouri's historical dairy inventory and expected inventory in the future. Missouri's milk cow inventory totaled 69,000 head in January 2022, according to USDA. Unless additional large dairies start or relocate from other states into Missouri, the state's dairy cow inventory will continue to shrink. By 2030, Missouri's dairy cow inventory will decline to an estimated 54,000 milk cows.

Exhibit 5.1. Missouri milk cow inventory



Source: USDA, National Agricultural Statistics Service (nass.usda.gov) and MU Food and Agricultural Policy Research Institute (fapri.missouri.edu)

Missouri's dairy industry is an amalgamation of several distinct production systems. Traditionally, the Ozark region of southwest and south central Missouri, where most of the state's dairies were located, was home to pasture-based dairies. In northern Missouri and counties that bordered the Missouri and Mississippi rivers, confinement or partial confinement dairies evolved. A farm's soil types and cropping potential influenced the systems that dairy producers chose as they developed their operations. In the past two decades, larger confinement farms have begun to appear throughout Missouri, and larger intensive rotational grazing dairies have also developed in the southern half of Missouri.

Soy-related feed consumption

Feed rations in confinement dairy operations frequently include a variety of soy-related products. Dairy cattle in confinement require large quantities of protein-rich, energy-dense feeds to produce at a competitive level. Soybean meal contains essential amino acids in more desirable concentrations than are provided by low-cost coproducts such as corn distillers grains or corn gluten feed. Additionally, soybean oil is rich in energy-dense fats, which contain 225% more energy per weight unit than the next most nutritious ingredient.

Annual Missouri feed consumption

- 19,776 tons of soybean seeds
- 17,947 tons of soy hulls
- 11,199 tons of soybean oil
- 10,326 tons of soybean meal

Missouri dairy cattle rations may also feature soy hulls and whole soybeans. Roasting or extruding soybeans can process whole beans for dairy diets. The heat treatment creates a protein and energy supplement that partially bypasses rumen degradation. As a result,

animals digest energy and protein-dense supplements further along the digestive tract and, therefore, produce more milk.

Energy-dense fats can be fed without the rumen acidosis issues caused by rapidly fermentable carbohydrates, such as starch in corn, barley or wheat. However, traditional soybean meal is commonly limited in the ration to less than 10% of dry matter due to concerns regarding butterfat suppression in milk when more oil, including soybean oil, is ingested. In rations, dairy nutritionists typically suggest limiting traditional soybean meal or raw soybean to 4 pounds to 5 pounds per head per day for confined, highly productive lactating dairy cows. Example confinement dairy feed requirements can be found in Exhibit 5.2.

Exhibit 5.2. Confinement dairy feed for two levels of milk production per cow per year

Feed	20,000 lb. milk	Percent of total	24,000 lb. milk	Percent of total
	Lb.	*%*	*Lb.*	*%*
Corn silage	12,223	44.4%	13,357	43.4%
Alfalfa baleage	3,741	13.6%	5,296	17.2%
Alfalfa hay	1,708	6.2%	1,934	6.3%
Grass hay	914	3.3%	914	3.0%
Corn, ground	3,470	12.6%	3,658	11.9%
Soybean meal	1,095	4.0%	1,354	4.4%
Dry distillers grain	1,005	3.7%	949	3.1%
Soybean hulls	1,125	4.1%	752	2.4%
Whole cotton seed	1,675	6.1%	1,897	6.2%
Minerals/vitamins	577	2.1%	656	2.1%

Source: University of Missouri Extension (extension.missouri.edu/publications/g676)

Feed use is different between confinement and rotational grazing dairies. Grazing dairies seek to feed a lot of high-quality, low-cost forage and provide minimal feed supplementation. Supplementation will be less than 10 pounds per cow per day for a milking group that is fed in the parlor. Dry cows receive about 5 pounds of supplement per day. During the spring and fall, pastures provide surplus protein in the grazing dairy diet. Soybean meal does tend to be included in a summer ration at about 6% of the feed concentrate. In spring and winter rations, soy hull pellets represent 20% to 25% of the feed concentrate.

Opportunity for Soyleic soybean meal

Soyleic soybean meal (SSBM) creates value for a dairy nutritionist because it allows dairy cows to consume a higher fat diet without causing butterfat suppression. When feeding SSBM, dairy nutritionists can feed mechanically pressed soybean meal or whole beans that contain more oil and not be as concerned about fat limits in the total diet. This higher inclusion limit of SSBM can deliver an energy dense diet without causing rumen acidosis or butterfat suppression, while providing excellent protein supplement with necessary amino acids.

Feeding SSBM allows dairy producers to reduce or eliminate expensive rumen-protected fats, such as Megalac or Soyclor, and expensive, unpalatable amino acid supplements, such as porcine blood meal, fish meal, Smartamine, LysiPearl or Metasmart, from the diet. Further, replacing expensive feed additives with SSBM simplifies rations, reduces mixing time and reduces complexity and errors in feeding. The end result is less subacute metabolic issues in a simpler package for high-producing dairy herds.

Targeted confinement dairy herd rations for SSBM include the following:

- *Transition Cow Ration*: Three weeks pre-calving until three weeks post-calving. Although the diet is only fed for six weeks, this time is the most important period of a dairy cow's lactation. High-producing dairy herd operators have learned not to be price-sensitive on transition ration costs. These operators prefer to prevent physiological problems that would later limit milk production.
- *High-Production Group Ration*: A cow's genetic milking capacity may be limited without sufficient amino acids present in the diet. Energy demands from high milk production may not be balanced by energy intake unless the diet is energy-dense. SSBM allows nutritionists to solve both of these problems with one supplement.

SSBM fits best in rations where higher milk yields can offset costs that are higher than those associated with traditional SBM rations. Dairy nutritionists serving high-producing herds want stable supplies of consistent product, so farms are not forced to change rations and upset milk production. Initial plantings of Soyleic soybean varieties may be limited and only available regionally.

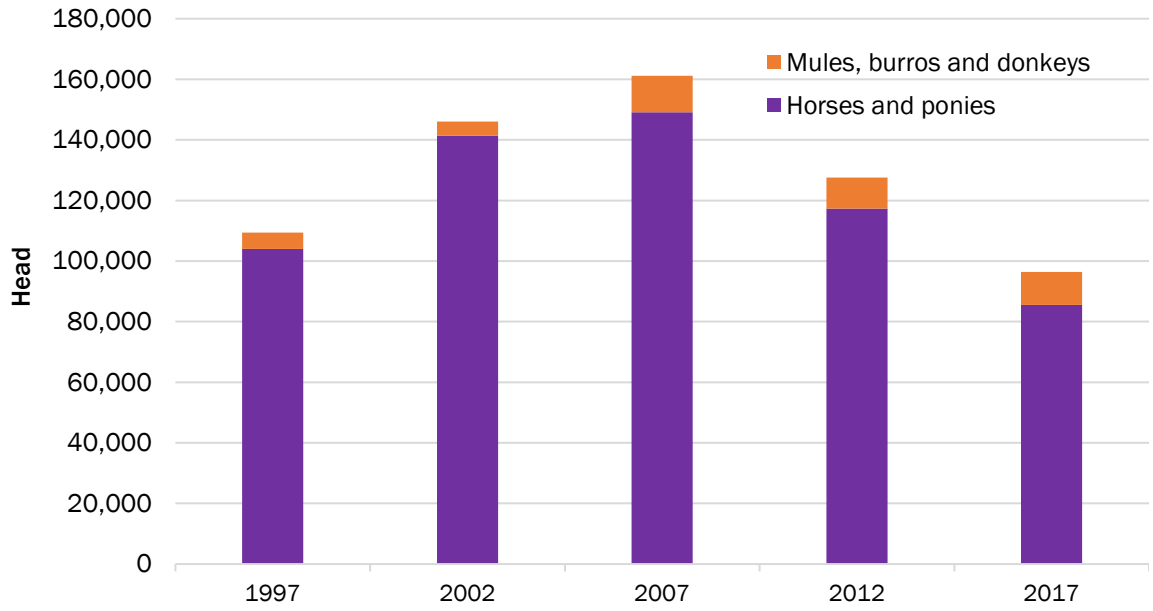
Mechanical soybean crushers willing to segregate SSBM in batches to consistently supply dairy feed dealers or dairy farm customers will need to identify nutritionists and target herd sizes in a way that matches demand with annual SSBM supply expectations. Large dairy farms buy soybean meal in 25-ton tractor-trailer loads and mix rations on their farms.

6. Equine

Industry perspective

Exhibit 6.1 reports Missouri equine inventory values provided in the U.S. Census of Agriculture on Dec. 31 of a given year. Data are reported for horses and ponies and mules, burros and donkeys. Inventory levels dropped considerably from 2007 to 2017. The 2017 census reported inventories to total 96,416 head. These data do not count wild horses.

Exhibit 6.1. Missouri equine inventory, 1997 to 2017



Source: USDA, National Statistics Service (nass.usda.gov/)

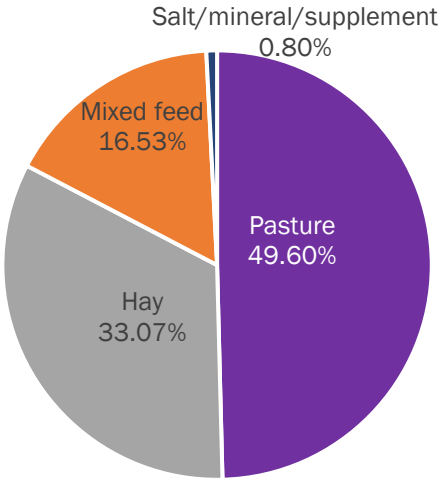
Soy-related feed consumption

A majority of a horse's diet comes from pasture and hay. See Exhibit 6.2 for a typical mare's feed ration allocation, assuming an animal consumes 1.6% of its body weight in forage per day. The University of Kentucky has produced budgets for broodmare marketing yearlings. The budgets highlight feed rations for mares, foals, weanlings and yearlings. Mixed feed would represent 1,500 pounds fed per mare per year. Soybean meal would be considered a minor feed ingredient in a horse's ration.

Annual Missouri feed consumption

- 5,906 tons of soybean meal

Exhibit 6.2. Feed allocation for broodmare marketing yearlings



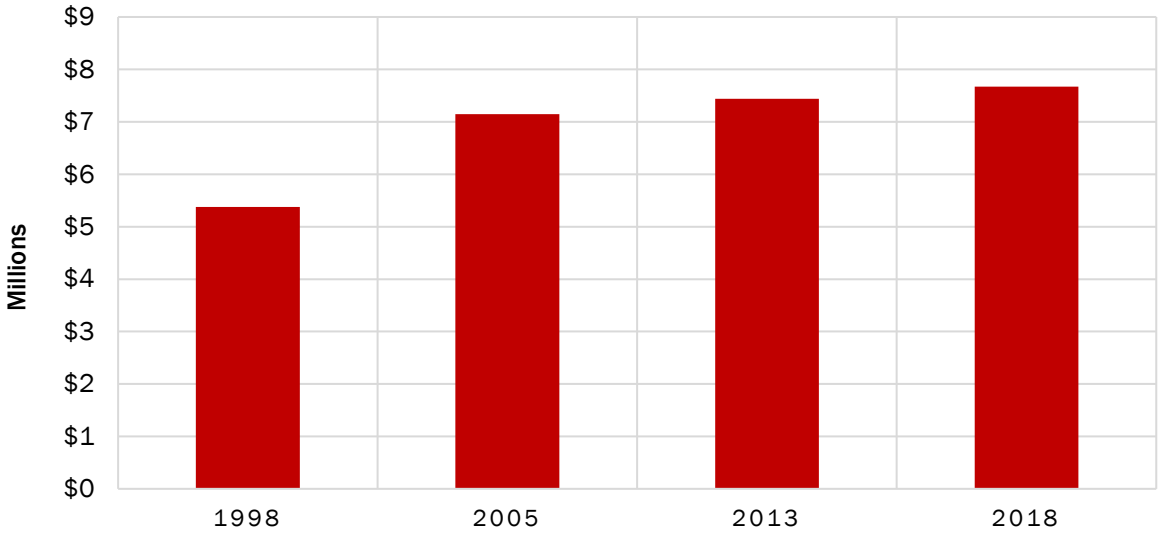
Source: Derived from University of Kentucky's equine enterprise budget (agecon.ca.uky.edu/files/extaec2006-0356.xls)

7. Aquaculture

Industry perspective

Aquaculture refers to fish and shellfish production. In 2018, the value of Missouri's aquaculture production totaled about $7.6 million. See Exhibit 7.1. Sales increased by 3.2% from 2013 to 2018. In Missouri, aquaculture operations produce food fish, ornamental fish and bait fish. Approximately 66% of Missouri's value of aquaculture production stems from food fish, which are primarily raised for human consumption. Food fish species include catfish and trout. Trout accounted for approximately $3.3 million in sales in 2018 — about 43% of total Missouri aquaculture production.

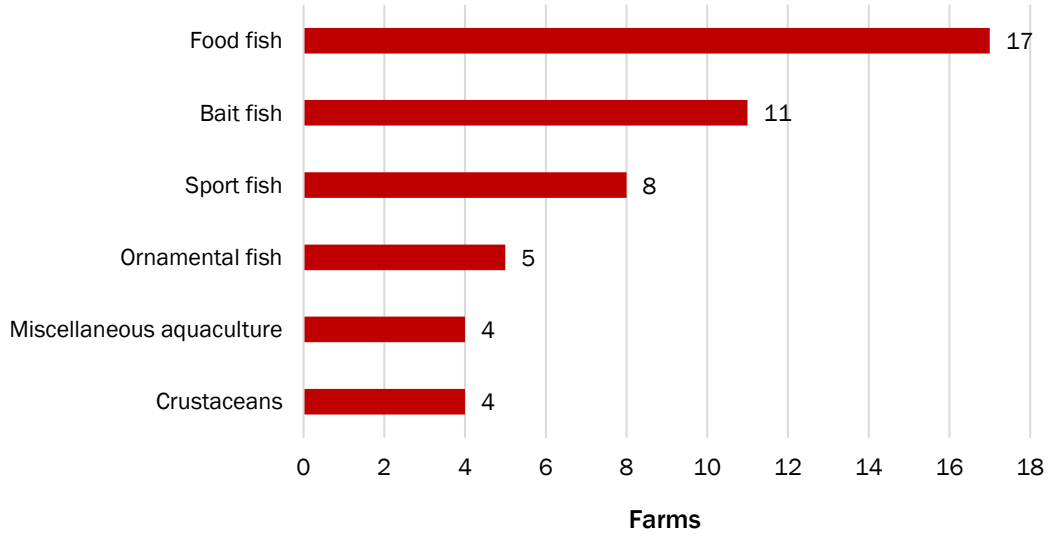
Exhibit 7.1. Missouri aquaculture sales



Source: USDA-National Agricultural Statistics Service (nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Census_of_Aquaculture)

In Missouri, 26 farming operations produced aquaculture products in 2018, according to the USDA Census of Aquaculture. Exhibit 7.2 details Missouri aquaculture farms by type of fish produced. The Missouri Department of Agriculture maintains a directory of Missouri aquaculture producers and allied industry at agriculture.mo.gov/cgi-bin/aqua.cgi.

Exhibit 7.2. Missouri aquaculture farms by type of production, 2018



Source: USDA-National Agricultural Statistics Service (nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Census_of_Aquaculture)

Missouri used 1,470 freshwater acres for aquaculture production in 2018. Ponds were the primary freshwater sources used for aquaculture production. In 2018, 943 ponds that covered 1,385 acres were used in Missouri aquaculture production. Pond size averaged an estimated 1.5 acres. Additionally, 276 flow-through raceways were also used on 13 farms in Missouri. Other systems that are used on Missouri farms include recirculating systems (six farms), noncirculating systems (seven farms) and aquaponic systems (one farm).

According to the Missouri Aquaculture Association, aquaculture businesses operating in the state include Crystal Lake Fisheries, Flowers Fish Farm and Ozark Fisheries.

- ***Crystal Lake Fisheries*** is located in Ava, Missouri. It specializes in raising rainbow trout and has 52 raceways on its farm.
- ***Flowers Fish Farm*** in Bloomfield, Missouri, is a family-owned business with 425 acres of water in production. The farm raises channel catfish, bluegill, crappie, grass carp and minnows.
- ***Ozark Fisheries*** produces goldfish, koi, minnows, snails, tadpoles and crawfish in Stoutland, Missouri. The business also operates a farm in Indiana. Between the two farms, the business has 800 ponds in production that cover 7,600 acres.

Soy-related feed consumption

Aquaculture is an emerging industry for increasing feed-based soybean demand. Fish in general require a diet higher in crude protein than most commercially produced livestock. Catfish are the most common fish species raised in aquaculture systems. Catfish require diets that are 25% to 50% crude protein. Most diets call for crude protein levels to range between 30% and 35%. Exhibit 7.3. contains examples of catfish diets.

Annual Missouri feed consumption

- 1,450 tons of soybean meal
- 27 tons of soybean oil

Exhibit 7.3. Examples of ingredient compositions for catfish fingerling and food fish feeds

Ingredient	36% protein fingerling	32% protein food fish	32% protein food fish	32% protein food fish	28% protein food fish	28% protein food fish	28% protein food fish
	percent						
Soybean meal (48% CP)	51.05	44.10	33.25	30.60	32.90	25.35	22.30
Cottonseed meal (41% CP)	10.00	10.00	25.00	25.00	10.00	20.00	20.00
Porcine meat & bone meal (52% CP)	10.00	5.00	—	—	5.00	—	—
Corn grain	20.00	20.00	18.21	15.00	25.00	20.00	15.00
Wheat middlings	5.50	18.20	—	10.82	24.32	11.08	24.10
Corn gluten feed	—	—	20.00	—	—	20.00	—
Distillers grains/solubles (27% CP)	—	—	—	15.00	—	—	15.00
Dicalcium phosphate	0.25	0.50	1.00	1.00	0.50	1.00	1.00
Lysine HCl	—	—	0.34	0.38	0.08	0.37	0.40
Vitamin mix	Included	Included	Included	Included	Included	Included	Included
Trace mineral mix	Included	Included	Included	Included	Included	Included	Included
Animal fat/oil	3.00	2.00	2.00	2.00	2.00	2.00	2.00

Source: Southern Regional Aquaculture Center (srac.tamu.edu)

Soybean meal plays a critical role in these aquaculture diets. It's the most economical high-protein feedstuff, and it contains all 10 essential amino acids that cannot be produced by the fish naturally. About one-third to one-half of a catfish's diet is soybean meal.

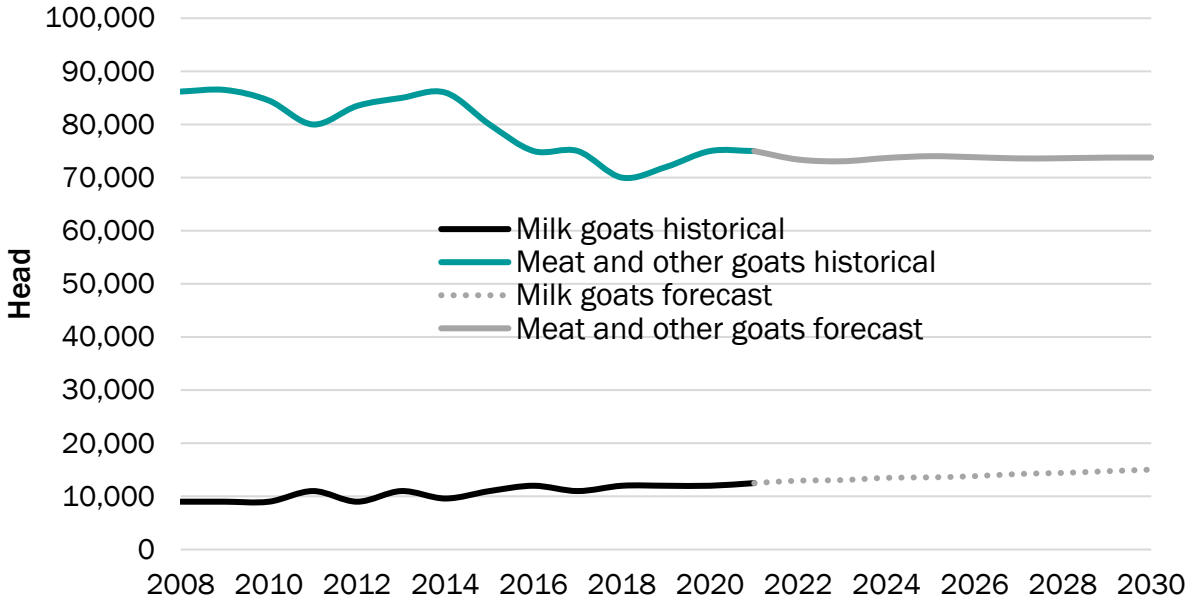
Additionally, aquaculture has outstanding growth potential because fish are rich in healthy fats and oils. Therefore, they represent a healthy protein source for human consumption.

8. Sheep and meat goats

Industry perspective

In 2021, Missouri ranked No. 5 in the U.S. for meat and milk goat inventory. Exhibit 8.1. shows Missouri's historical goat inventories and future forecasts. Milk goat inventory is forecast to grow by approximately 1.66% per year through 2030. Meat goat inventory is also expected to grow after 2021 but only by 0.6% per year. Missouri is forecast to have 73,782 meat goats in 2030. According to the U.S. Census of Agriculture, Missouri had 4,132 goat farms in 2017.

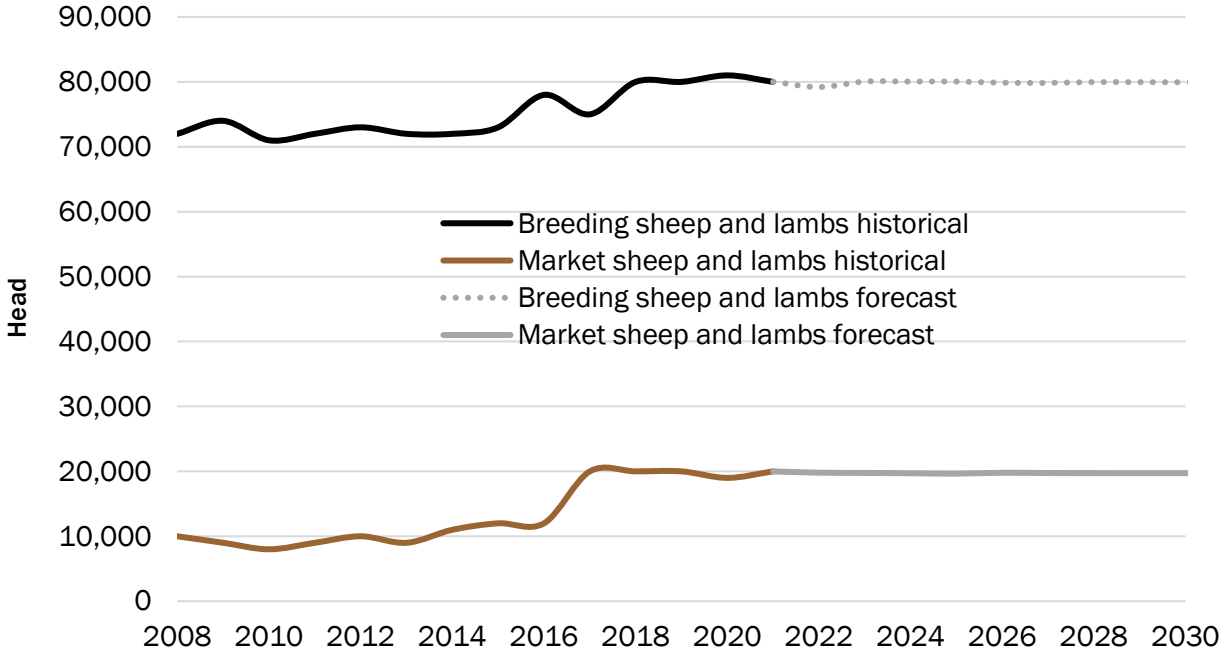
Exhibit 8.1. Missouri meat and milking goat inventory



Source: USDA, National Agricultural Statistics Service (nass.usda.gov) and industry experts

For 2008 to 2030, Exhibit 8.2 shows Jan. 1 Missouri sheep and lamb historical and projected inventories, which include breeding and market animals. Missouri's lamb crop in 2019 was 79,000 head. Breeding sheep and lamb inventories are expected to grow by 0.1% per year. Market sheep and lamb inventories are anticipated to slightly decrease through 2030. According to the U.S. Census of Agriculture, Missouri had 3,103 sheep farms in 2017.

Exhibit 8.2. Missouri sheep and lamb inventory



Source: USDA, National Agricultural Statistics Service (nass.usda.gov) and industry experts

Soy-related feed consumption

Feed needs for a meat goat enterprise include pasture, hay, supplement and minerals. Pasture and hay represent more than 75% of a meat goat's diet. Protein supplements represent a small portion of the feed requirement. Approximately 1,500 pounds of supplement will be fed to a 50-doe goat enterprise consisting of adults and kids. Exhibit 8.3 details feed supplement needs per head. Made with soy hulls, the protein supplement represents about 15% of the supplement and mineral needs.

Current Missouri feed consumption

- 614 tons of soybean meal

Exhibit 8.3. Supplement feed for a Missouri goat enterprise, early kidding

	Fed to adults	Fed to kids
	lb. per head	lb. per head
Milk replacer	0.000	0.01
Corn equiv.	22.0	0.00
Protein supplement (soy hulls, corn gluten and corn)	5.5	0.00
Pellet, commercial mix	0.0	0.97
Salt-trace mineral mix	8.0	0.3

Source: University of Missouri Extension (extension.missouri.edu/publications/g690)

Sheep flock feed needs share similarities with meat goat feed needs. Exhibit 8.4 provides a snapshot of supplemental feed needs for a 50-ewe sheep enterprise. Soybean meal or its equivalent represents about 15% of the supplement and mineral needs for an enterprise.

Exhibit 8.4. Supplement feed for a Missouri sheep flock enterprise, early lambing

	Fed to adults	Fed to lambs
	lb. per head	lb. per head
Milk replacer	0.000	0.01
Corn equiv.	22.0	0.00
Protein supplement (soy hulls, corn gluten and corn)	5.5	0.00
Pellet, commercial mix	0.0	0.97
Salt-trace mineral mix	8.0	0.3

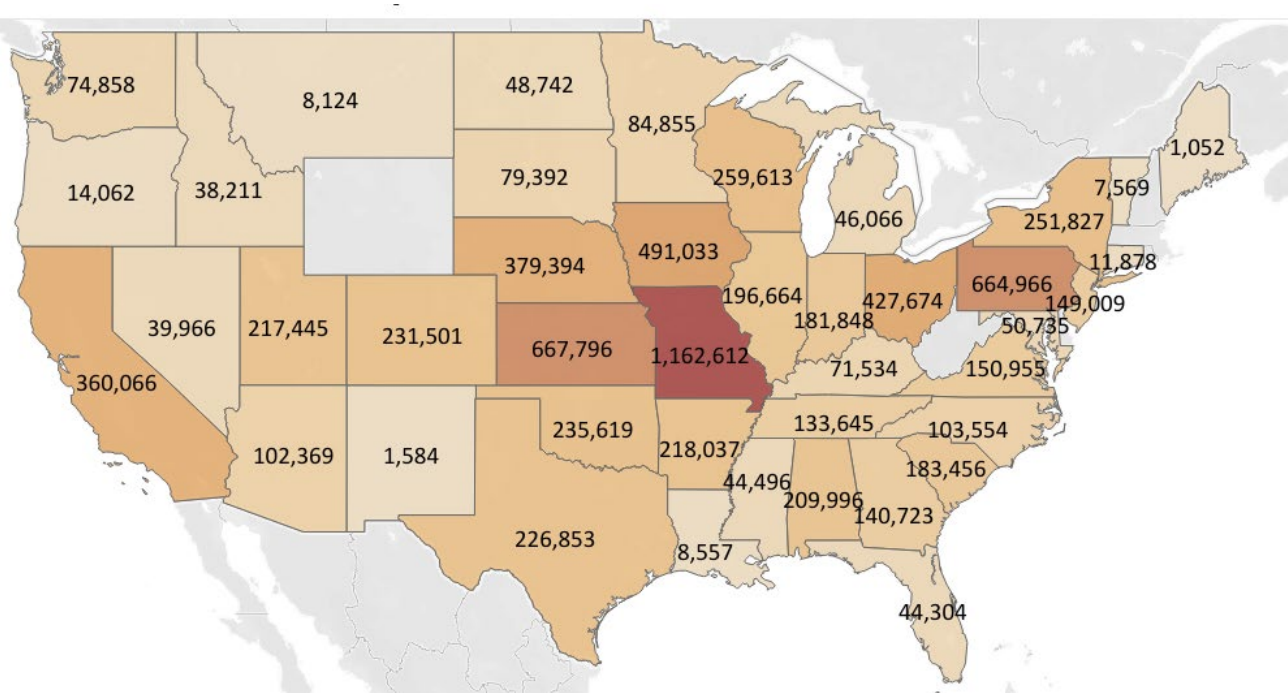
Source: University of Missouri Extension (extension.missouri.edu/publications/g685)

9. Cat and dogs

Industry perspective

Missouri is America's leading producer of pet food products. By total volume, Missouri buys 14.5% of pet food inputs procured in the U.S. Missouri had 15 pet food facilities that purchased 1.16 million tons of pet food ingredients in 2018, according to a study completed by Decision Innovation Solutions. Figure 9.1 shows the difference in pet food ingredient procurement by state. Missouri ranked first in farm and farm-product processing sales to pet food manufacturers ($999 million).

Exhibit 9.1. Pet food ingredients purchased, total tons



Source: Decision Innovation Solutions (ifeeder.org/pet-food-report/)

Industry giants such as Purina, Mars Petcare and Diamond Pet Foods all have large presences in Missouri. They maintain plants in St. Louis, Kansas City and Meta, respectively. Although supermarket shelves feature many pet food brands, the pet food industry has a high concentration ratio, meaning relatively few firms manufacture much of the total pet food that's produced. Many brand names sold across the country directly tie to these three large manufacturers that have operations in Missouri.

Additionally, Missouri is centrally located on the continent. This positioning allows manufacturers located here to economically transport product to the East and West coasts. The bulk of the U.S. pet population is in coastal states, and centrally located manufacturing facilities allow these companies to take advantage of multiple key markets.

A final factor benefitting Missouri and Midwest pet food manufacturing facilities is easy access to ingredients. By weight, the two ingredients most used in pet food are animal products and non-meat farm products. These ingredients are easily procured in the Midwest.

Pet food growth potential is difficult to quantify due to the noncommercial nature of pet ownership. The size of the pet population largely depends on regional culture and overall economic health. To project pet populations in total or regionally, assume a positive correlation between population and average income in an area.

Soy-related pet food consumption

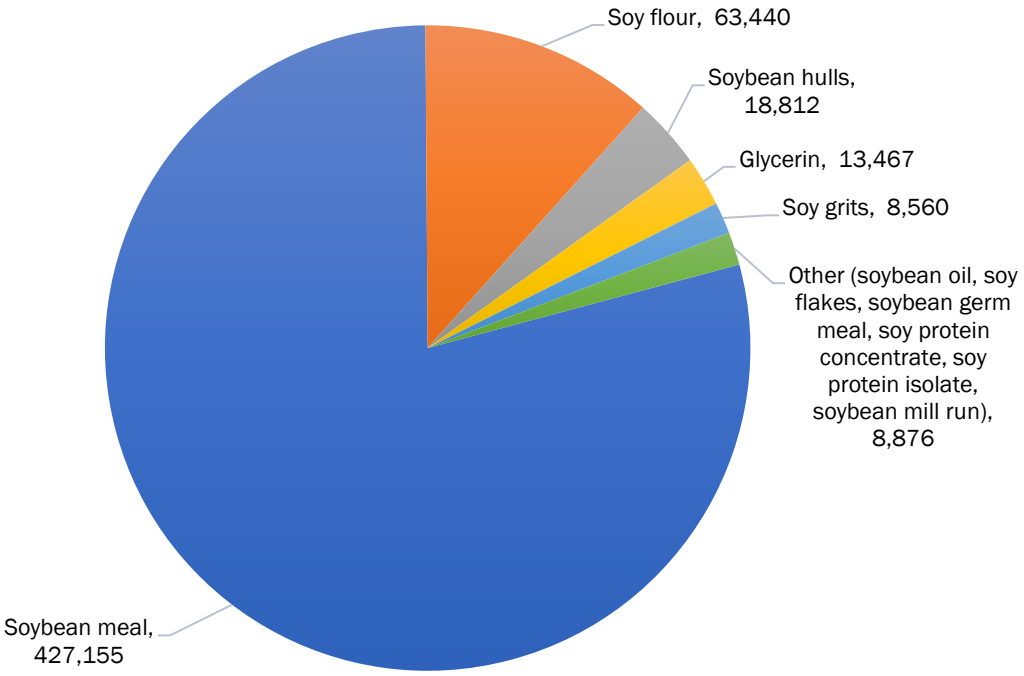
Corn is the most dominant plant-based ingredient used in pet food. Following it are corn gluten meal and soybean meal. Overall, U.S.-produced pet food demands an estimated 540,310 tons of soy-related products per year.

Average Missouri plant consumption

- 77,507 tons of pet food ingredients annually
- 4,844 tons are soy-related (6.2% of total pet food ingredients)

Of all soy-related products used in U.S. pet food production, Exhibit 9.2 shows the distribution by type. By volume, soybean meal represents 79% of total soybean products used in pet food. Other key products — and their share of total soy-related ingredient tonnage used — are soy flour (12%), soybean hulls (3%), glycerin (2%) and soy grits (2%). Pet food manufacturers use smaller quantities — less than 1% of total soy product tonnage — of soybean oil, soy flakes, soybean germ meal, soy protein concentrate, soy protein isolate and soybean mill run.

Exhibit 9.2. Soy-related ingredients in U.S. pet food, tons



Source: Decision Innovation Solutions (ifeeder.org/pet-food-report)

10. Recommendations

Based on the research conducted for this project, Exhibit 10.1 identifies strengths, weaknesses, opportunities, and threats related to the Missouri soybean industry's opportunity to expand soybean use within Missouri animal agriculture industries.

Exhibit 10.1. SWOT analysis of Missouri's future animal agriculture growth

Strengths	Weaknesses
• Farms are likely to position new sow units in remote, biosecure locations instead of hog production-dense areas in the Corn Belt. • Chicken consumption continues to grow, and Missouri is just north of a dense broiler production cluster in Arkansas. • Expanding Missouri's beef slaughter capacity will lead to finishing more cattle in the state. • Growth in free-range layer facilities will likely occur at the same latitude where these facilities have already emerged in Missouri.	• State permitting and local planning and zoning restrictions affect the potential for new CAFO facilities to start up and operate. • For businesses that run large confinement dairies or open feedlots, Missouri's climate is not as attractive as the climate in other states. • Access to immigrant labor affects where processors decide to locate and where new production complexes have the most opportunity.
Opportunities	**Threats**
• Consumers' emerging health and animal welfare preferences opens the potential for specialty egg production growth. • The commodity egg industry will rebuild layer housing to adhere to cage-free rules — a trend led by a segment of consumers. • U.S. will become more export-competitive in poultry and pork meat due to its increasing soybean meal supply — a side effect of trying to meet renewable diesel oil demand.	• Consumer move to plant-based substitutes for animal products hinders industry growth potential. • Competing states have lower soybean meal prices because of their access to new crush plants. • Future growth in animal production tends to follow existing industry clusters.

To quantify the opportunity for Missouri soybeans to satisfy in-state feed demand, Exhibit 10.2 estimates the soybean meal and hulls demanded by different animal species raised by operations of varying sizes. According to these estimates, raising chickens for meat production or egg production has the greatest chance to increase soy feed ingredient demand on a per-complex basis.

Exhibit 10.2. Estimated soybean demand from potential animal industry growth

Sector	Operation or complex size	Annual soybean meal and hull demand (tons)	Bushels needed	Acres needed*
Broilers	50 million birds/complex	75,000	3,225,806	64,516
Egg-laying hens	2 million birds/complex	17,000	731,183	14,624
Dairy cattle	3,500 cows/operation	3,686	153,200	3,064
Breeding hogs	1,200 sows/operation	326	14,022	280
Market hogs	2,480 head/operation, 2 turns	290	12,473	249
Turkeys	10,000 birds/building, 2 turns	140	6,022	120
Beef stockers	1,000 head backgrounded, 2 turns	105	4,364	87
Beef fed cattle	1,000 head capacity, 2 turns	100	4,156	83
Aquaculture	60 acres pond, catfish production	85	3,656	73

*Assumes 50 bushels per acre yield.

To increase Missouri soybean feed demand, Exhibit 10.3 reports multiple recommendations and organizes those recommendations by animal agriculture sector.

Exhibit 10.3. Recommendations to increase soybean demand by animal sector

Sector	Category	Recommendations
Broilers	Goals	• Attract a new broiler complex (50 million birds annually, 200 contract-grower houses) into Missouri. • Strengthen soybean coproduct use in existing Missouri broiler diets.
	Tactics	• Identify an industry liaison experienced in the Missouri poultry industry. • Connect with key poultry stakeholders and nutritionists from leading Missouri companies and other leading U.S. businesses. • Identify areas of Missouri that accept poultry production, have farmers willing to be contract-producers and offer the labor force necessary for poultry processing to locate a new broiler complex.
	Contacts	• Georges, Simmons Foods and Tyson Foods have operations in Missouri. • The Poultry Federation (thepoultryfederation.com) • Missouri Poultry Yearbook from Missouri Department of Agriculture • Top U.S. poultry companies from Watt Global Media (wattglobalmedia.com)
Egg-laying hens *(Commodity eggs, large scale)*	Goals	• Attract new egg complexes (2 million birds each) into Missouri. • Strengthen soybean coproduct use in existing Missouri layer diets.
	Tactics	• Identify an industry liaison experienced in the Missouri egg industry. • Connect with key poultry stakeholders and nutritionists from leading Missouri companies and other leading U.S. businesses. • Identify an area in Missouri that accepts egg production and processing.
	Contacts	• The Missouri Egg Council • The Poultry Federation (thepoultryfederation.com) • Missouri Poultry Yearbook from Missouri Department of Agriculture • Rose Acres and Cal Maine have operations in Missouri.

Exhibit 10.3. Recommendations to increase soybean demand by animal sector, cont.

Sector	Category	Recommendations
Egg-laying hens *(Specialty eggs, contract production)*	Goals	• Strengthen soybean coproduct use in existing Missouri layer diets. • Develop demand for SOYLEIC non-GMO soybean meal.
	Tactics	• Develop an industry liaison who has experience in the Missouri specialty egg industry. • Connect with feed mills and nutritionists serving organic and non-GMO egg markets for SOYLEIC non-GMO soybean meal.
	Contacts	• Opal Foods, Vital Farms and Mid-States Specialty Eggs operate in Missouri. • Ozark Organics, LLC (feed mill in Buffalo, Missouri) • Feed mill directory available from Missouri Department of Agriculture.
Turkeys	Goals	• Expand turkey inventory in Missouri with existing companies. • Strengthen soybean coproduct use in existing Missouri turkey diets.
	Tactics	• Survey Missouri companies to judge interest in a turkey meat export strategy. Assist in developing export strategies to stimulate growth. • Develop an industry liaison who has experience in the Missouri turkey industry and meat export brokers. • Connect with key turkey stakeholders and nutritionists.
	Contacts	• Missouri Department of Agriculture international marketing team • Missouri Poultry Yearbook from Missouri Department of Agriculture • The Poultry Federation (thepoultryfederation.com) • Butterball and Cargill have operations in Missouri. • U.S. Meat Export Federation (usmef.org)
Hogs for breeding	Goals	• Add sow inventory and farms in Missouri.
	Tactics	• Identify areas in Missouri suitable for swine production.
	Contacts	• Smithfield Foods, JBS and Pipestone have sow operations in Missouri. • Missouri Pork Association (mopork.com) • Pork Powerhouse list from Successful Farming (agriculture.com/system/files/Pork%20Powerhouse%202021%2010-5-21.pdf)
Market hogs	Goals	• Finish more Missouri-born pigs within state.
	Tactics	• Identify areas in Missouri suitable for swine production. • Work with existing swine integrators to locate feeding barns in Missouri.
	Contacts	• Smithfield Foods, JBS and Pipestone have operations in Missouri. • Missouri Pork Association (mopork.com)
Beef cattle	Goals	• Encourage additional beef stocker/backgrounding production in Missouri. • Encourage additional beef cattle finishing in Missouri.
	Tactics	• Connect with larger Missouri backgrounding operators to seek new channels for marketing, risk management and financing for farmers growing cattle. • Support intentional crossbreeding of beef on dairy for seasonal dairy grazing herds to supply batched herds of feedlot-ready calves with known performance and grading. • Support finishing cattle in Missouri by encouraging SWCD cost share of finishing facilities, supporting MU Beef Finishing School and encouraging use of Livestock Rick Protection to control price risk.
	Contacts	• Veterinarians/Craig Payne (missouri.edu/directory) • Regional livestock markets • MU Finishing School/Eric Bailey (cafnr.missouri.edu/person/eric-bailey) • Work with semen companies to identify seasonal dairy customers who might be interested in breeding to beef.

Exhibit 10.3. Recommendations to increase soybean demand by animal sector, cont.

Sector	Category	Recommendations
Dairy cattle	Goals	• Attract new large-scale confinement dairies to Missouri. • Develop demand for SOYLEIC non-GMO soybean meal.
	Tactics	• Partner with Missouri Department of Agriculture and Missouri Dairy Growth Council to facilitate new large dairies starting or moving to Missouri. • Connect with feed mills and nutritionists serving organic dairy to help build dairy market for SOYLEIC non-GMO soybean meal. • Connect with Mid-South Dairy Records for list of 100 top-producing cow herds and introduce SOYLEIC non-GMO soybean meal to them.
	Contacts	• Organic/non-GMO contact: NEMO Feed (nemofeed.com) • Mid-South Dairy Records (mydhia.org) • Kurt Olsen, MO Department of Agriculture (agriculture.mo.gov/abd/staff.php)
Aquaculture	Goals	• Add soybean coproducts to Missouri aquaculture diets.
	Tactics	• Develop new aquaculture enterprise budgets and increase educational programming around aquaculture in Missouri. • Connect with existing Missouri aquaculture businesses about soybean coproduct usage in their operations.
	Contacts	• Missouri Aquaculture Directory (agriculture.mo.gov/abd/aqua) • Missouri Aquaculture Association • MU Aquaculture/Fisheries Extension (extension.missouri.edu/programs/aquaculture-extension) • Lincoln University Extension (lincolnu.edu/web/cooperative-research/aquaculture)

Growing Missouri Soybean Demand: Food Product Manufacturing

Commissioned by the Missouri Soybean Merchandising Council

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Missouri Soybeans

Extension
University of Missouri

MASBDA
Missouri Agricultural and Small Business Development Authority

Growing Missouri Soybean Demand: Food Product Manufacturing

This report explores opportunities to supply soy components to use in Missouri-produced food products. It highlights the market landscape for whole soy products such as tofu and soy milk. Plus, it identifies potential markets for oil and protein and lists Missouri firms that may procure soy ingredients to make products for several key markets.

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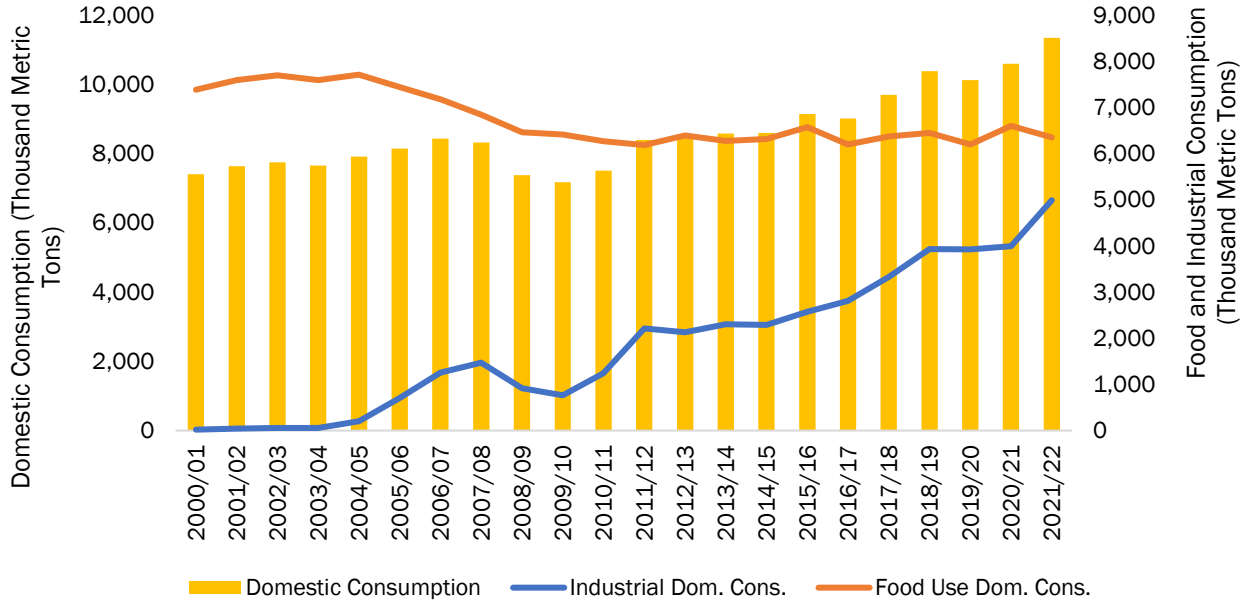
1. Summary

Missouri exports 45% of the soybeans it grows to other states or countries as raw beans. In-state crushing and other uses consume 55% of the state's soybean crop. This chapter summarizes opportunities to increase in-state Missouri soybean use for food applications.

Soy foods made from whole soybeans consume a relatively small share of the world's soybeans. Just 6% of the soybeans produced globally are used to make whole soybean products such as tofu and soy milk (tabledebates.org/building-blocks/soy-food-feed-and-land-use-change#SOYBB2).

Other food products containing soy ingredients may feature oil or meal — ingredients yielded from crushing whole soybeans. Historically, the U.S. has consumed more soybean oil for food uses than industrial uses, but the difference between the two has closed over time. Exhibit 1.1 charts U.S. domestic soybean oil use from 2000/01 to 2021/22 (apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery).

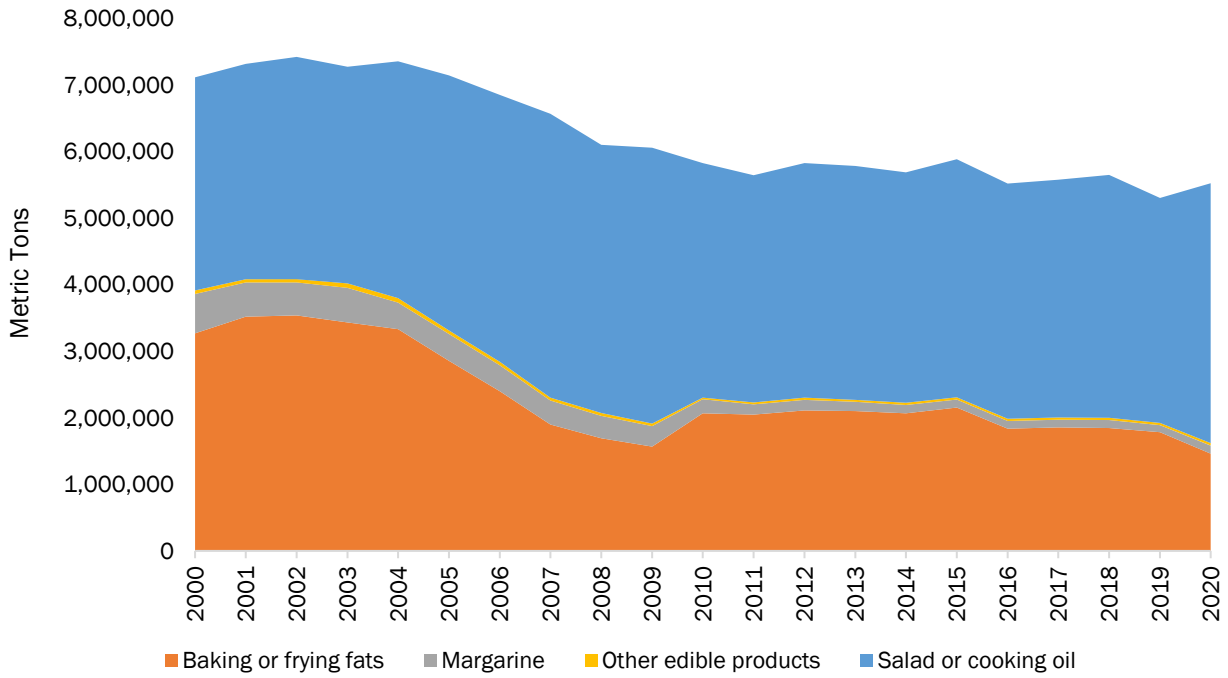
Exhibit 1.1. U.S. domestic soybean oil use, 2000/01 to 2021/22



Source: USDA Foreign Agricultural Service Production, Supply and Distribution (apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery)

With respect to soybean oil use in food, Exhibit 1.2 details U.S. consumption by category from 2000 to 2020. Early during this period, the U.S. predominantly used soybean oil as a baking or frying fat or salad or cooking oil. During the mid- to late 2000s, soybean oil demand for baking and frying uses dropped, and the industry saw an uptick in the oil's use as a salad or cooking oil. In most recent years, the salad or cooking oil category annually has used between 3.4 million metric tons and 3.9 million metric tons of soybean oil (marketviewdb.centrec.com).

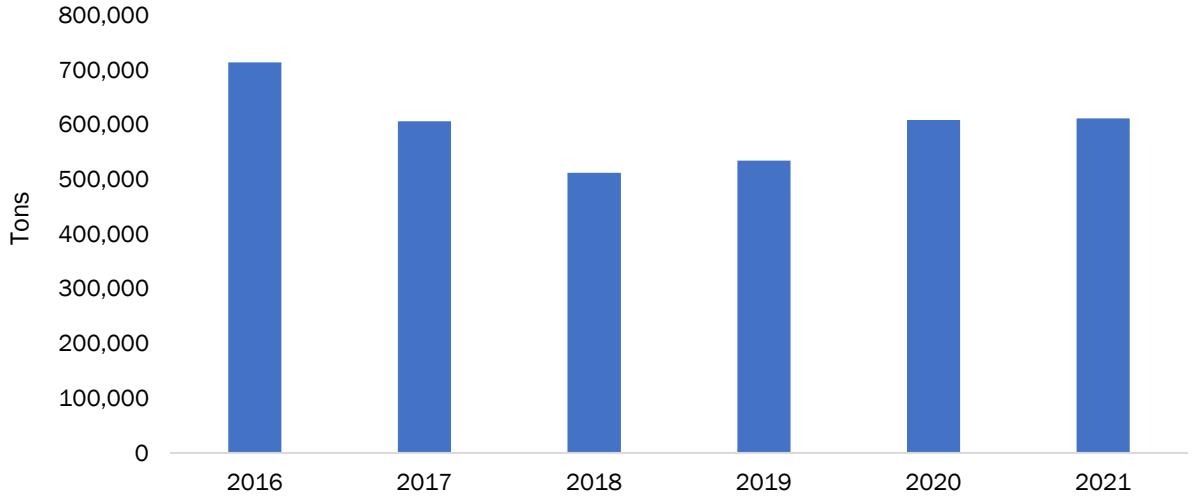
Exhibit 1.2. U.S. soybean oil food use by category, 2000 to 2020



Source: Centrec and the United Soybean Board (marketviewdb.centrec.com)

From 2016 to 2021, U.S. soybean cake and meal produced for edible uses declined and then experienced an uptick. See Exhibit 1.3. Production totaled roughly 713,000 tons in 2016 and 611,000 tons in 2021. Of all soybean cake and meal produced, the portion directed to edible protein products has been relatively small — just 1.1% to 1.7% from 2016 to 2020 (nass.usda.gov/Quick_Stats).

Exhibit 1.3. Soy cake and meal production for edible protein products, 2016 to 2021



Source: USDA National Agricultural Statistics Service (nass.usda.gov/Quick_Stats)

Missouri is home to several food manufacturing industries that may use Missouri-grown soybeans as ingredients. Data from Emsi indicate the extent to which certain industries concentrate in Missouri relative to the U.S. overall based on employment information. In 2020, several food manufacturing industries had a location quotient that at least equaled a 2.0 — suggesting that Missouri has twice the employment in an industry compared with the country overall. Those industries with at least a 2.0 location quotient were *creamery butter manufacturing*, *soybean and other oilseed processing*, *breakfast cereal manufacturing* and *meat processed from carcasses*. Several other industries had location quotients that ranged from 1.0 to 1.9 (Emsi).

The Missouri Soybean Merchandising Council has invested in developing several innovations that have the potential to open or expand markets for soybeans in Missouri-produced food products. Those include high-oleic soybean oil, vitamin B12-fortified soy foods such as soy milk and tofu, nondairy ice cream made from high-oleic soybean oil and spray-dried powder to substitute for soy protein isolate. Exhibit 1.4 summarizes the various end markets where these and other innovations have the potential to be adopted. For each market explored, Missouri has manufacturers or food service businesses that represent potential buyers.

Exhibit 1.4. Opportunities to expand soy-related demand within Missouri-produced food

Sector	Discussion
Soyleic oil	With the stability needed to extend frying life and packaged product shelf life, Missouri food businesses may use Soyleic high-oleic soybean oil in products such as the following: roasted nuts, dried fruit, pie, chips, baked goods, cooking oil, food service dishes, donuts, snack foods, shortening and margarine.
Soyleic milk	Plant-based milk sales have increased in recent years; however, soy milk has had competitive challenges. Its sales have declined. The category leaders are now made from almonds and oats, despite some research showing that soy milk has nutritional advantages compared with alternatives such as almond milk. Soy milk has also had acceptability problems, which may need to be addressed in new products.
Soyleic yogurt	Plant-based yogurt has captured only a small share of total yogurt sales, but the category did show sales growth in recent years. Nutritional benefits and health reasons have driven plant-based yogurt interest among consumers. Brands have consolidated yogurt offerings to simplify purchase decisions for consumers. Yogurt may have new opportunities in snacks and drinks.
Soyleic tofu	Tofu sales have improved in recent years. The COVID-19 pandemic and related supply chain challenges caused tofu sales to increase. Sales have the potential to grow further. Tofu may appeal to consumers who want to consume more plant-based protein but feel concerned about the processing of meat alternatives. As consumers better understand how to prepare tofu — and have options available to expedite its preparation — then sales may grow further.
Soyleic okara	Made of pulp and fiber, okara is created when making tofu or soy milk. Used as an animal feed, compost component and fertilizer, okara also has potential in food uses. Its high moisture content makes it susceptible to spoiling and heavy. Drying can open market opportunities, including those for okara flour.
Soyleic ice cream	Soyleic oil may displace other fats in ice cream alternatives, which is a still a relatively small share of total ice cream and frozen novelty sales. Research suggests that plant-based ice cream and frozen novelty shoppers may most prefer almond and coconut ingredients as dairy substitutes. These shoppers are most interested in choosing products based on taste.
Meat substitutes	Wheat-soy and soybean-based are two common formulations used when making plant-based meat alternatives. Projections from the Good Food Institute suggest that plant-based meat will capture a 6% share of the worldwide meat market by 2030. A majority — 62% — of those products will feature soy protein concentrate and wheat gluten as major ingredients, and 14% will have a soy-based formula that includes soy protein concentrate as a major ingredient and soy protein isolate as a minor ingredient.
Snack bars	Protein has been one of the major nutrients consumers look for in snack bars. Soy, a traditional protein source used in bars, will increasingly compete with emerging proteins such as peas, lentils and beans. Manufacturers may incorporate protein in various snack bar components, including the dough, filling, coating and mix-ins. When the COVID-19 pandemic forced consumers to stay home, the bar market suffered — likely as consumers were traveling less and not as reliant on convenient snacks.
Cheese	A relatively small product category, plant-based cheese sales have increased in recent years. Some functional characteristics (e.g., stretch, melt, mouthfeel, shredding abilities) typical in dairy-based cheese can be difficult to replicate in plant-based options.
Breakfast cereal	Hot and cold cereals may have added protein, and protein represents one of three characteristics most likely to motivate cereal product trial, according to Mintel research. The pandemic led to a resurgence in breakfast cereal popularity. If that continues as behaviors return to pre-pandemic norms, then the category may have stronger appeal to ingredient suppliers.
Bread	Behavioral changes attributed to the COVID-19 pandemic triggered an increase in bread sales. Consumers also showed interest in breads they considered healthier or indulgent. Healthier options include low-carb, high-protein and high-fiber products. Added protein can cause formulation challenges, but soy protein has been a traditional choice to add protein to bread products.
Beverages	Plant-based beverage formats include juices, wellness shots, energy drinks, fortified water, teas and sport drinks. In a 2021 study, Kerry, an ingredients business, identified the following beverage products as those where consumers thought protein fortification would be most appealing: smoothies, milkshakes, nutritional beverages, drinkable yogurt and dairy-based milk.
Supplements	In 2019, roughly one-quarter of supplement users chose protein supplements, according to the Council for Responsible Nutrition. More than 40% of those protein supplement consumers said they used plant protein options.

2. Soybean use in food products

In food products, whole soybeans may undergo further processing into products such as soy milk and tofu. Alternatively, soybeans may be crushed into meal and oil, which have varied food product use. This section details the extent of soybean or soy ingredient use in food.

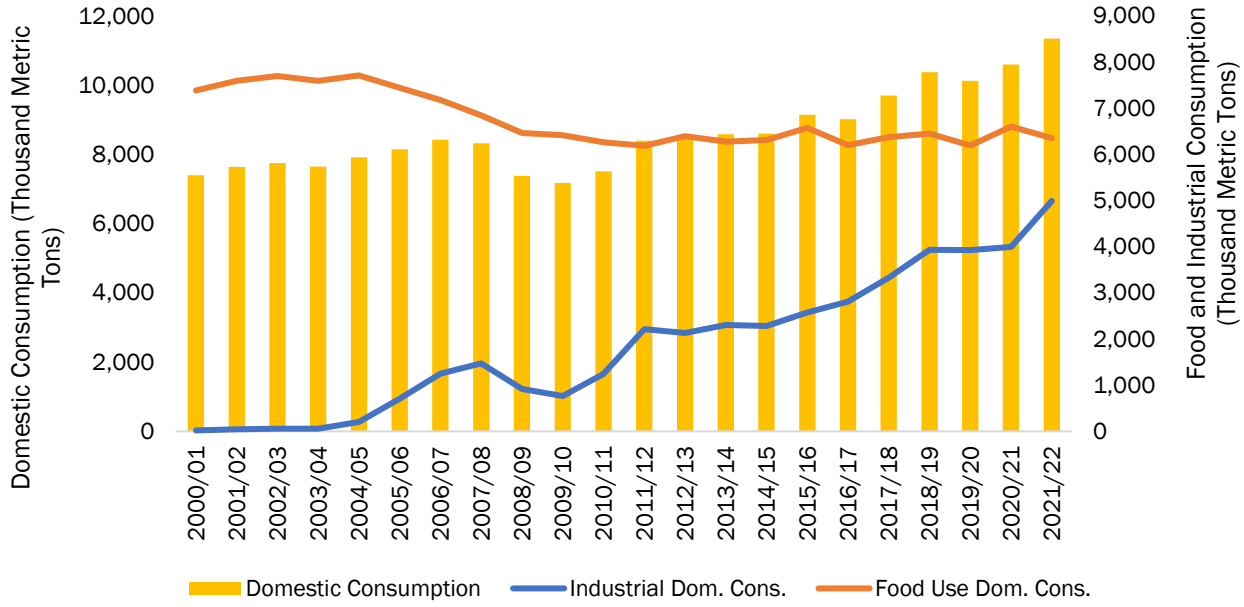
2.1 Whole soybeans

Of global soybean production, 6% finds use as whole soybeans used in food products. Tofu and soy milk consume the bulk of these whole soybeans. Using data from the USDA and United Soybean Board, a graphic published by the Food Climate Research Network suggests that 44% of whole soybeans directed to food use are directed to tofu, and soy milk uses 25% of whole soybeans made into food products. Other soy foods, including edamame, soy sauce and tempeh, use 20% of the whole soybeans directed to food uses (tabledebates.org/building-blocks/soy-food-feed-and-land-use-change#SOYBB2).

2.2 Oil

Historically, the U.S. has consumed more soybean oil for food uses than industrial uses, but the difference between the two has closed over time. Exhibit 2.2.1 charts U.S. domestic soybean oil use from 2000/01 to 2021/22. Total domestic consumption grew 53% during this time. It totaled 11.34 million metric tons in 2021/22, and food uses consumed 56% of that total. For food use, soybean oil consumption totaled 6.35 million metric tons — a drop from the 7.71 million metric ton peak recorded in 2004/05 (apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery).

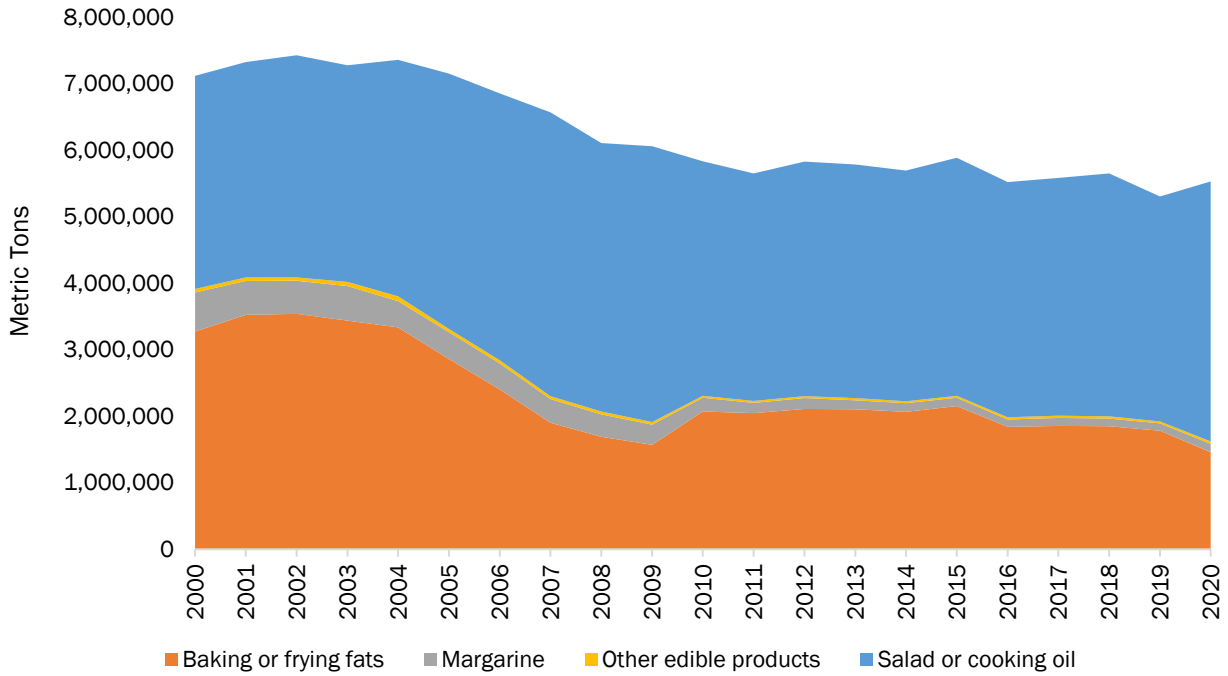
Exhibit 2.2.1. U.S. domestic soybean oil use, 2000/01 to 2021/22



Source: USDA Foreign Agricultural Service Production, Supply and Distribution (apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery)

Published by Centrec, the Market View database from the United Soybean Board provides additional insights into soybean oil's use in food. Exhibit 2.2.2 illustrates the trend in soybean oil use for food from 2000 to 2020. Early during this period, soybean oil most commonly was used as a baking or frying fat or salad or cooking oil. During the mid- to late 2000s, soybean oil demand for baking and frying uses dropped. To work well as a frying fat, much soybean oil had been partially hydrogenated, which yields trans fats linked to health problems. As soybean oil's use as a baking or frying fat declined, the industry saw an uptick in the oil's use as a salad or cooking oil. In most recent years, the salad or cooking oil category annually has used between 3.4 million metric tons and 3.7 million metric tons of soybean oil. In 2020, soybean oil use for cooking or salad uses jumped to 3.9 million metric tons (marketviewdb.centrec.com).

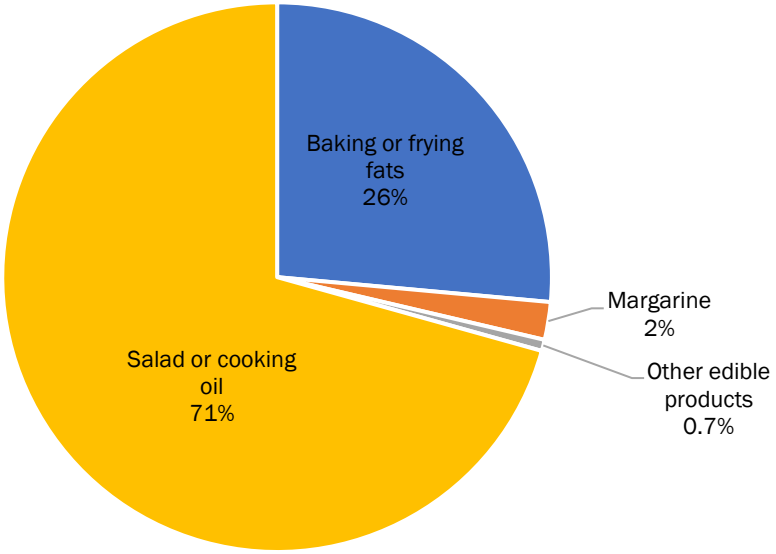
Exhibit 2.2.2. U.S. soybean oil food use by category, 2000 to 2020



Source: Centrec and the United Soybean Board (marketviewdb.centrec.com)

In 2020, the salad or cooking oil category consumed more than two-thirds of all soybean oil directed to food uses, according to the Centrec and United Soybean Board database. The baking or frying fats category used roughly one-quarter. See Exhibit 2.2.3. Margarine and other edible products demanded negligible soybean oil (marketviewdb.centrec.com).

Exhibit 2.2.3. Share of U.S. soybean oil food use by category, 2020

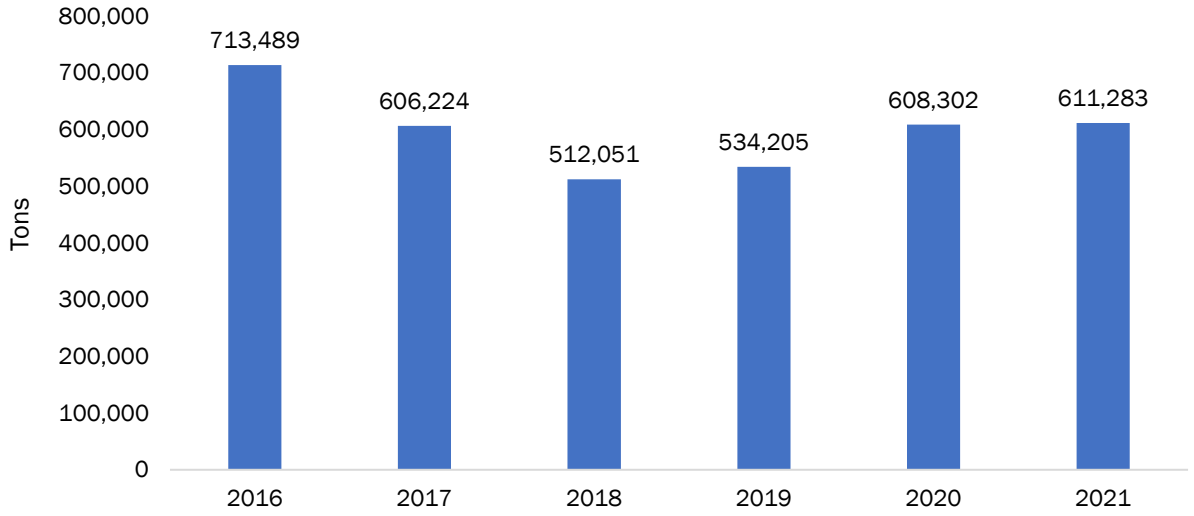


Source: Centrec and the United Soybean Board (marketviewdb.centrec.com)

2.3 Meal

The U.S. National Agricultural Statistics Service reports U.S. soybean cake and meal production on an annual basis. From 2016 to 2021, the data indicate that soybean cake and meal produced for edible uses declined and then experienced an uptick. See Exhibit 2.3.1. Production totaled roughly 713,000 tons in 2016 and 611,000 tons in 2021. Of all soybean cake and meal produced, the portion directed to edible protein products has been relatively small. Between 2016 and 2020, just 1.1% to 1.7% of total soybean cake and meal production was meant for edible protein product use. Animal feed has been the predominant cake and meal user (nass.usda.gov/Quick_Stats).

Exhibit 2.3.1. Soy cake and meal production for edible protein products, 2016 to 2021



Source: USDA National Agricultural Statistics Service (nass.usda.gov/Quick_Stats)

3. Missouri food products manufacturing

A location quotient communicates the extent to which an industry concentrates in a particular locale compared with the U.S. overall, according to employment data. Industries with higher location quotients in an area will demand more components for manufacturing than areas where those industries have lower location quotients. For Missouri food manufacturing industries, Exhibit 3.1 highlights those with location quotients that exceeded 2.0 in 2020. With a 2.0 location quotient, an area would have twice the employment attributed to a particular industry as the country overall.

The Missouri industry with the greatest location quotient was *creamery butter manufacturing*, though it only had one payrolled business location in 2019. Other top Missouri industries based on location quotient included *soybean and other oilseed processing*, *breakfast cereal manufacturing* and *meat processed from carcasses* (Emsi).

Exhibit 3.1. Missouri food products manufacturing industries with location quotients that exceed 2.0, 2020

	2019 payrolled business locations	2020 jobs	% change in jobs, 2015-20	2020 location quotient
Creamery butter manufacturing	1	371	3,283%	6.13
Soybean and other oilseed processing	12	644	47%	3.72
Breakfast cereal manufacturing	4	838	0%	3.55
Meat processed from carcasses	58	6,961	60%	2.66
Cheese manufacturing	7	2,459	5%	2.28
Dry pasta, dough and flour mixes manufacturing from purchased flour	12	879	(16%)	2.21
Ice cream and frozen dessert manufacturing	7	915	(5%)	2.21
Fats and oils refining and blending	5	290	22%	2.14
All other miscellaneous food manufacturing	26	1,445	24%	2.06
Flour milling	8	566	(10%)	2.06

Source: Emsi

The Missouri industries listed in Exhibit 3.2 had 2020 location quotients that ranged from 1.0 to 2.0 — indicating these industries are relatively more concentrated in Missouri than the U.S. overall — and jobs that exceeded 1,000 people. Of the industries in this group, *frozen specialty food manufacturing* and *breweries* had 1.82 and 1.81 location quotients, respectively. Frozen specialty food manufacturers increased employment from 2015 to 2020 whereas employment in Missouri breweries declined. *Fluid milk manufacturing*

increased its employment in percentage terms more than the other industries highlighted. *Breweries* had the greatest number of payrolled business locations in 2019 (Emsi).

Exhibit 3.2. Missouri food products manufacturing industries with location quotients between 1.0 and 2.0 and employ at least 1,000 workers, 2020

	2019 payrolled business locations	2020 jobs	% change in jobs, 2015-20	2020 location quotient
Frozen specialty food manufacturing	23	2,144	10%	1.82
Breweries	68	2,875	(6%)	1.81
Poultry processing	12	7,372	(1%)	1.58
Fluid milk manufacturing	10	1,574	45%	1.53
Animal, except poultry, slaughtering	70	4,251	(20%)	1.52

Source: Emsi

4. MSMC commercialization opportunities

The Missouri Soybean Merchandising Council has invested in a key technology that has food industry appeal: Soyleic high-oleic soybeans. Compared with commodity soybeans, Soyleic high-oleic soybeans contain 2.5 times to more than three times more oleic acid (mosoy.org/wp-content/uploads/2019/05/High-Oleic-Flyer-GP.pdf). In a May 2019 story from *Food Business News*, a Qualisoy representative identified three application categories well-suited for high-oleic oil disruption:

- ***Food service***: The elevated oleic acid content makes high-oleic soybean oil a good choice when the oil must hold up well during high-heat exposure. High-oleic soybean oil can lengthen the oil fry life for food service companies.
- ***Consumer packaged goods***: The oil's stability also lends itself to packaged goods that may benefit from a longer shelf life. High-oleic soybean oil may displace other oils used in packaged snack foods and liquid coffee creamers.
- ***Shortenings***: High-oleic soybean oil offers stability similar to that offered by partially hydrogenated soybean oil. However, because of its trans fat content, partially hydrogenated oil no longer meets the generally recognized as safe definition for food use. In shortenings meant for baking, frying or making icing or puff pastry, high-oleic soybean oil can serve as a substitute.

The U.S. soybean industry has promoted high-oleic soybean oil's uses in frying, sauteing, baking and snack food preparation. Exhibit 4.1 outlines targeted applications in these four use categories (ussec.org/wp-content/uploads/2020/07/2019-U.S.-Grown-High-Oleic-Soybean-Oil-Brochure-1.pdf).

Exhibit 4.1. High-oleic soybean oil applications

Frying	Sauteing	Baking	Snack foods
Potatoes	Stir-frying	Muffins	Crackers
Vegetables	Pan-frying	Quick breads	Chips
Fish	Griddle-cooking	Brownies	Roasted nuts
Donuts		Pie crusts	
Chicken		Cakes	

Source: U.S. Soy (ussec.org/wp-content/uploads/2020/07/2019-U.S.-Grown-High-Oleic-Soybean-Oil-Brochure-1.pdf)

For Soyleic oil, its non-GMO attribute may appeal more to consumers when they're purchasing food to eat at home instead of away from home (i.e., packaged foods instead of items purchased at food service establishments). The 2020 food and health survey conducted by the International Food Information Council evaluated the extent to which certain labels or claims affected food purchases when consumers shop for food and beverages and when they eat away from home. When "shopping for food and beverages," non-GMO ranked as the third most likely label to influence purchases. More than 30% of respondents indicated they viewed non-GMO as a label that affected their purchases. Only natural and no added hormones or steroids ranked higher. When "eating away from home,"

nearly 20% of respondents said the non-GMO attribute affects their purchases. Attributes that ranked as more important were natural, clean ingredients, locally sourced, raised without antibiotics and no added hormones or steroids (foodinsight.org/wp-content/uploads/2020/06/IFIC-Food-and-Health-Survey-2020.pdf).

Non-GMO high-oleic oil also carries a premium that buyers must accept. The Veri high-oleic soybean oil available from Benson Hill has certification through the Non-GMO Project Verified program, and it's marketed as a high-heat cooking oil used for frying, roasting, searing or baking (dtnpf.com/agriculture/web/ag/crops/article/2021/07/22/high-oleic-soybean-acres-oil-demand). To process the non-GMO, high-oleic soybeans, the brand uses an expeller press — a point of differentiation relative to most cooking oils produced using solvent extraction. Exhibit 4.2 lists the Veri oil price posted on the brand's website. Buyers may purchase, 1-, 2- or 3-gallon packs (vericookingoil.com). Based in Ohio, The Jewell Grain Co. sells Plenish high-oleic soybean oil from its office at a steep discount compared with the Veri non-GMO, high-oleic soybean oil —$12.50 per gallon (jewellgrain.com/?publisher=localcom_rbl&placement=octane360). Veri's price was more than twice the Plenish price.

Exhibit 4.2. High-oleic soybean oil retail price comparisons

	Price per gallon
Veri*	$29.99
Plenish**	$12.50

* Source: Veri Cooking Oil (vericookingoil.com/product/veri-oil-1-gal)
** Source: Jewell Grain (jewellgrain.com/?publisher=localcom_rbl&placement=octane360)

Since developing the Soyleic technology, the Missouri Soybean Merchandising Council has funded additional research into discovering how Soyleic soybeans or ingredients made from these soybeans may be used in food products. The following discussion highlights the products where researchers have focused. It summarizes trends shaping these product categories, and it indicates Missouri firms — or other Midwest manufacturers — that may use the technology and corresponding food-grade soy ingredient.

Exhibit 4.3 lists firms located in or near Missouri may represent prospective buyers of high-oleic soybean oil. Note, this list has been narrowed to food or ingredients manufacturers or multiunit food service operators based in Missouri.

Exhibit 4.3. Potential high-oleic oil users, Missouri and nearby states

Firm	Products with oil	Location	Website
8th Avenue Food & Provisions	Snack nuts, dried fruit, trail mix	Hazelwood, Missouri	8avegranola.com
American Pie Company	Pie	Rolla, Missouri	ampieco.com
Backer's Potato Chips	Chips	Fulton, Missouri	backerchips.com
Bimbo Bakeries	Brownies, muffins	Brookfield, Columbia, Hollister, Kansas City, Lebanon, Manchester, Maryland Heights, Mountain Grove, Rolla, Sedalia, Springfield	bimbobakeriesusa.com
Bright Future Foods	Food incubator	St. Louis, Missouri	bit.ly/3KN7imq
CMC Foods	Cooking oil	Kansas City, Missouri	cmcfoodsus.com
Crazy Bowls and Wraps	Restaurant	St. Louis, Missouri	crazybowlsandwraps.com
Garden Complements	Sauces	Kansas City, Missouri	gardencomplements.com
Golden Boy Pies	Pies	Kansas City, Missouri	goldenboypies.com
Guy's Snacks	Chips	Kansas City, Kansas	getguyschips.com
Hawaiian Bros.	Restaurant	Kansas City, Missouri	hawaiianbros.com
Hostess Brands	Snack cakes	Lenexa, Kansas	hostessbrands.com
Hurts Donuts	Donuts	Springfield, Missouri	wannahurts.com
IFPC	Soybean oil	Fenton, Missouri	ifpc.com
It's Easy As Pie	Pie	St. Louis, Missouri	itseasyaspie.com
Lee's Famous Recipe Country Chicken	Fried chicken	Rolla, Missouri	leesrolla.com
Li'L Guy Foods	Tortilla chips	Kansas City, Missouri	lilguyfoods.com
Lion's Choice	Restaurant	St. Louis, Missouri	lionschoice.com
Lutfi's Fried Fish	Restaurant	Raytown, Missouri	lutfisfish.com
Mound City Shelled Nut Co.	Roasted nuts	St. Louis, Missouri	moundcity.com
Old Vienna of St. Louis	Chips	Fenton, Missouri	oldviennallc.com
Par-Way Tryson	Spray oil	St. Clair, Missouri	parwaytryson.com
Peggy Jean's Pies	Pies	Columbia, Missouri	peggyjeanspies.com
PFSbrands	Champs Chicken fried chicken	Holts Summit, Missouri	pfsbrands.com
Quaker Oats	Rice cakes	Columbia, Missouri	quakeroats.com
Riceland	Oil	Stuttgart, Arkansas	riceland.com
STL Baking	Keto crackers	Earth City, Missouri	stlbaking.com
Sweet Dreams Donuts	Donuts	St. Joseph, Missouri	sweetdreamdonuts.com
Strange Donuts	Donuts	St. Louis, Missouri	strangedonuts.com
The Billy Goat Chip Co.	Chips	St. Louis, Missouri	buythegoat.com
Uncle Ray's	Chips	Montgomery City, Missouri	unclerays.com
Ventura Foods	Shortening, oil, margarine	St. Joseph, Missouri	venturafoods.com

4.1 Soyleic milk

Manufacturers may use a wet or dry process to make soy milk. The wet process begins by soaking soybeans to soften them and improve their nutritional content (i.e., make nutrients more available and digestible, remove enzyme inhibitors). Next, a hammer mill or other equipment grinds the soaked soybeans into a puree or paste, which undergoes blanching. Depending on particle size, the product may require further grinding or filtering to produce a smooth texture. Last, manufacturers may treat the soy milk with heat and homogenization. The dry process begins by milling dry soybeans into flour. Then, separating protein from starch and fiber makes a protein concentrate or isolate (ift.org/news-and-publications/food-technology-magazine/issues/2018/december/columns/processing-how-plant-based-milks-are-processed).

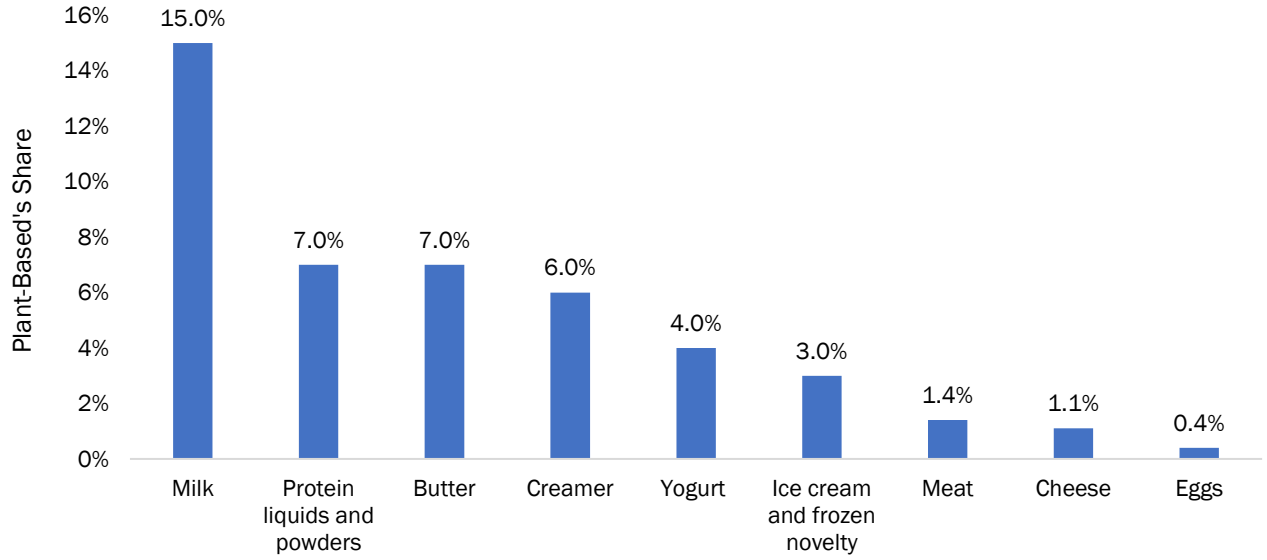
To the base soy milk, manufacturers may add water, flavoring, vitamins, minerals, thickeners, stabilizers, fat or sugar. They may also blend the plant-based milk with another beverage, such as a different plant-based milk or cold-brew coffee (ift.org/news-and-publications/food-technology-magazine/issues/2018/december/columns/processing-how-plant-based-milks-are-processed). As an alternative, plant-based milk may blend with dairy milk — a formulation Shamrock Farms launched in 2021. Based in Phoenix, the company blended chocolate dairy milk with plant-based alternatives to make a "hybrid beverage." Called Swirled, the brand has two SKUs. One mixes dairy milk and coconut cream, and another blends dairy milk, coconut cream and almonds. Shamrock Farms communicates that Swirled has less sugar than other chocolate milks (dairyfoods.com/articles/95315-2021-state-of-the-industry-milk-is-on-a-long-and-winding-road).

MSMC Research Connection
In its research, a University of Missouri team, funded by the Missouri Soybean Merchandising Council, has focused on identifying a process to fortify Soyleic soy milk with vitamin B12. The shelf-stable milk could provide additional vitamin B12 to audiences prone to experiencing deficiencies. Those include lactating and pregnant women, adolescents, children, vegetarians, older adults and consumers who experience gastrointestinal disorders or pernicious anemia.

Part of the research has evaluated how to encapsulate vitamin B12 with a Soyleic carrier and make an instant powder that contains the high protein content and vitamin B12 fortification.

Soy milk fits in the plant-based milk product category, which captured $2.5 billion in sales during 2020, according to SPINS data prepared for the Good Food Institute and Plant Based Foods Association. This total includes sales made in grocery stores, drug stores, mass retailers, dollar stores, club stores, military outlets and natural stores. It doesn't include sales made at select retailers, including Whole Foods Market and Trader Joe's. Plant-based milk sales increased by 20% from 2019 to 2020, and these products represented 15% of all 2020 milk sales. Compared with other product categories, such as those for butter, creamer and yogurt, the milk category has seen plant-based capture a larger share of total sales. Exhibit 4.1.1 presents plant-based products' share for several product categories (gfi.org/resource/plant-based-meat-eggs-and-dairy-state-of-the-industry-report).

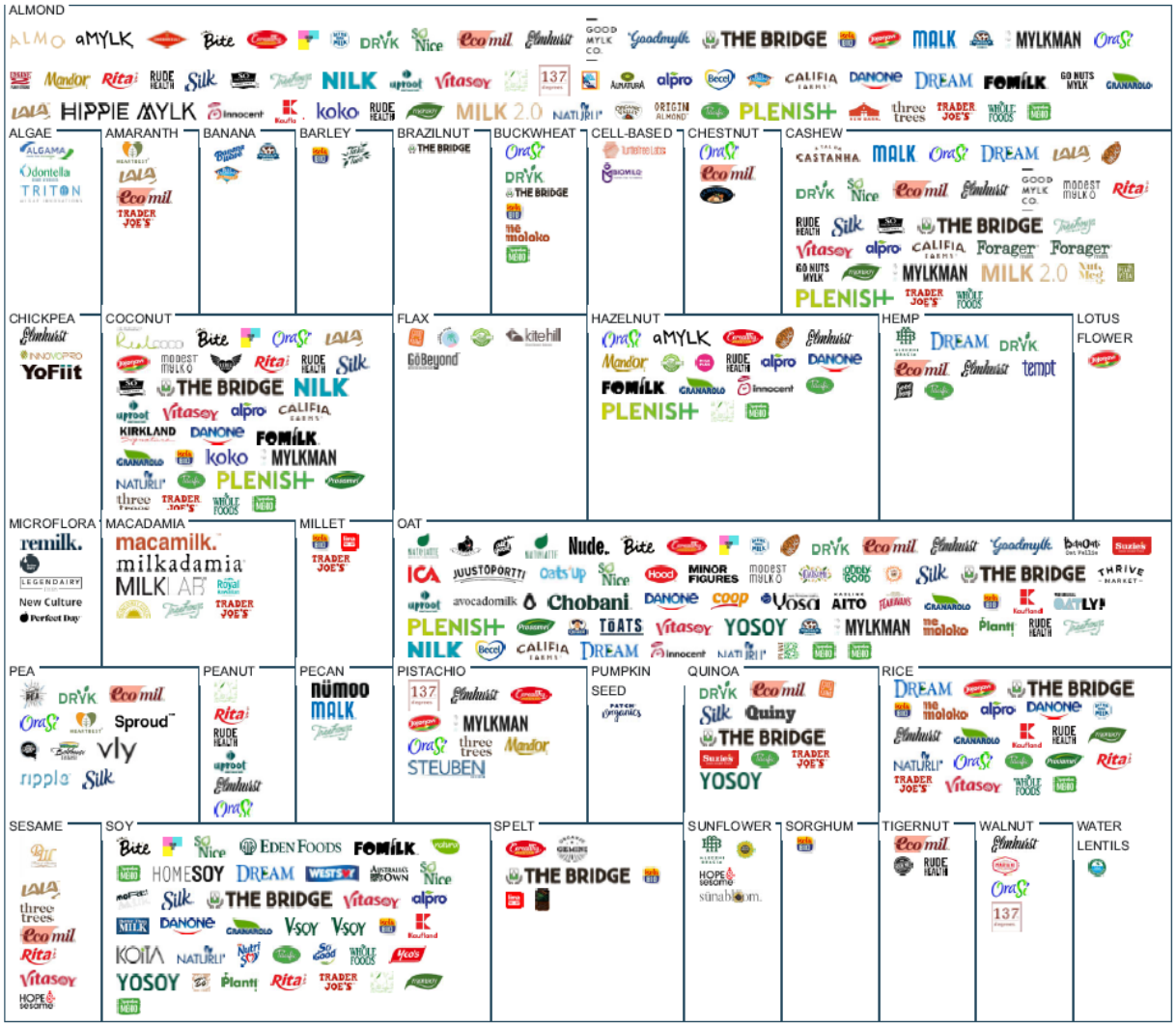
Exhibit 4.1.1. Retail sales share captured by plant-based products by category, 2020*



* Data reported for the year ending Dec. 27, 2020
Source: SPINS data reported by the Good Food Institute and Plant Based Foods Association

Within the plant-based milk category, soy milk has experienced competitive challenges in recent years. To visualize the competitive landscape for plant-based milk, see Exhibit 4.1.2. Created by Kind Earth Technology in August 2020, the graphic reinforces the diversity of ingredients used to make plant-based milk — everything from nuts and algae to grain and cell-based technology. Additionally, it illustrates how brands have proliferated to use these various ingredients in their plant-based milk products (newprotein.org).

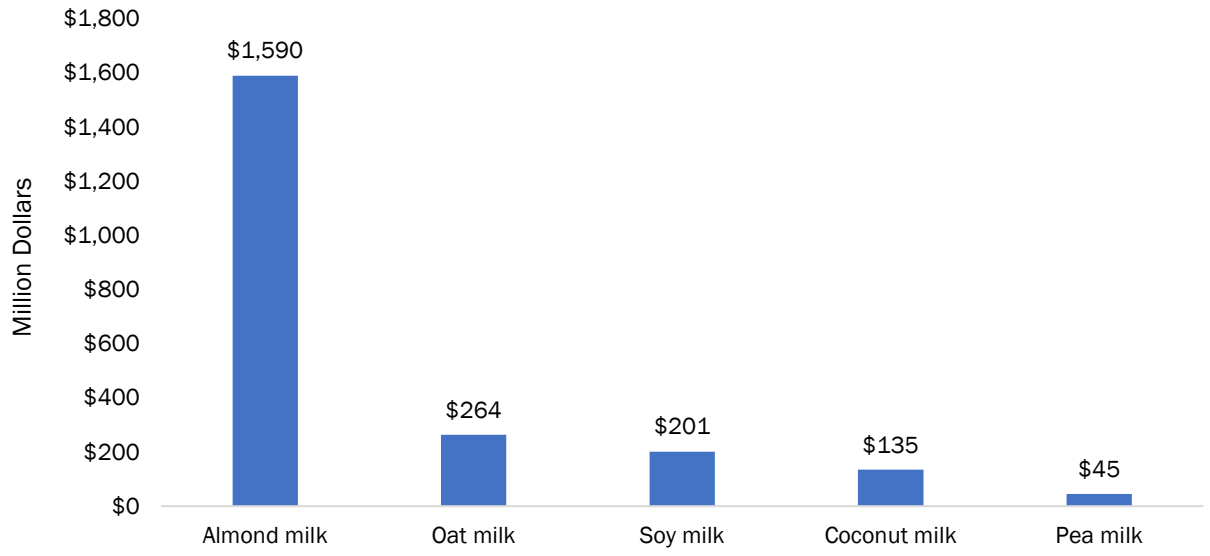
Exhibit 4.1.2. Competitive landscape for plant-based milk brands and inputs, August 2020



Source: Kind Earth Tech (newprotein.org)

In terms of sales, those for soy milk exceeded $1 billion annually in the early 2010s (foodnavigator-usa.com/Article/2020/09/25/Oatmilk-edges-past-soymilk-for-2-slot-in-US-plant-based-milk-retail-market-as-almondmilk-continues-to-drive-category-sales). Exhibit 4.1.3 presents plant-based milk sales by ingredient for the year ending Jan. 24, 2021. Almond milk and oat milk sales surpassed soy milk sales. Almond milk, which commanded the No. 1 position, reached nearly $1.6 billion in sales. In contrast, soy milk sales totaled $210 million. Some soy milk forms performed better than others from a sales perspective in the year ending on Jan. 24, 2021. For example, refrigerated soy milk retail sales declined slightly, but shelf-stable soy milk sales improved (foodnavigator-usa.com/Article/2021/03/03/Danone-North-America-CEO-on-plant-based-trends-why-soymilk-is-back-in-growth-and-the-Follow-Your-Heart-deal#).

Exhibit 4.1.3. Plant-based milk sales by featured ingredient*

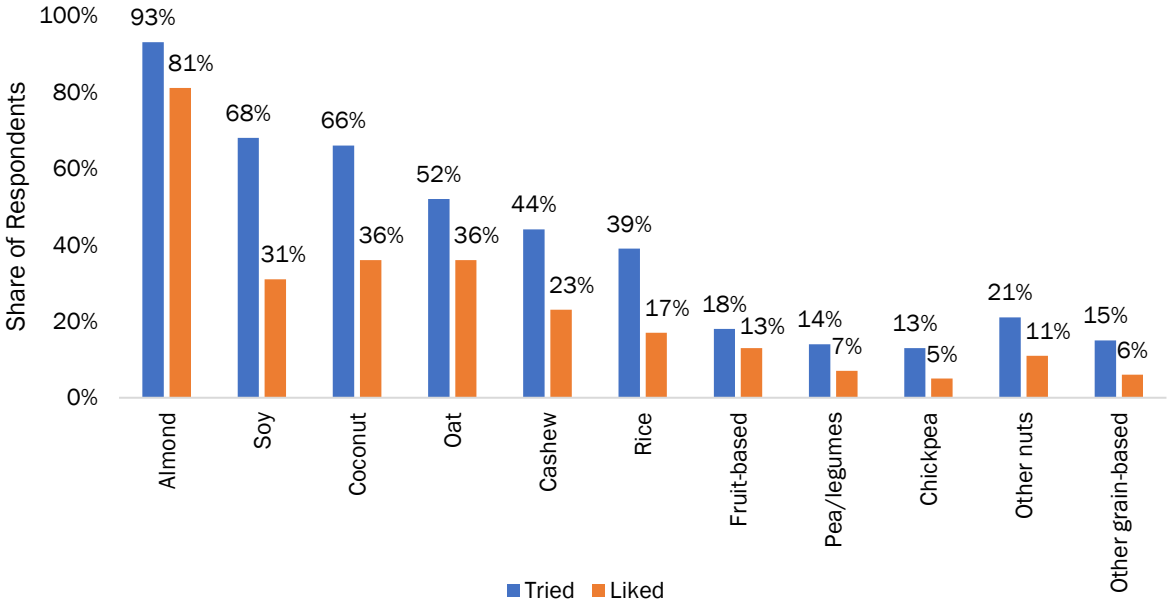


* Data reported for the year ending Jan. 24, 2021
Source: SPINS data reported by FoodNavigator-USA

Consumers perceive almond milk to have a health halo compared with soy milk — especially when considering protein content. Of U.S. milk consumers, roughly 25% said they viewed soy milk to be a good protein source, according to research cited by Mintel. For almond milk, roughly 30% viewed the product as a good protein source. Nutritional comparisons, however, point to soy milk's protein content exceeding almond milk's protein content. Due to this misunderstanding, Mintel challenged soy ingredient and product manufacturers to better message their products' protein content as a strategy to compete with alternative protein sources. Soy milk also tends to compete well on cost. Of U.S. dairy alternative consumers, more than half expect a lower price for dairy alternatives relative to traditional dairy, according to research published in a Mintel summary. Soy's affordability makes it suitable for products reaching value-oriented buyers (mintel.com/blog/food-market-news/soy-the-original-plant-protein-needs-a-makeover).

Soy dairy alternatives have had some acceptability problems among consumers. Cargill conducted a nationally representative survey in early 2021, and it solicited input from 301 U.S. adult grocery shoppers who said they had purchased a plant-based dairy alternative in the preceding three months. Exhibit 4.1.4 reports the share of participating consumers who said they had tried and liked plant-based dairy alternatives that used varying ingredients. Soy ranked second in terms the likelihood that consumers had tried these products; it followed almond. However, soy ranked lower than almond, coconut and oat in terms of the share of consumers who said they liked a given plant-based dairy alternative (cargill.com/food-beverage/na/plant-based-dairy-alternatives-insights-report).

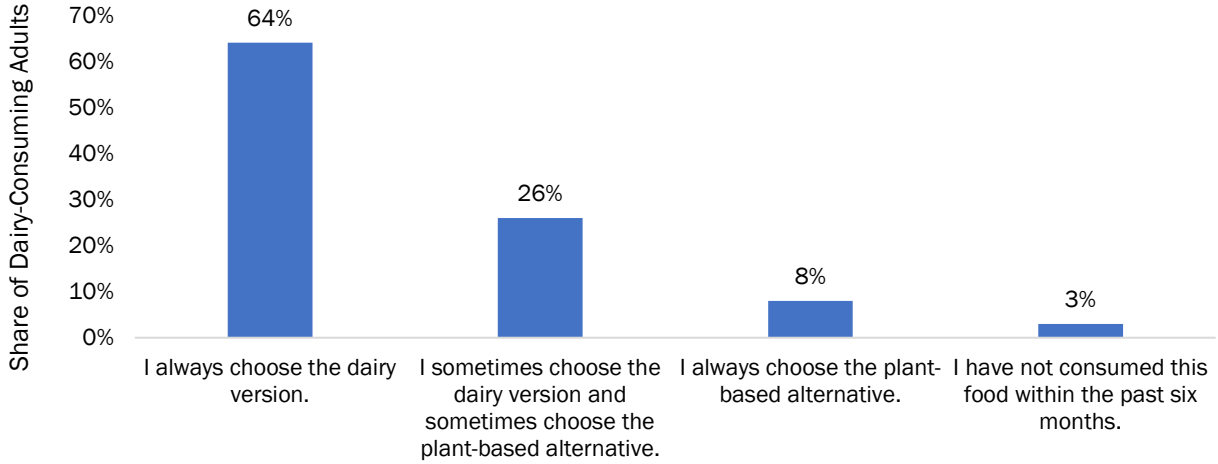
Exhibit 4.1.4. Plant-based dairy alternative trial, acceptability among U.S. adult grocery shoppers who had purchased plant-based dairy alternatives in previous three months



Source: Cargill (cargill.com/food-beverage/na/plant-based-dairy-alternatives-insights-report)

A majority of U.S. adults continue to choose dairy milk instead of plant-based alternatives, according to an International Food Information Council survey of 1,014 U.S. 18- to 80-year-olds in April 2021. Nearly two-thirds of respondents said they always chose dairy milk in the six months before the survey. Exhibit 4.1.5 reports that 26% of respondents said they sometimes chose dairy and plant-based alternatives, and 8% exclusively chose plant-based milks (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf).

Exhibit 4.1.5. Share of U.S. dairy-consuming adults who chose dairy and plant-based milk in six months preceding April 2021*



* Data represent consumption in six months preceding April 2021
Source: International Food Information Council (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf)

Demographic attributes tend to correlate with dairy-consuming adults' choice of traditional dairy milk or plant-based milks. Exhibit 4.1.6 presents data from the International Food Information Council survey conducted in April 2021. In the six months preceding the survey, women were more likely than men to have chosen both plant-based alternatives and traditional dairy. Men were more likely to only choose traditional dairy milk. Age also shaped milk purchase preferences. Roughly half of 18- to 34-year-olds said they always chose traditional dairy milk compared with two-thirds of 35- to 54-year-olds and three-quarters of consumers who were at least 55 years old. Thus, younger consumers felt more inclined to either choose traditional dairy milk and nondairy alternatives or only the nondairy choices (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf).

Exhibit 4.1.6. U.S. dairy-consuming adults milk purchase preferences and associated demographic characteristics*

	I always choose the dairy version.	I sometimes choose both — dairy and plant-based.	I always choose the plant-based (nondairy alternative).
Men	66.3%	22.8%	7.5%
Women	61.0%	28.9%	8.0%
18-34 years old	51.7%	36.6%	10.3%
35-54 years old	66.7%	23.8%	7.3%
55+ years old	75.4%	14.3%	4.4%
Noncollege	62.9%	26.9%	8.2%
College	63.9%	25.5%	7.4%

* Data represent consumption in six months preceding April 2021
Source: International Food Information Council (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf)

Marketplace dynamics in the plant-based milk category may influence a plant-based product's market potential in the future. IBIS World included the following points in a June 2020 report about soy and almond milk production ("Soy & Almond Milk Production," Industry Report OD4195, IBISWorld).

- Milk alternatives made from soybeans and almonds tend to carry a price premium relative to traditional dairy. Strong consumer confidence often results in consumers choosing more dairy alternatives, but consumers who choose nondairy milks also tend to have less price sensitivity.
- Nondairy milks first gained popularity among consumers whose dietary restrictions precluded traditional dairy intake. As this product category has matured, some consumers concerned about health have gravitated toward alternative milk products.
- Soy milk often carries messages about how it affects heart health. Other products appeal to consumers who required specialized diets to respond to digestive health and calcium absorption issues.
- In recent years, soy milk lost market share as consumers perceived alternatives such as almond milk and coconut milk to have better taste, fewer calories and an ability to address health concerns. Other stumbling blocks for soy milk have included the

phytoestrogen compounds found in soy, genetic modification involved in developing some soybean varieties and off flavors that can arise during processing and storage.
- Although sales tend to concentrate among a few firms, many firms including those that make private-label products compete in this industry. The competition has led firms to lower their prices to attract customers.
- Manufacturers innovate as a strategy to grow.

Exhibit 4.1.7 lists manufacturers located in or near Missouri that make plant-based milk. As such, they may have interest in sourcing Missouri-grown soybeans as ingredients.

Exhibit 4.1.7. Soy milk manufacturers in Missouri and nearby states

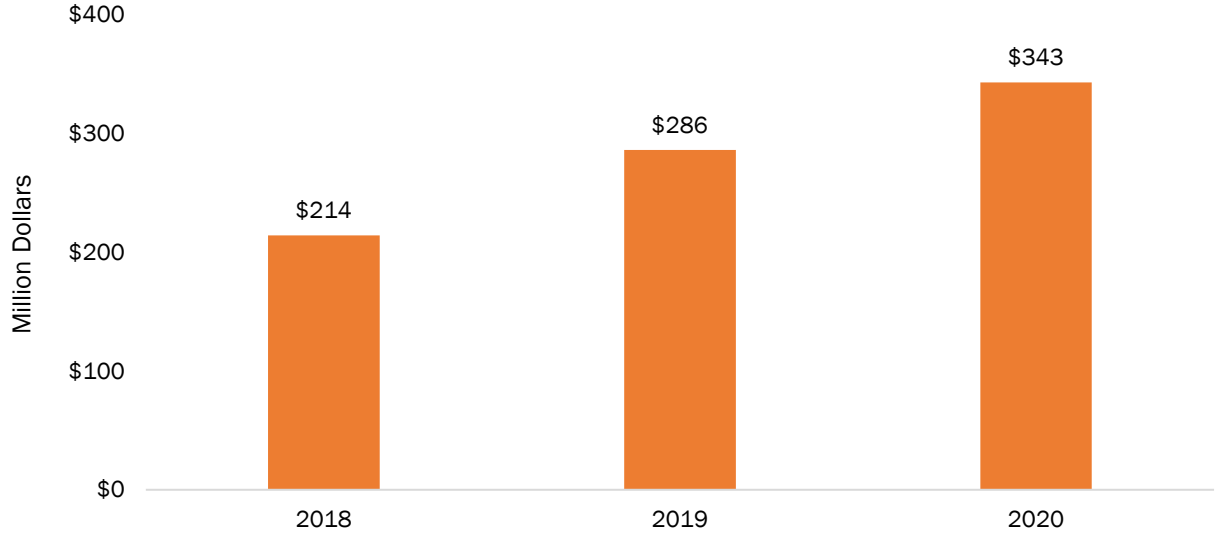
Firm	Location	Website
Jasper Products	Joplin, Missouri	heritage-foods.com/jasper
Osage Food Products	Washington, Missouri	osagefood.com
SmithFoods	Pacific, Missouri	smithfoods.com

4.2 Soyleic yogurt

SPINS data reported by the Good Food Institute track plant-based yogurt sales in the U.S. For 2018 to 2020, Exhibit 4.2.1 presents dollar sales, which grew from $214 million in 2018 to $343 million in 2020 — a 60% increase in dollar sales. In terms of units, sales in 2020 exceeded 162 million units — 16% growth (gfi.org/marketresearch/#yogurt). Nielsen estimated U.S. retail sales in 2019 to total roughly $263 million, which is slightly less than the SPINS estimations (kerry.com/na-en/explore/winning-with-plant-based-report).

MSMC Research Connection
The University of Missouri research into fortifying Soyleic soy milk with vitamin B12 also includes work related to identifying a process engineering process for creating a fortified Soyleic yogurt.

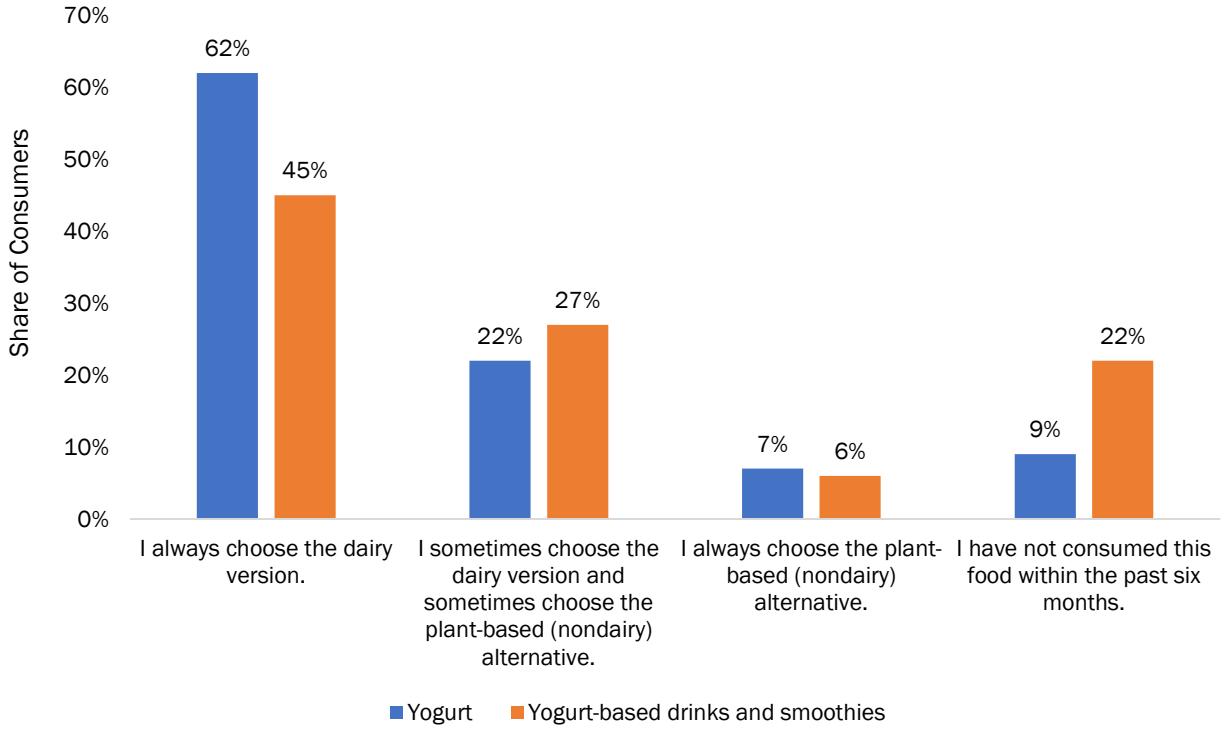
Exhibit 4.2.1. Plant-based yogurt dollar sales, 2018 to 2020



Source: SPINS and Good Food Institute (gfi.org/marketresearch/#yogurt)

Although plant-based yogurt sales have grown, consumers continue to largely choose dairy yogurt. During April 2021, the International Food Information Council surveyed 1,014 dairy-consuming adults. When asked about dairy products they had consumed in the past month, 62% had exclusively chosen dairy yogurts. Of the dairy-consuming adults, 22% had selected dairy and plant-based yogurts, and 7% said they only chose plant-based yogurt options. Exhibit 4.2.2 reports these data points and compares them to consumers' expertise with yogurt-based drinks and smoothies. Compared with results for yogurt, a slightly larger share of dairy-consuming adults said they would sometimes choose dairy and plant-based yogurt-based drinks and smoothies. Additionally, a larger share of responding consumers said they had not consumed yogurt-based drinks and smoothies in the six months preceding the survey (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf).

Exhibit 4.2.2. Share of U.S. dairy-consuming adults who chose dairy and plant-based milk yogurt and yogurt-based drinks and smoothies in six months preceding April 2021



* Data represent consumption in six months preceding April 2021
Source: International Food Information Council (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf)

The International Food Information Council survey further explored how demographic characteristics affect dairy or plant-based yogurt consumption. Exhibit 4.2.3 presents data by gender, age and educational attainment. Younger consumers were more likely to only choose plant-based yogurt or choose both dairy and plant-based yogurt. Men and consumers without a college degree were slightly more likely than women and college degree-holders, respectively, to only choose plant-based yogurt (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf).

Exhibit 4.2.3. U.S. dairy-consuming adults yogurt purchase preferences and associated demographic characteristics*

	I always choose the dairy version.	I sometimes choose both — dairy and plant-based.	I always choose the plant-based (nondairy alternative).
Men	59.4%	22.6%	8.5%
Women	63.7%	21.7%	6.0%
18-34 years old	53.2%	29.3%	14.5%
35-54 years old	63.5%	23.8%	4.4%
55+ years old	70.4%	7.4%	2.0%
Noncollege	59.5%	20.6%	9.0%
College	62.9%	23.4%	6.0%

* Data represent consumption in six months preceding April 2021
Source: International Food Information Council (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf)

For yogurt-based drinks and smoothies, Exhibit 4.2.4 shares the demographic characteristics of consumers who have tended to choose only dairy, plant-based and dairy or only plant-based options. Again, younger consumers were more likely to have chosen plant-based products at least part of the time. Consumers without a college education were more likely than college-educated consumers to have always chose plant-based yogurt-based drinks and smoothies, but college-educated respondents were more likely to choose both dairy and plant-based options. The gender data indicate that men were slightly more likely to choose only plant-based products, but women were slightly more inclined to use dairy and plant-based yogurt-based drinks and smoothies (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf).

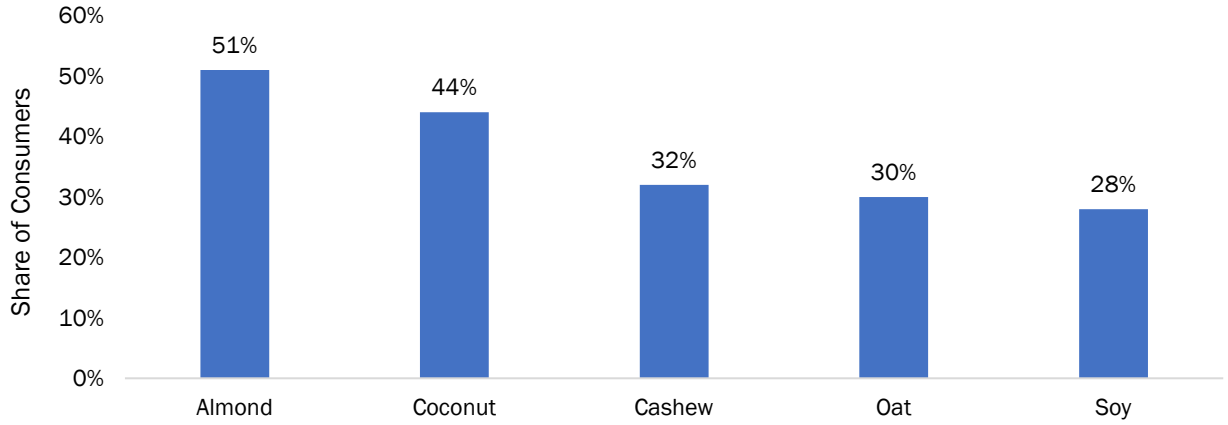
Exhibit 4.2.4. U.S. dairy-consuming adults yogurt-based drinks and smoothies purchase preferences and associated demographic characteristics*

	I always choose the dairy version.	I sometimes choose both — dairy and plant-based.	I always choose the plant-based (nondairy alternative).
Men	45.9%	25.2%	7.5%
Women	44.4%	28.7%	5.0%
18-34 years old	45.0%	38.4%	10.3%
35-54 years old	48.5%	27.3%	5.6%
55+ years old	37.4%	7.9%	1.0%
Noncollege	43.0%	25.1%	8.5%
College	46.6%	28.3%	4.7%

* Data represent consumption in six months preceding April 2021
Source: International Food Information Council (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf)

In survey research it conducted in December 2019, Kerry worked to understand consumer preferences and behaviors related to plant-based yogurt. The survey captured responses from three groups: consumers who recently purchased plant-based food, those who didn't recently choose plant-based options but had interest in them and those who had no plant-based product interest. Responding consumers most commonly named nutritional benefits and health reasons as purchase drivers for plant-based yogurt. One-quarter of respondents named these two factors as purchase drivers. When purchasing plant-based yogurt, the product attributes identified as being most important to consumers were taste, 27%; dairy-free, 23%; and natural, 20%. Half of respondents identified almond as a preferred alternative dairy source for plant-based yogurt. Exhibit 4.2.5 lists the other sources included in the top-five list of dairy alternative ingredients for plant-based yogurt. Coconut followed almond as the second-most preferred alternative dairy source. Soy ranked fifth at 28% (kerry.com/na-en/explore/winning-with-plant-based-report).

Exhibit 4.2.5. Five most preferred alternative dairy sources in plant-based yogurt

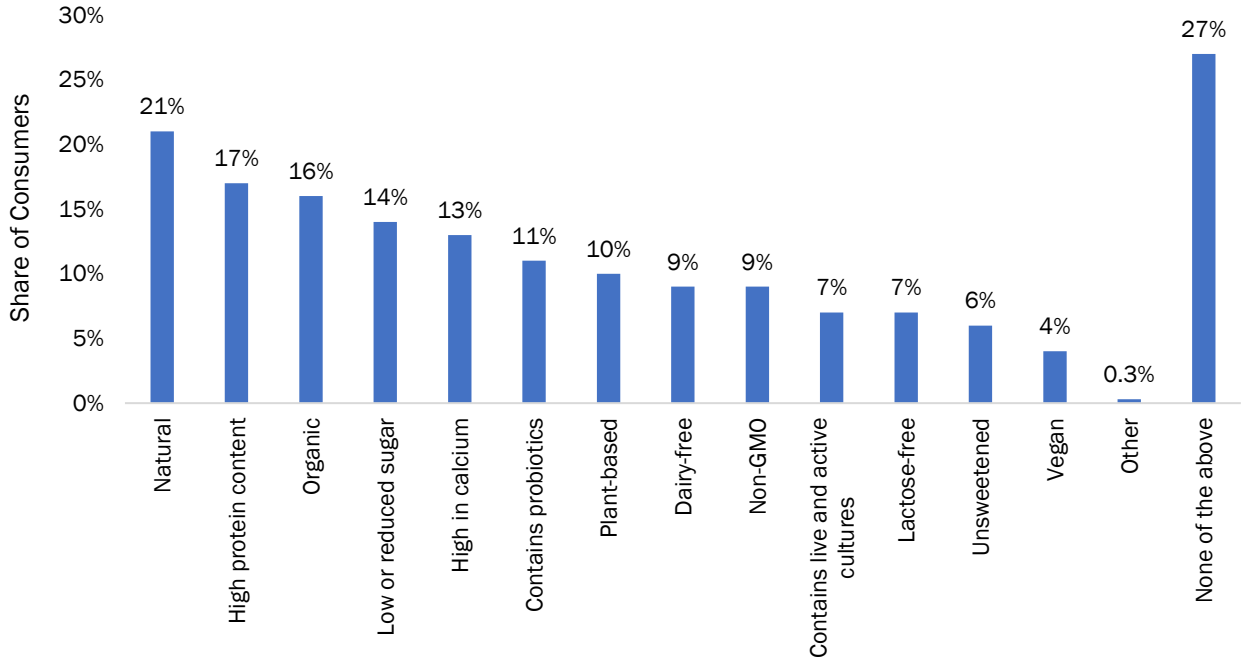


Source: Kerry (kerry.com/na-en/explore/winning-with-plant-based-report)

To understand the types of claims consumers seek when buying plant-based yogurt, the International Food Information Council asked the adults responding to its survey to choose their top two priority claims. Exhibit 4.2.6 presents the share of consumers who noted the particular claims as their No. 1 or No. 2 priorities. Natural ranked collectively as the top claim dairy consumers seek; 21% of respondents named it No. 1 or No. 2 in their list of priorities. Rounding out the collective top five were high-protein content, 17%; organic, 16%; low or reduced sugar, 14%; and high in calcium, 13%. Non-GMO collectively ranked as the ninth priority as 9% of respondents selected it as their first or second priority (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf).

To an extent, demographic characteristics correlated with claims preferences. With respect to age, 57.1% of dairy-consuming adults who were at least 55 years old said they seek out none of the claims listed compared with just 27% of all respondents. Compared with the average, the share of 18- to 34-year-olds who seek out the following claims was at least 3 percentage points higher: organic, high in calcium, plant-based, dairy-free, non-GMO and vegan. The responding 35- to 54-year-olds didn't vary from the average as significantly for any claim. Education level also had minimal effect on plant-based yogurt claims preferences (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf).

Exhibit 4.2.6. Share of dairy-consuming consumers who ranked claims as first or second priority when shopping for plant-based yogurt*



* Data represent consumption in six months preceding April 2021
Source: International Food Information Council (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf)

For the yogurt category overall, sales changed moderately in recent months. Market researcher IRI found yogurt dollar sales to increase by 2.8% in the year preceding Sept. 5, 2021. Conversely, yogurt experienced a 2.7% unit sales decline. Dairy Foods interviewed a Chobani representative for its 2021 cultured dairy state of the industry report, and he indicated that yogurt brands have consolidated and simplified yogurt purchase decisions. The Dairy Foods story cited snacks and drinks as trends that may benefit yogurt product manufacturers (dairyfoods.com/articles/95320-2021-state-of-the-industry-cultured-dairy-is-at-a-fork-in-road).

The Missouri firms named in Exhibit 4.1.6 list nondairy products and yogurt as items in their portfolios. They may represent firms interested in procuring soy-based ingredients for nondairy yogurt products.

Exhibit 4.1.6. Missouri firms involved in producing yogurt alternatives

Firm	Products	Location	Website
Allied Blending	PlantWise brand for yogurt applications	St. Louis, Missouri	alliedblending.com
Balchem Ingredient Solutions	Nondairy yogurt	St. Louis, Missouri	balchem.com
SmithFoods	Frozen yogurt, nondairy specialty products	Pacific, Missouri	smithfoods.com

4.3 Soyleic tofu

> **MSMC Research Connection**
> University of Missouri research funded by MSMC also has focused on creating the technology needed to make Soyleic tofu fortified with vitamin B12.

To produce tofu, the process begins with soaking, cooking and grinding soybeans and then separating the liquid fraction — the soy milk — from the pulp or fiber. In some cases, the process may begin with sprouted soybeans, which may yield a more palatable tofu — one that has a more appealing aroma and flavor. Next, manufacturers add a salt, acid or enzyme to the soy milk to coagulate the protein and oil. Using a press or centrifuge, the tofu curds are then pressed to yield the desired firmness. If making a soft or silken tofu, then the manufacturer skips the pressing step. To lengthen the product's shelf life, tofu may undergo pasteurization (ift.org/news-and-publications/food-technology-magazine/issues/2016/february/columns/processing-how-tofu-is-processed).

Tofu's applications vary according to the product's characteristics. Firm tofu works well as a main dish when it's seared or grilled. The Soyfoods Council and Iowa Restaurant Association have collaborated to experiment with making salad dressings from silken tofu. With features similar to those of sour cream or mayonnaise, soft tofu applications include dips, sauces and smoothies. Tofu's advantages include its protein content, tendency to take flavors well and ability to be shelf-stable (supermarketperimeter.com/articles/7556-a-fresh-and-complete-take-on-plant-protein).

In past years, U.S. households have more frequently choose to consume tofu. Citing data from Pulmone, which makes Nasoya tofu, The Washington Post reported that at least 16% of households used the company's tofu in fall 2020. That's a jump from just 5% two years earlier (washingtonpost.com/news/voraciously/wp/2020/09/21/tofu-sales-skyrocket-during-the-pandemic-as-consumers-search-for-affordable-meat-alternatives). The COVID-19 pandemic further stimulated U.S. tofu sales. Nielsen data cited by FoodNavigator-USA identified 4.6% sales growth for tofu protein-containing products in 2019. Between roughly March and July 2020, sales grew by 42% compared with the prior year (foodnavigator-usa.com/Article/2020/08/03/Tofu-s-time-has-come-says-Nasoya-It-s-the-simplest-form-of-plant-based-protein-on-the-market). In its state of the industry report for 2021-22, the Specialty Food Association listed tofu as one of the top 10 fastest-growing categories (specialtyfood.com/news/article/specialty-food-sales-hit-high-1704-billion-specialty-food-association-state-specialty-food-industry-report).

Despite the sales growth, tofu continues to represent a relatively small portion of the total U.S. meat substitute market, which is dominated by products categorized as plant-based meat (gfi.org/wp-content/uploads/2021/05/COR-SOTIR-Plant-based-meat-eggs-and-dairy-2021-0504-1.pdf). Mintel suggests tofu sales have room to grow. In the U.S. it estimated the tofu market to total $91 million in 2018 and projected it to grow to $182 million by 2022 (yahoo.com/now/pulmuone-makers-americas-leading-tofu-141600675.html).

Several factors may have contributed to tofu's popularity. For one, consumers seeking out plant-based protein may perceive tofu as a less processed alternative — compared with other meat alternatives. Second, tofu manufacturers have removed some of the guesswork

involved in how to use tofu. Rather than only sell a water-packed tofu that takes time and creativity to use, they've introduced baked, marinated and seasoned options. These new product formats have made tofu more convenient to use (foodnavigator-usa.com/Article/2020/08/03/Tofu-s-time-has-come-says-Nasoya-It-s-the-simplest-form-of-plant-based-protein-on-the-market). Other forces motivating more tofu purchases included meat shortages and consumer interest in protein dishes that offered health benefits at an affordable price. These demand-boosting events counter another pandemic-related problem for tofu sales. That is, universities use a lot of tofu, and the pandemic caused many of them to close (washingtonpost.com/news/voraciously/wp/2020/09/21/tofu-sales-skyrocket-during-the-pandemic-as-consumers-search-for-affordable-meat-alternatives).

Research from the International Food Information Council sheds some light into the consumers who began using tofu and soy-based products in the year preceding November 2020. To collect consumer information, the council interviewed 1,009 U.S. adults. It found that 11% of respondents tried tofu/soy-based products in the year before their interviews. Exhibit 4.3.1 summarizes how first-time tofu/soy-based product consumers vary according to multiple demographic factors. Gender, income level and education level had little effect on the likelihood that consumers had tried tofu/soy-based products. Race and ethnicity and age did appear to shape first-time trial. African American and Hispanic consumers were more likely than white consumers to have tried tofu/soy-based products. With respect to age, a larger share of younger consumers reported trying tofu/soy-based products (foodinsight.org/plant-and-animal-protein-consumer-survey/).

Exhibit 4.3.1. First-time tofu/soy-based product trial in year preceding November 2020

	Share of Respondents
Men	10%
Women	12%
Less than $40,000	11%
$40,000 to $79,000	10%
$80,000 or more	12%
White	8%
African American	18%
Hispanic/Latinx	17%
Under 45	14%
45-64	10%
65+	5%
Noncollege	11%
College	11%

Source: International Food Information Council (foodinsight.org/plant-and-animal-protein-consumer-survey)

Tofu manufacturers located through the Midwest may have interest in sourcing Soyleic high-oleic soybeans to use in their tofu production process, and they may choose to fortify these products with vitamin B12 to serve the nutritional needs of deficient groups. The firms in Exhibit 4.3.2 — located in Missouri and neighboring states — make tofu. Several

manufacturers in other states produce tofu, but they note exclusively sourcing in-state soybeans as ingredients for their products.

Exhibit 4.3.2. Potential tofu manufacturer-buyers, Missouri and nearby states

Firm	Products	Location	Website
Central Soyfoods	Tofu, tempeh	Lawrence, Kansas	facebook.com/Central-Soyfoods-102961111220336
Chunco Tofu	Tofu	Kansas City, Missouri	bit.ly/3g8BxpD
House Foods American Corp.	Tofu	Louisville, Kentucky	bit.ly/3udKYfN
Pulmuone Foods USA	Nasoya tofu, Wildwood Organic tofu	Grinnell, Iowa	pulmuonefoodsusa.com
Rootberry	Meat alternatives	St. Louis, Missouri	rootberry.com

4.4 Soyleic okara

Okara refers to the pulp and fiber byproduct created when making tofu or soy milk. When manufacturing tofu, the process begins with cooking soaked soybeans and making a slurry substance. Next, manufacturers process the slurry through a centrifuge or filter to separate the liquid fraction, which is soy milk, from the pulp or fiber, called okara (ift.org/news-and-publications/food-technology-magazine/issues/2016/february/columns/processing-how-tof-is-processed). Annually, global okara production exceeds 4 million metric tons, according to one estimate. China and Japan generate most of the world's okara — estimates suggest more than 70% (newfoodmagazine.com/article/77078/unlocking-additional-value-from-soybeans-via-the-circular-economy).

MSMC Research Connection
With MSMC funding, University of Missouri researchers have studied how to process okara. They have considered how to optimize an okara processing technology that leads to fortifying the ingredient with vitamin B12. The effort also considers how to use extrusion to process okara.

Often, manufacturers direct okara to animal feed, compost or fertilizer uses. Okara not used for these purposes may be discarded (newfoodmagazine.com/article/77078/unlocking-additional-value-from-soybeans-via-the-circular-economy/). In some cases, okara has served as a food ingredient. High-moisture okara's uses have included stir fries and pancakes. The ingredient's high moisture content, however, makes okara more likely to spoil and adds weight (foodbusinessnews.net/articles/13164-soybean-pulp-the-next-superfood). Drying okara opens other market opportunities, assuming the drying costs don't exceed the final product's ultimate value. Example dried okara uses include baked goods, cereals and meat substitutes (newfoodmagazine.com/article/77078/unlocking-additional-value-from-soybeans-via-the-circular-economy).

From a nutritional perspective, okara has several advantages. For example, compared with white flour, okara offers more fiber, protein and calcium. It also contains fewer carbohydrates on a net basis (foodbusinessnews.net/articles/13164-soybean-pulp-the-next-

superfood). Okara also includes isoflavones. The ingredient's insoluble dietary fiber content, however, may present a challenge for product formulations and consumer acceptability. The high fiber content can cause products made with okara to have grittiness, which may yield products that have a crumbly texture or unappealing mouthfeel (newfoodmagazine.com/article/77078/unlocking-additional-value-from-soybeans-via-the-circular-economy). The insoluble fiber may also trigger bloating or indigestibility problems for consumers (nutraingredients-asia.com/Article/2020/09/17/Oh-soy-Singapore-team-eyes-commercialisation-after-turning-okara-into-DHA-rich-products-to-aid-brain-health#).

Research and development efforts have identified further processing technologies that may increase okara's potential as a food ingredient. Research at a Singapore university has studied how to use enzymatic or fermentation processes to make okara more suitable for food applications. One method involves adding a fungus and yeast to facilitate fermentation and drying the product into a "bio-okara." The dried ingredient would contain less insoluble fiber. A second method adds a probiotic and yeast to okara to make a probiotic beverage (newfoodmagazine.com/article/77078/unlocking-additional-value-from-soybeans-via-the-circular-economy). Another Singapore university has explored how to treat okara with an enzymatic and fermentation process and make a cream cheese, sliced cheese or cream soup powder. In this innovation, the researchers added DHA, an omega-3 fatty acid, to enhance the nutritional composition (nutraingredients-asia.com/Article/2020/09/17/Oh-soy-Singapore-team-eyes-commercialisation-after-turning-okara-into-DHA-rich-products-to-aid-brain-health#). European researchers have studied how to ferment okara and use the final product in meat analogues. Alone, okara doesn't deliver the protein needed in a meat alternative, but it can serve as an ingredient and impart some health benefits, including those related to digestibility and fat content (foodnavigator.com/Article/2021/09/23/Okara-meat-analogue-developed-with-less-salt-fat-and-more-flavour-than-real-meat-claim-researchers).

California-based Renewal Mill has commercialized okara flour and marketed it to large and small food brands. Plus, it has used its own okara flour to make and sell individually packaged cookies and baking mixes in retailers including Whole Foods Market and Thrive Market (foodbusinessnews.net/articles/18072-three-startups-setting-out-to-transform-the-food-system). Renewal Mill sources the raw okara from a tofu manufacturer, and it dries the okara using a dehydration technology. After drying, Renewal Mill grinds the okara in flour, which has a milky, nutty flavor and serves as a gluten-free option for food manufacturers (foodbusinessnews.net/articles/13164-soybean-pulp-the-next-superfood). Renewal Mill shares okara flour uses may include pastas, biscuit mixes, cookies, sauces, pizza dough and extruded puff snacks. The ingredient is suitable for savory and sweet foods. When marketing its okara flour, Renewal Mill emphasizes the product's "upcycled" attribute — in that it diverts a possible waste stream toward a value-added use. The business has participated in the Upcycled Food Association and supported forming an Upcycled Certification Standard. Since introducing the okara flour, Renewal Mill has developed an oat milk flour made from the byproduct created when making oat milk (foodbusinessnews.net/articles/18072-three-startups-setting-out-to-transform-the-food-system).

The businesses in Exhibit 4.4.1 make soy products (i.e., soy milk, tofu) that yield okara as part of the production process. These firms may have interest in developing value-added products that allow them not only to use okara as an ingredient but also minimize waste.

Exhibit 4.4.1. Potential tofu manufacturer-buyers, Missouri and nearby states

Firm	Products	Location	Website
Central Soyfoods	Tofu, tempeh	Lawrence, Kansas	facebook.com/Central-Soyfoods-102961111220336
Chunco Tofu	Tofu	Kansas City, Missouri	bit.ly/3g8BxpD
House Foods American Corp.	Tofu	Louisville, Kentucky	bit.ly/3udKYfN
Jasper Products	Soy beverages	Joplin, Missouri	heritage-foods.com/jasper
Pulmuone Foods USA	Nasoya tofu, Wildwood Organic tofu	Grinnell, Iowa	pulmuonefoodsusa.com
SmithFoods	Plant-based beverages	Pacific, Missouri	smithfoods.com

4.5 Soyleic oil for ice cream

MSMC Research Connection

University of Missouri researchers received funding in 2021 to assess whether high-oleic, low-linolenic soybean oil may substitute for milk fat in ice cream alternatives. The high-oleic, low-linolenic soybean oil may offer manufacturers a fat source that behaves similarly to milk fat and provides a nutritional profile that's different from other fats such as palm oil, palm kernel oil, coconut oil or hydrogenated oil used in nondairy ice creams (soybeanresearchdata.com/Project.aspx?id=53967).

- **Soy ingredients used:** soy milk and soy oil
- **Ingredients displaced**: dairy milk, other plant-based milk, tropical vegetable oil, dairy cream

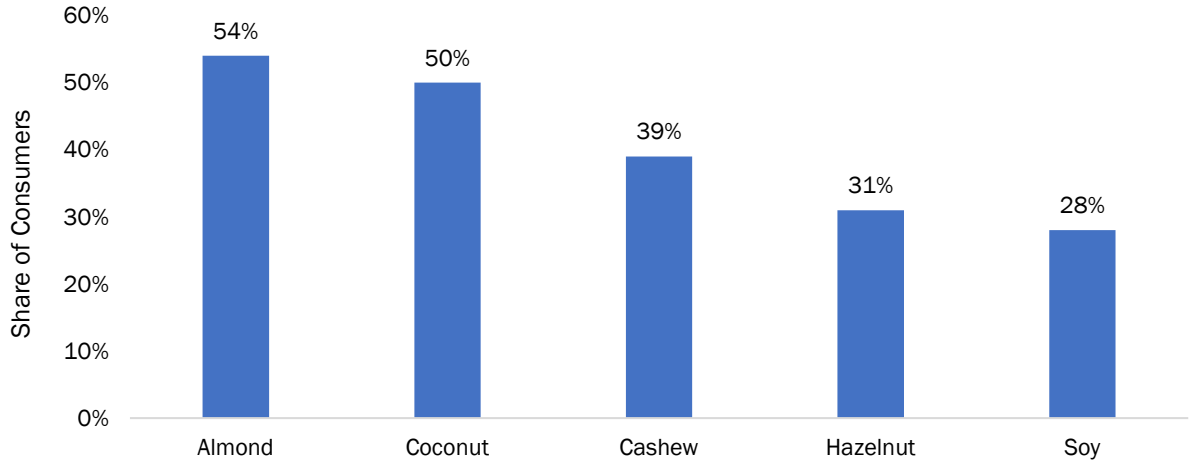
U.S. plant-based ice cream and frozen novelties retail sales in 2019 totaled roughly $407 million, according to Nielsen data cited by Kerry, an ingredients provider. Retail sales grew an estimated 28% between 2017 and 2019. During this same period, Mintel found 88 new plant-based ice cream or frozen novelty products launched (kerry.com/na-en/explore/winning-with-plant-based-report). Globally, 6% of dessert and ice cream launches in 2020 were nondairy ice cream products, based on Innova Market Insights data. In North America, one-quarter of 2020 ice cream product launches fit the nondairy criteria (foodingredientsfirst.com/news/ice-cream-trends-non-dairy-and-low-sugar-npd-soars-but-flavor-remains-key-purchasing-factor.html).

Data from SPINS, another market research company, also suggest plant-based ice cream and frozen novelty sales have grown. According to SPINS data, this category's sales totaled $330 million in 2018 but grew to $435 million in 2020 (gfi.org/marketresearch/#ice-cream-and-frozen-novelty). Despite the dramatic increase in sales, plant-based only represented 3% of all ice cream and frozen novelty sales in 2020, according to SPINS. The household penetration rate for plant-based ice cream indicates that roughly 8% of households chose

these products in 2020 (gfi.org/resource/plant-based-meat-eggs-and-dairy-state-of-the-industry-report).

To understand consumer preferences for plant-based ice cream and frozen novelty products, Kerry surveyed consumers. Respondents fit in one of three groups: those who identify as current plant-based food and beverage users, those who may had interest in plant-based products and those who had no interest in such products. Conducted in December 2019, the survey found that participating consumers most preferred almond or coconut ingredients as the dairy alternative included in plant-based ice creams or frozen novelties. At least half said they preferred these two ingredients. See Exhibit 4.5.1. Just more than one-quarter of respondents indicated a preference for soy dairy alternatives (kerry.com/na-en/explore/winning-with-plant-based-report).

Exhibit 4.5.1. Consumers' most preferred dairy alternatives in plant-based ice cream and frozen novelty products



Source: Kerry (kerry.com/na-en/explore/winning-with-plant-based-report)

The International Food Information Council surveyed consumers in April 2021 to learn about their perceptions and use of nondairy products. In one question, the survey asked respondents to indicate how frequently they chose dairy or nondairy ice cream in the six months preceding the survey. Two-thirds said they always selected dairy options, and 5% always chose the plant-based option. Roughly one-quarter consumed dairy and nondairy ice cream. Exhibit 4.5.2 summarizes the results according to gender, age and education. As illustrated, results didn't noticeably vary according to gender and education. Age, however, did appear to affect whether consumers would choose dairy or nondairy ice cream. Younger consumers were much less likely to exclusively eat only dairy ice cream, and they were more likely to switch between dairy and nondairy ice cream. Half always ate dairy ice cream, but nearly 40% said they consumed both (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf).

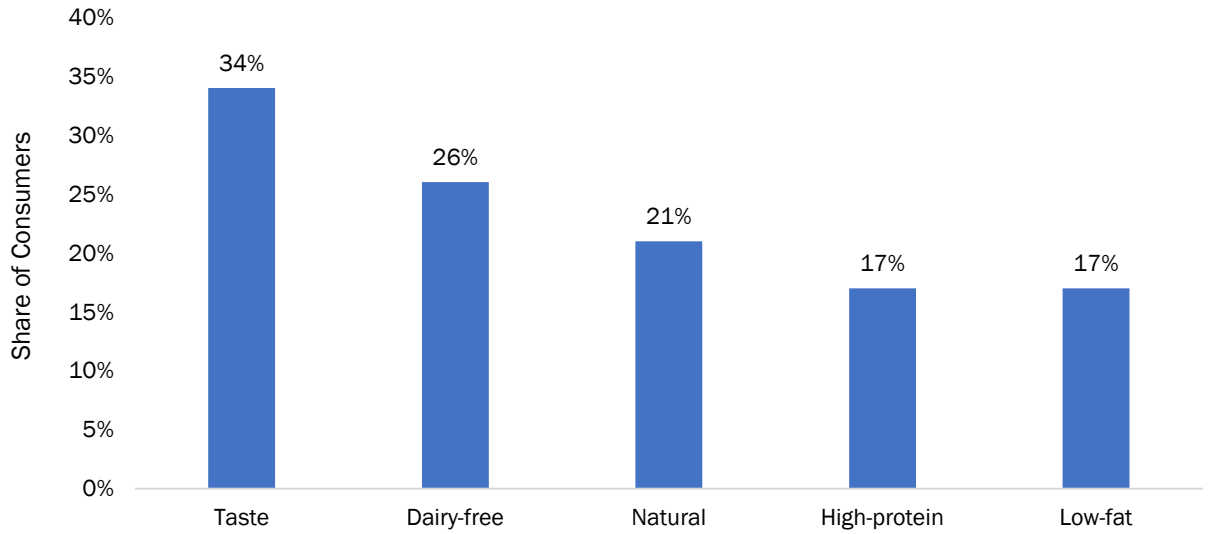
Exhibit 4.5.2. U.S. dairy-consuming adults ice cream purchase preferences and associated demographic characteristics*

	I always choose the dairy version.	I sometimes choose both — dairy and plant-based.	I always choose the plant-based (nondairy alternative).
Men	65.0%	25.0%	5.5%
Women	66.1%	26.5%	4.4%
18-34 years old	50.5%	38.4%	8.5%
35-54 years old	69.0%	24.4%	3.8%
55+ years old	82.3%	8.4%	2.0%
Noncollege	66.9%	24.1%	5.0%
College	64.7%	26.8%	4.9%

* Data represent consumption in six months preceding April 2021
Source: International Food Information Council (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf)

Varied purchase drivers contribute to consumers choosing plant-based ice cream and frozen novelties. The Kerry research found 31% of consumers named health reasons as a purchase driver. More specifically, reducing cholesterol and making you feel better were health-related motivations. Other reasons driving plant-based ice cream purchases were health benefits, 29%; try something new, 28%; easier to digest, 27%; and lactose intolerance, 22%. The Kerry research also investigated the attributes important to buyers when they consider plant-based ice cream products. As shown in Exhibit 4.5.3, taste ranked as the most important attribute, and dairy-free followed. Other attributes that made the top-five list were natural, high-protein and low-fat (kerry.com/na-en/explore/winning-with-plant-based-report).

Exhibit 4.5.3. Plant-based ice cream and frozen novelty product attributes most important to consumers



Source: Kerry (kerry.com/na-en/explore/winning-with-plant-based-report)

Plant-based ice cream and frozen novelties have had some features that may have limited their acceptability and market potential. The Kerry research found that consumers associated plant-based ice cream and frozen novelty products with unappealing taste and texture. Terms used to describe plant-based ice cream included gritty, grainy, flavorless and weird flavor. Additionally, these products tend to lack flavor variety and the nutritional profile consumers demand (kerry.com/na-en/explore/winning-with-plant-based-report). With respect to flavors, three that have gained popularity are salted caramel, strawberry and mango (foodingredientsfirst.com/news/ice-cream-trends-non-dairy-and-low-sugar-npd-soars-but-flavor-remains-key-purchasing-factor.html).

A September 2021 industry report from IBISWorld details more of the ice cream industry's dynamics, including activity related to introducing nondairy options. The following points represents highlight from the IBISWorld report ("Ice Cream Production in the US," Industry Report 31152, IBISWorld).

- In recent years, the ice cream industry's sales have declined. Some firms, including large ones, have introduced nondairy frozen treats — in addition to other innovative products — to encourage sales.
- The nondairy options may appeal to consumers who feel concerned about health.
- Ice cream manufacturers have increasingly consolidated as a strategy to maintain their relevancy and compete with smaller firms, which have tended to innovate.
- As firms have innovated, the ice cream-related product categories have become more fragmented. The "other frozen desserts" category, which includes nondairy treats, has grown its sales share in recent years. IBISWorld estimates that captured a 10% market share in 2021.
- Although supermarkets and pharmacies make for a majority of ice cream sales, the foodservice market plays an important role. Limitations placed on foodservice establishments, such as COVID-19 pandemic-related closures, would affect ice cream sales potential.

Several Missouri firms produce nondairy ice cream alternatives that may use a Missouri-produced soybean components as ingredients. The list in Exhibit 4.5.4 introduces some of these firms and where they're located.

Exhibit 4.5.4. Nondairy frozen dessert manufacturers in Missouri

Firm	Products	Location	Website
Clementine's Naughty and Nice Ice Cream	Ice cream, including vegan and nondairy products	St. Louis, Missouri	clementinescreamery.com
Cones + Cups	Ice cream and nondairy frozen desserts	St. Louis, Missouri	conesandcups-bentonpark.com
Good Humor Breyers	Nondairy frozen desserts	Sikeston, Missouri	breyers.com/us/en/products/non-dairy.html
Ice Cream Factory	Vegan and nondairy options	Eldon, Missouri	icecreamfactoryco.com
Twisted Whip	Nondairy frozen dessert	Mid-Missouri	facebook.com/twisted.whip.desserts

4.6 Soy protein

Food products may incorporate three types of protein, which the United Soybean Board's Jean Heggie highlighted at an October 2021 event titled "Tapping the Potential of Plant-Based Protein in the Soy Value Chain: A National Discussion." Exhibit 4.6.1 summarizes these ingredients: soy flour, soy protein concentrate and soy protein isolate. It also describes their characteristics and typical applications, according to USDA FoodData Central. Note the high-protein soy protein isolate has the most potential applications. As protein content increases, the soy protein ingredient has a blander flavor, which makes it more acceptable to use in foods — particularly those sensitive to off-flavors (youtu.be/Tk2aGlNsLWA).

Industry Sets Goal for Food-Related Soybean Demand

A soybean convening held during fall 2021 centered on one goal: "By 2026, 8 million tons of U.S. soybeans are processed annually specifically for human consumption." Stakeholders at the convening addressed opportunities to use soy protein generated by these 8 million tons of domestically grown soybeans.

Exhibit 4.6.1. Soy protein ingredients, characteristics and applications

	Soy flour	Soy protein concentrate	Soy protein isolate
Protein content, dry basis	50%	65%-70%	90%
Applications	Bakery, low-end processed meat, textured vegetable protein	Meat, poultry, seafood, meat-free products, cereals snacks	Protein beverages, infant formulas, weight management drinks, nutritional bars, snacks, cereals, dairy alternatives, meat, poultry, seafood, meat-free products

Source: USDA FoodData Central via Tapping the Potential of Plant-Based Protein in the Soy Value Chain: A National Discussion (youtu.be/Tk2aGlNsLWA)

MSMC Research Connection

Research at the Missouri University of Science & Technology has studied how functional properties of soy protein isolate vary according to whether commodity or high-oleic soybeans serve as the raw material. It found similar amino acid profiles in both types of soy protein isolate. Soy protein isolate made from high-oleic soybeans had better functionality in some cases (soybeanresearchdata.com/download.aspx?file=Progress5File&name=52488__402_Phase_II_Final_Report.docx).

Soy flour itself may undergo additional processing to become modified soy flour, which has added functionality. For example, the ingredient contributes texture and structure. Modified soy flour also doesn't have an off-taste, though it lacks some health benefits tied to raw soy flour. Manufacturers who produce bakery, snack and confectionary goods are examples of modified soy flour buyers. The method used to make this product may involve chemicals, enzymes or a physical process. The most common method involves heat treatment, which removes volatile and lipoxygenase compounds that cause polyunsaturated fats to oxidize.

Plus, the heat treatment makes soy protein more digestible and bleach the flour. From 2017 to 2026, the volume compound annual growth rate for modified soy flour will average 2.7%, according to estimates from Future Market Insights, a market research firm. The Asia Pacific and Middle East and Africa regions may increase their demand for modified soy flour most quickly. Extruded snacks represents one category thought to have growing modified soy flour demand (bakeryandsnacks.com/Article/2018/04/12/Soya-flour-offers-bakers-the-protein-boost-to-capitalize-on-growing-tend).

Heggie's presentation also described three formats soy protein ingredients can take: spray-dried powder, extruded meat-like texture and extruded crisps. Exhibit 4.6.2 summarizes these formats' defining characteristics and their potential applications. Powders have functionality that varies, and their uses include meat alternatives and beverages. Extrusion may produce ingredients that resemble flakes, granules or chunks and find use in meat alternatives. The process also can make crisps for snack products (youtu.be/Tk2aGINsLWA).

Exhibit 4.6.2. Soy protein ingredients formats

	Spray-dried powder	Extruded meat-like texture	Extruded crisps
Physical attributes	Dry powder with tan color	Flakes, granules, chunks; color and size vary	Crisps with varying shape and size
Functional characteristics	Vary according to end use	Meat-like texture	High protein content; add texture
Applications	Meat and beverages	Meat, poultry, seafood, meat-free products	Protein bars, cereals, snacks

Source: Tapping the Potential of Plant-Based Protein in the Soy Value Chain: A National Discussion (youtu.be/Tk2aGINsLWA)

MSMC Research Connection

Funded in 2020, an MSMC research project initiated by a University of Missouri faculty member planned to formulate a spray-dried soy powder made from high-oleic soybeans. The spray-drying technology process would cut costs compared with the method ordinarily used to produce soy protein isolate. The end product — spray-dried powder — would lack the beany flavor typical of some soybean ingredients and could have vitamins and minerals added (soybeanresearchdata.com/Project.aspx?id=53309).

- **Cost to make powder**: half the cost of soy protein isolate production
- **High-oleic advantage**: easy to spray dry, blends well, good whiteness, works well with added flavors, better shelf life for the powder and reconstituted liquids
- **Applications**: similar to soy protein isolate uses; products or uses where manufacturers or buyers value higher protein
- **Market opportunity**: startups may have more flexibility to experiment with new ingredients than firms making existing formulations; some buyers look for the term "isolate," which the powder would not offer

In terms of the protein ingredients manufacturers choose, Mintel tracks new product introductions in its global new products database. Data for 2020 show that roughly 3% of all newly launched food and beverage products listed soy protein as an ingredient. Wheat protein was included in 2% of product launches. Through October 2021, the product introduction data from Mintel showed that roughly 1% of new food and beverage products included pea protein. Just a few years earlier, pea protein had captured a share less than 0.5%. A Mintel representative has described pea protein as "the darling of the plant-based movement." However, emerging proteins that may compete include lupin bean and almond protein powder (foodbusinessnews.net/articles/19596-trending-plant-proteins). Soy protein has several advantages that make it a popular choice. Those include the ingredient's availability and cost. Plus, depending on the product application, soy protein offers certain functional benefits. The following are examples cited in an October 2021 story from *Food Business News* (foodbusinessnews.net/articles/19596-trending-plant-proteins):

- Add elasticity to dough.
- Enable bread to have a good crumb structure.
- Minimize fat absorption in fried foods.
- Produces a nice viscosity in batters.
- Provide body in gluten-free baked goods.

Dietary Guidelines Include Soy Protein

The 2020-25 Dietary Guidelines for Americans suggests that U.S. consumers who consume 2,000 calories a day should include 5 ounces of nuts, seeds and soy products in their diets each week. Roughly half of Americans fail to reach this goal. The guidelines consider the following soy foods to fit in this product category: tofu; tempeh; and those that include soy flour, soy protein isolate and soy protein concentrate.

Industry Protein Collaboration Opportunities

Missouri soybean stakeholders may consider collaborating with industry groups vested in developing plant protein ingredients that meet buyer needs. The following two groups have coordinated plant protein work in the Upper Midwest.

- An interdisciplinary research center, ***the Plant Protein Innovation Center*** at the University of Minnesota has 37 members committed to plant and alternative protein research at the breeding, genetics, processing, formulation and marketing stages of the value chain. It describes itself as "the first center of its kind in the nation for plant and other alternative proteins." See more at ppic.cfans.umn.edu.

- The ***Plant Protein Highway*** describes itself as a "network for plant-based protein innovation." Groups in six states have partnered with those in three Canadian provinces to create the network. The six participating states are Montana, North Dakota, Minnesota, South Dakota, Nebraska and Iowa. It has a mission "to support and facilitate bilateral, precompetitive initiatives that unite industry, academia and government in advancing the North American protein sector. See more at proteinhighway.org.

To compare various plant-based proteins, including soy protein, the Good Food Institute published a plant protein primer. Exhibit 4.6.3 illustrates how soy protein compares with 18 other plant protein sources. Relative to most other protein sources, soy protein has advantages related to protein concentration, the protein digestibility corrected amino acid

score, commercial availability, functionality and cost. Allergen risk and flavor represent two areas where soy protein fails to compete well with alternatives (gfi.org/wp-content/uploads/2021/02/2021-02-23_Plant_Protein_Primer_GFI.pdf).

Exhibit 4.6.3. Soy and plant protein alternative comparisons*

	Protein concentration	PDCAAS^	Allergen risk	Commercial stage	Flavor	Functionality	Cost	Global crop volume
Soy								
Pea								
Wheat								
Canola								
Chickpea								
Fava bean								
Lentil								
Lupin								
Mung bean								
Navy bean								
Peanut								
Sunflower								
Almond								
Corn								
Oat								
Potato								
Quinoa								
Rice								
Sorghum								

* Blank boxes indicate lack of data for the specific metric; dark green = excellent; light green = good; yellow = OK; orange = low; and red = poor
^ PDCAAS refers to protein digestibility corrected amino acid score — a value meant to indicate protein quality
Source: Good Food Institute (gfi.org/wp-content/uploads/2021/02/2021-02-23_Plant_Protein_Primer_GFI.pdf)

Soy protein manufacturing data are limited. In terms of manufacturing capacity, changes in final protein product demand have the potential to pressure available soy protein supplies. In a recent report, the Good Food Institute projected how much soy protein concentrate and soy protein isolate the world would need to satisfy demand from plant-based meat manufacturers. Exhibit 4.6.4 shows that the institute projects the world will need 2.43 million metric tons of soy protein concentrate and 0.01 million metric tons of soy protein isolate. This assumes that 6% of global meat demand transitions to plant-based options and that soy-wheat products represent 62% of the plant-based meat sold and soy-based products represent 14% of the products sold. For soy protein concentrate, the report highlights that additional intermediate processing would be needed to satisfy demand (gfi.org/resource/anticipating-plant-based-meat-production-requirements-2030). Note, these estimates represent demand from just one use. Other uses could add to the soy protein concentrate and soy protein isolate that's needed globally.

Exhibit 4.6.4. Estimated soy protein demand to fulfill 2030 plant-based meat demand

	Projected demand (million metric tons)	Share of projected global ingredient production	Share of projected global raw commodity production
Soy protein concentrate	2.43	3 times	2%
Soy protein isolate	0.01	1%	

Source: Good Food Institute (gfi.org/resource/anticipating-plant-based-meat-production-requirements-2030)

One option to fill the need for soy protein concentrate would be to commercialize high-protein soybeans. Processing those high-protein soybeans into flour would yield a final product with more protein — potentially, enough protein to compare to concentrates. In February 2022, Benson Hill announced its new TruVail high-protein soy flour, which the company markets as an alternative to soy protein concentrate that undergoes less processing (bensonhill.com/2022/02/10/benson-hill-launches-truvail-soy-protein-ingredient-portfolio-featuring-unique-sustainability-benefits-for-broad-food-application). Assuming high-protein soybean adoption grows, intermediate processors could choose to process raw soybeans into soy flour instead of invest in soy protein concentrate manufacturing practices.

The firms listed in Exhibit 4.6.5 have a U.S. presence and manufacture soy protein concentrate. Little data are available to indicate the scale of these operations.

Exhibit 4.6.5. Soy protein concentrate manufacturers

Firm	Location	Website
ADM	Chicago, Illinois	adm.com
Batory Foods	Rosemont, Illinois	batoryfoods.com
Capitol Food Company	Cerritos, California	capitolfoodco.com
CHS Inc.	Inver Grove Heights, Minnesota	chsinc.com
Improved Nature	Garner, North Carolina	improvednature.com
Meelunie America	Southfield, Michigan	meelunie.com
Osage Food Products	Washington, Missouri	osagefood.com
Scoular	Omaha, Nebraska	scoular.com

Exhibit 4.6.6 lists companies that have a U.S. presence and manufacture soy protein isolate. Several more businesses promote that they manufacture soy protein isolate compared with soy protein concentrate.

Exhibit 4.6.6. Soy protein isolate manufacturers

Firm	Location	Website
ADM	Chicago, Illinois	adm.com
Batory Foods	Rosemont, Illinois	batoryfoods.com
Brenntag North America	Reading, Pennsylvania	food-nutrition.brenntag.com
Cambridge Commodities	Lincoln, California	cambridgecommodities.com
Capitol Food Company	Cerritos, California	capitolfoodco.com
Cargill	Wayzata, Minnesota	cargill.com
Clofine Dairy & Food Products	Linwood, New Jersey	clofinedairy.com
CHS Inc.	Inver Grove Heights, Minnesota	chsinc.com
Farbest Brands	Park Ridge, New Jersey	farbest.com
IFF Nutrition & Biosciences	St. Louis, Missouri	dupontnutritionandbiosciences.com
Meelunie America	Southfield, Michigan	meelunie.com
NOW Sports	Bloomingdale, Illinois	nowfoods.com
Nutra Food Ingredients	Kentwood, Michigan	nutrafoodingredients.com
Osage Food Products	Washington, Missouri	osagefood.com
Prinova U.S.	Carol Stream, Illinois	prinovaglobal.com
Scoular	Omaha, Nebraska	scoular.com
SunOpta	Edina, Minnesota	sunopta.com
True Nutrition	Vista, California	truenutrition.com

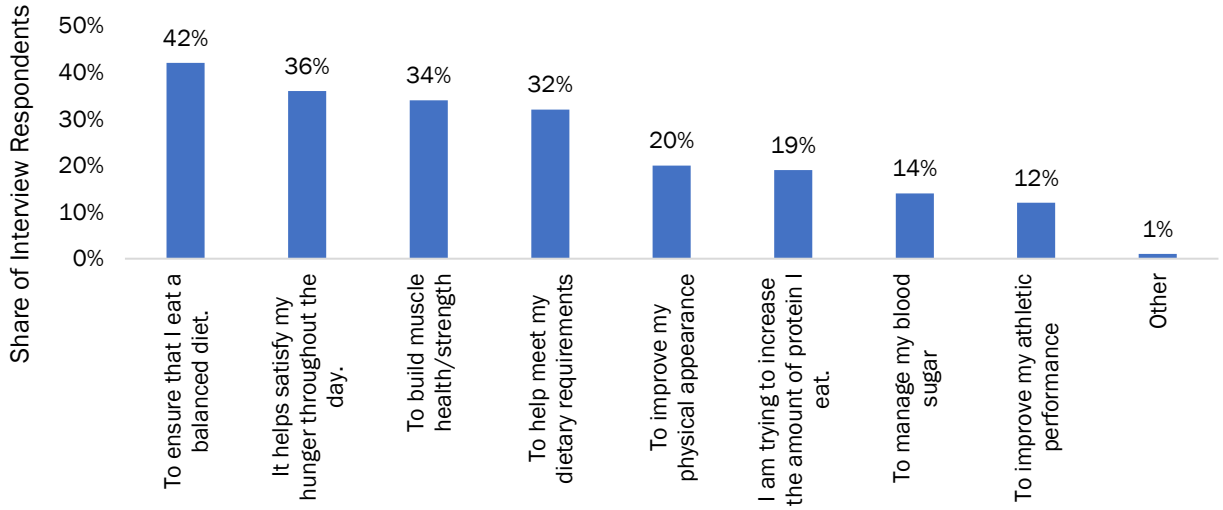
High-oleic soy protein offers its own set of functional attributes. At the "Soy for Plant-Based Protein Convening" held in November 2021, conversations highlighted several high-oleic soy protein benefits. Those include the protein's whiteness, its low viscosity and its stable flavor.

Making a conscious effort to formulate with protein-rich ingredients aligns with consumer interest in the nutrient. In November 2020, the International Food Information Council interviewed more than 1,000 U.S. adults to evaluate their protein attitudes and behaviors. Of the participating adults, 936 stated they try to incorporate protein into their diets each day. Exhibit 4.6.7 reports reasons why they add protein to their diets. Note, numbers don't add to 100% because respondents could choose as many as three reasons. The most frequently named driver was a balanced diet. Roughly one-third said they try to consume protein daily because it helps them to satisfy hunger, build muscle and strength and meet dietary requirements (foodinsight.org/plant-and-animal-protein-consumer-survey).

Protein and Plant Evolution Conference

The first Protein and Plant Evolution conference will take place from June 1-3, 2022. Designed as a virtual conference and trade show, the event will cover the plant-based, traditional, cellular, fermentation and insect protein markets. Topics address during the event will include consumer trends, product development, business development and go-to-market strategies. The Food Institute and The Lempert Report will host the free event. Find more information at proteinplantevolution.com.

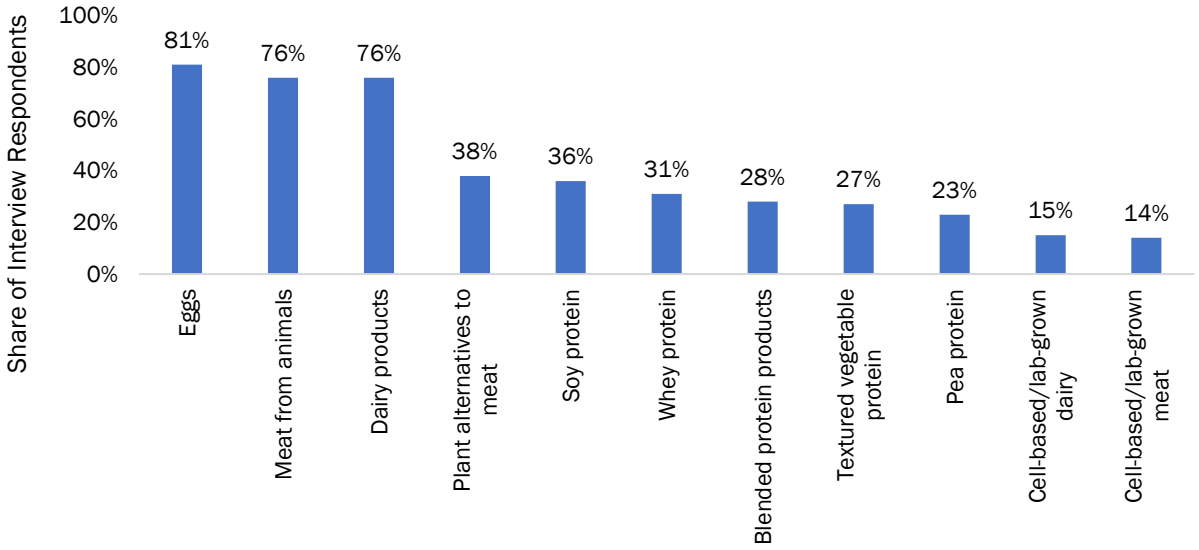
Exhibit 4.6.7. Reasons why U.S. adult consumers try to consume protein daily



Source: International Food Information Council (foodinsight.org/plant-and-animal-protein-consumer-survey)

In its research, the International Food Information Council also asked respondents to identify the protein sources that were familiar to them and that they ate at least sometimes. Exhibit 4.6.8 shares the results. Eggs, meat from animals and dairy products ranked as the top three protein sources based on familiarity and consumption. Of the specific plant-based proteins named, soy ranked first. More than one-third of respondents — 36% — selected soy protein as a familiar protein source they ate at least sometimes. Pea protein followed at 23%. Whey protein was another specific protein that a sizable share of consumers said was familiar and they consumed at least sometimes. Note, 38% said plant-based meat alternatives were familiar and a food they ate at least sometimes (foodinsight.org/plant-and-animal-protein-consumer-survey).

Exhibit 4.6.8. Familiar protein sources eaten at least sometimes*



* Share that reported "I have heard of it, and I eat it at least sometimes."
Source: International Food Information Council (foodinsight.org/plant-and-animal-protein-consumer-survey)

The demographic analysis found soy protein familiarity and consumption did correlate with certain personal attributes. The International Food Information Council research found men, high-earners, young and middle-aged consumers and adults with a college education to more consistently report that they felt familiar with soy protein and consumed it at least sometimes. Pea protein users had similar demographic characteristics. Compared with soy and pea proteins, whey protein users had some distinctions. See Exhibit 4.6.9. Unlike with soy protein, whey protein consumption varied somewhat by race and ethnicity; Hispanics were more likely to name whey as a familiar and consumed protein compared with white and African American adults (foodinsight.org/plant-and-animal-protein-consumer-survey).

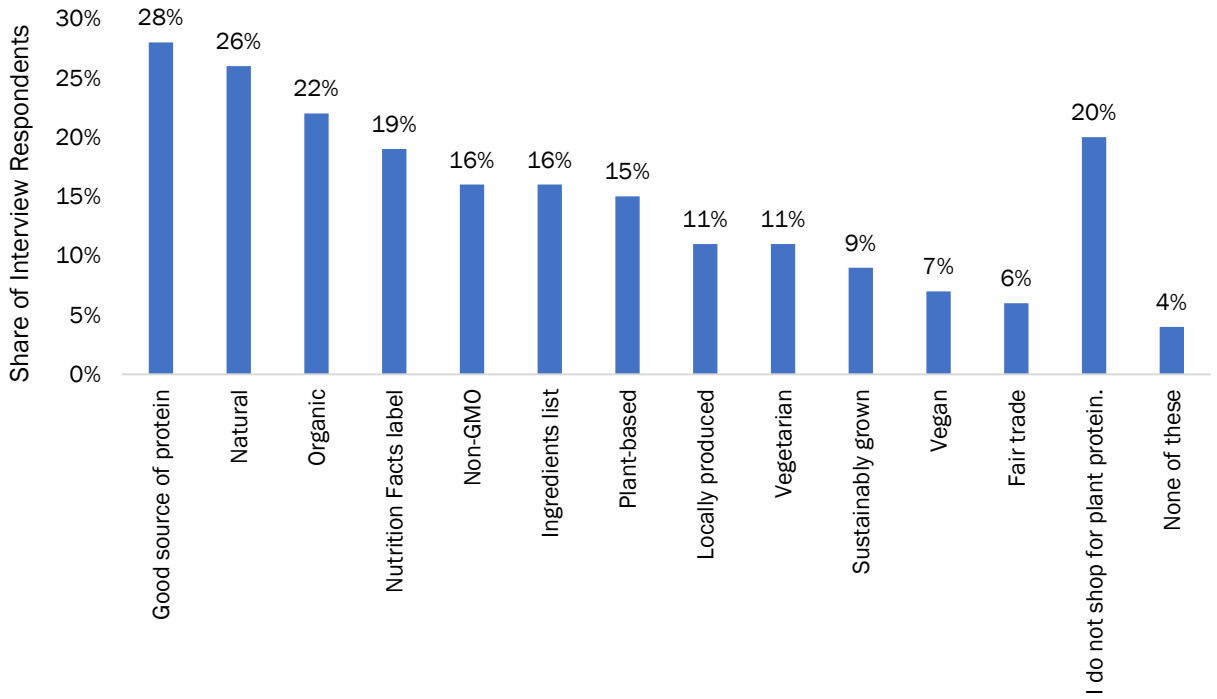
Exhibit 4.6.9. Demographic characteristics of soy, whey and pea protein consumers who felt familiar with these proteins and ate them at least sometimes*

	Soy protein	Whey protein	Pea protein
Total	**36%**	**31%**	**23%**
Men	42%	39%	28%
Women	31%	24%	18%
Less than $40,000	29%	24%	22%
$40,000 to $79,000	32%	32%	18%
$80,000 or more	42%	46%	30%
White	34%	29%	23%
African American	37%	29%	21%
Hispanic/Latinx	35%	37%	25%
Under 45	37%	37%	25%
45-64	41%	27%	26%
65+	22%	22%	12%
Noncollege	28%	26%	17%
College	43%	36%	28%

* Share that reported "I have heard of it, and I eat it at least sometimes."
Source: International Food Information Council (foodinsight.org/plant-and-animal-protein-consumer-survey)

U.S. adults who do choose plant proteins most frequently look for two labels on plant protein products when they shop: good source of protein and natural. Of 1,009 individuals interviewed by the International Food Information Council in November 2020, 28% and 26% mentioned these labels, respectively, when selecting as many as three labels they perceive as being most important when they shop for plant proteins. Exhibit 4.6.10 communicates the percentage of all participating interviewees who identified certain labels as their "top three" important attributes to seek when purchasing food. Organic ranked as the third most selected label with 22% of respondents selecting it as an important label for plant protein. Non-GMO ranked fifth with 16% of respondents naming it as important, and 11% identified locally produced as important (foodinsight.org/plant-and-animal-protein-consumer-survey). To deliver on consumer needs, firms developing plant protein products may prioritize these attributes important to consumers when they source plant protein ingredients.

Exhibit 4.6.10. Labels U.S. adults consider important when shopping for plant protein



Source: International Food Information Council (foodinsight.org/plant-and-animal-protein-consumer-survey)

During the year preceding November 2020, a segment of U.S. adults noted trying new proteins sourced from plants, according to the International Food Information Council interview research. First-time trial of plant-based meat alternatives was most common; 28% of respondents said they had tried such a product. Additionally, 21% and 19%, respectively, shared they had tried packaged foods high in plant protein and new legume varieties for the first time (foodinsight.org/plant-and-animal-protein-consumer-survey).

Exhibit 4.6.11 breaks down how first-time trial of these products varied by demographics. First-time plant-based meat alternative trial correlated with income. A greater share of high-earners tried these products for the first time. White consumers were less likely than African Americans and Hispanics to report first-time trial. Respondents with a college education and those who were younger also noted an increasing likelihood of have tried plant alternatives to meat for the first time. The high-plant protein packaged foods category most notably saw younger people and Hispanics more likely to try these products. First-time consumers of new legume varieties were most likely to be high-earners, Hispanic, young and have a college degree (foodinsight.org/plant-and-animal-protein-consumer-survey).

Exhibit 4.6.11. First-time plant protein product trial in year preceding November 2020

	Plant alternatives to meat	Packaged foods high in plant protein	New legume varieties
Total	**28%**	**21%**	**19%**
Men	26%	21%	21%
Women	29%	21%	18%
Less than $40,000	25%	21%	17%
$40,000 to $79,000	27%	20%	18%
$80,000 or more	32%	22%	24%
White	26%	18%	19%
African American	31%	19%	20%
Hispanic/Latinx	29%	31%	25%
Under 45	32%	26%	22%
45-64	26%	19%	19%
65+	20%	11%	14%
Noncollege	22%	19%	14%
College	32%	22%	24%

Source: International Food Information Council (foodinsight.org/plant-and-animal-protein-consumer-survey)

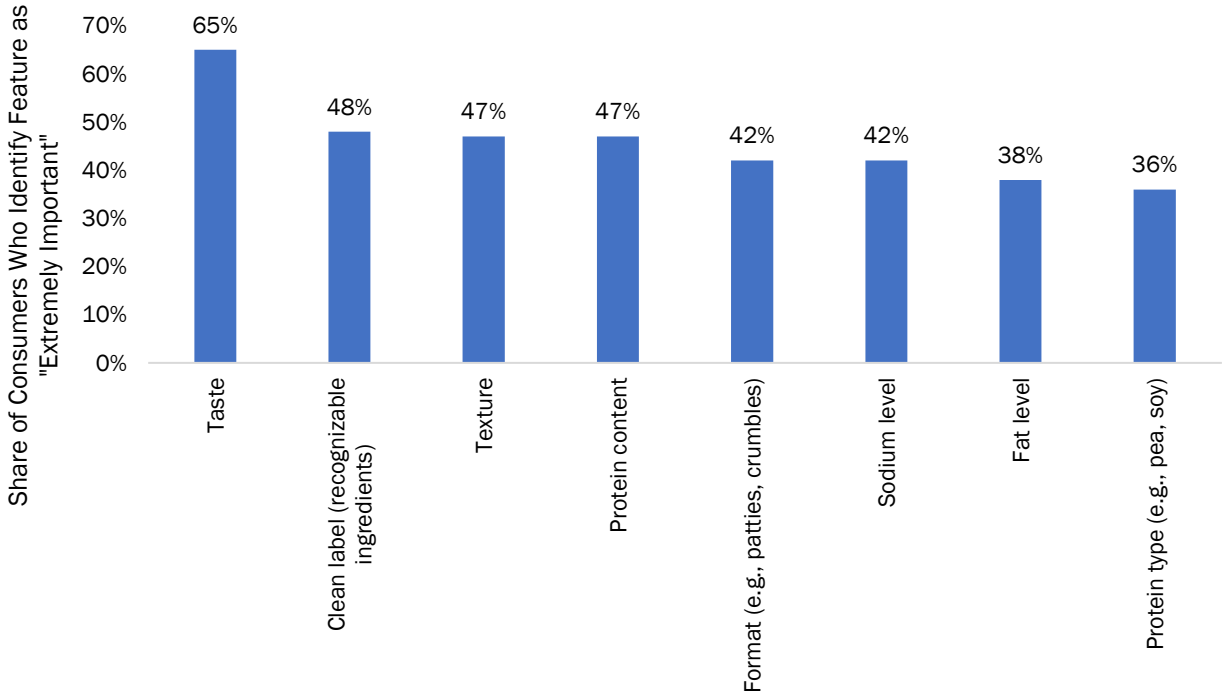
4.6.1 Meat substitutes

To make a plant-based meat or fish product, manufacturers combine textured protein with the following ingredients: water, binder, seasoning and color and oil (gfi.org/wp-content/uploads/2021/02/2021-02-23_Plant_Protein_Primer_GFI.pdf). In the U.S., plant-based meat sales totaled $1.4 billion in 2020, according to SPINS data cited by the Good Food Institute. Sales grew 45% between 2019 and 2020 (gfi.org/marketresearch). Outlook from Research and Markets suggest that U.S. plant-based meat sales may grow to nearly $2.7 billion by 2027 (plantbasednews.org/news/economics/us-plant-based-meat-market/).

According to 2019 research from Ingredion, consumers most identified taste as a meat alternative purchase driver. Two-thirds described taste as an extremely important attribute. The three attributes that followed in importance were clean label, texture and protein content. See Exhibit 4.6.1.1. Note, response choice that consumers were least likely to identify as extremely important was the protein type (ift.org/news-and-publications/food-technology-magazine/issues/2020/march/features/meet-the-next-generation-of-plant_based-meat).

In a January 2022 webinar, an RBC Capital Markets representative cited data from Numerator to understand the factors consumers dislike about plant-based meat alternatives. Based on input collected from 1,200 survey respondents, consumers were most likely to dislike the following: taste, price and texture (The Food Institute 2022).

Exhibit 4.6.1.1. Meat alternative purchase drivers, 2019

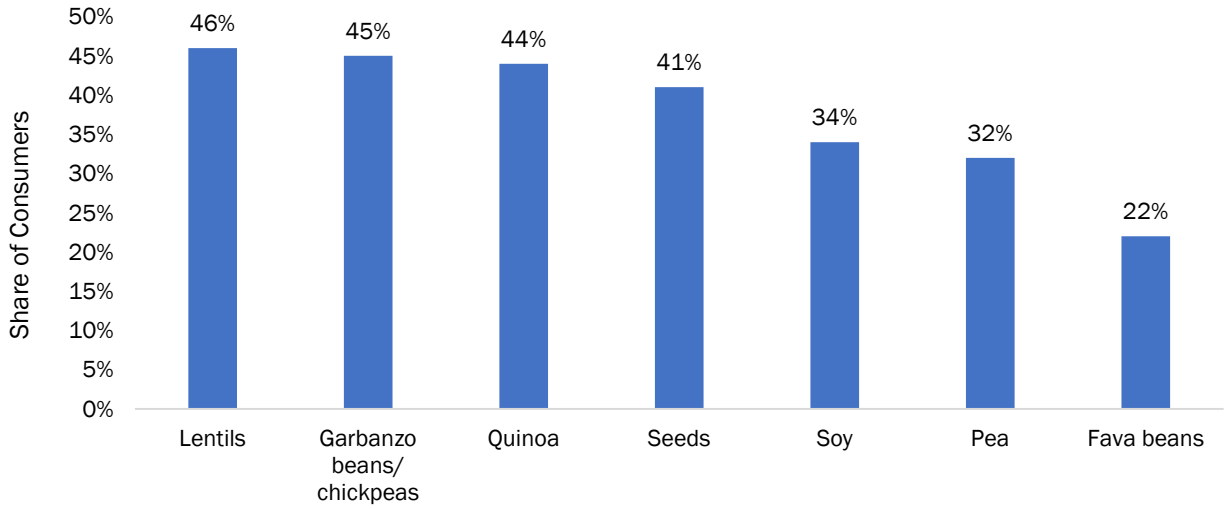


Source: Ingredion via IFT (ift.org/news-and-publications/food-technology-magazine/issues/2020/march/features/meet-the-next-generation-of-plant_based-meat)

Research from Glanbia Nutritionals found that consumers value products with a clean label. Two-thirds say they'll pay a 5% premium for such "clean" products. From the consumer's perspective, the most important feature of a clean label is that it lists no artificial colors or flavors. Also, products that use few ingredients, include non-GMO ingredients, feature ingredients that consumers know and lack preservatives are those that consumers perceive to have clean labels (glanbianutritionals.com/en/nutri-knowledge-center/insights/plant-based-meat-alternatives-market-snapshot). Further, 2020 research from FMCG Gurus found consumers look for those clean labels. Of the respondents who consumed meat alternatives, nearly three-quarters felt "100% natural" was an important characteristic. Six in 10 would like to see as few ingredients as possible and said they had concern about ingredients with names that "sound chemical" (foodbeverageinsider.com/vegetarian/plant-based-meat-brands-must-address-issue-ingredient-lists).

To understand preferences for proteins used in plant-based meat substitutes, Lightspeed and Mintel surveyed U.S. consumers. Results published in a March 2020 report suggested that surveyed consumers most preferred lentils as the protein source in plant-based meat substitutes. In the preferences survey — Exhibit 4.6.1.2 summarizes the findings — garbanzo beans or chickpeas and quinoa ranked as the second and third, respectively, most preferred protein sources for plant-based alternatives. One-third of U.S. consumers said they preferred soy protein in plant-based meat substitutes (foodbusinessnews.net/articles/19469-lab-grown-proteins-begin-to-impact-meat-dairy-categories).

Exhibit 4.6.1.2. Protein sources U.S. consumers prefer in plant-based meat alternatives



Source: Lightspeed and Mintel data cited by Food Business News (foodbusinessnews.net/articles/19469-lab-grown-proteins-begin-to-impact-meat-dairy-categories)

Despite these preferences leaning toward relatively novel plant proteins, commercially available products tend to use proteins with wider commercial availability. In its plant protein primer, the Good Food Institute lists the plant-based meat retail brands that rank in the top 10 within the U.S. marketplace. Of those 10, seven include soy in their formulations, and most blend soy with another protein source. Exhibit 4.6.1.3 details these brands and the protein sources they use. Many of these products combine soy and wheat proteins. When blended, the two create a texture that can mimic meat. Of note, the three brands that exclude soy from their ingredient statements — Beyond Meat, Field Roast and Quorn — use pea, wheat and mycoprotein, respectively, in their formulations (gfi.org/wp-content/uploads/2021/02/2021-02-23_Plant_Protein_Primer_GFI.pdf).

Exhibit 4.6.1.3. Top 10 U.S. retail plant-based meat brands that use soy protein*

Retail brand	Protein source(s)
Boca	Soy and wheat
Dr. Praeger's	Soy, pea and other
Gardein	Soy and wheat
Impossible Foods	Soy
Lightlife	Soy, wheat and pea
Morningstar	Soy, wheat and other
Tofurky	Soy and wheat

* Other brands in the top 10 are Beyond Meat, Field Roast and Quorn
Source: Good Food Institute (gfi.org/wp-content/uploads/2021/02/2021-02-23_Plant_Protein_Primer_GFI.pdf)

Compared with consumers who choose meat from animals, those who have become familiar with plant-based meat alternatives have some defining characteristics. Exhibit 4.6.1.4 reports the share of U.S. adults interviewed by the International Food Information Council

who felt familiar with the given protein and said they ate it at least sometimes. Demographic characteristics did appear to yield some differences in familiarity with and consumption of these products (foodinsight.org/plant-and-animal-protein-consumer-survey)

- **Earnings**: High-earners were most likely to choose plant-based meat alternatives.
- **Race and ethnicity**: Hispanic consumers were most likely to eat plant-based meat alternatives, but a large share also chose meat from animals. African Americans were less likely to choose meat from animals, but they were more likely than average to choose plant alternatives.
- **Age**: Older people over-indexed for meat from animals and under-indexed for plant alternatives. Middle-aged consumers appear to choose both, and younger consumers were less likely to eat meat from animals.

Exhibit 4.6.1.4. Demographic characteristics consumers who felt familiar with meat from animals and plant alternatives and ate them at least sometimes*

	Meat from animals	Plant alternatives to meat
Total	**76%**	**38%**
Men	76%	38%
Women	76%	37%
Less than $40,000	78%	32%
$40,000 to $79,000	79%	39%
$80,000 or more	72%	42%
White	79%	35%
African American	63%	40%
Hispanic/Latinx	75%	46%
Under 45	70%	41%
45-64	78%	41%
65+	88%	21%
Noncollege	72%	32%
College	80%	43%

* Share that reported "I have heard of it, and I eat it at least sometimes."
Source: International Food Information Council (foodinsight.org/plant-and-animal-protein-consumer-survey)

St. Louis-Based Center for Plant-Based Living

Called "the nation's first plant-based nutrition and culinary education center, the Center for Plant-Based Living offers in-person and virtual education to consumers interested in eating more plant-based foods. Based in St. Louis, the center offers cooking classes and opens its doors to private gatherings. Consumers who join the center receive member access to the center's recipe library and virtual cooking classes. Each month, members also participate in a monthly support group check-in. In 2022, the center will coordinate the first Plant-based Restaurant Week, which will feature plant-based-focused restaurants in Kirkwood and Webster Groves. For more information, go to cpbl-stl.com.

The Missouri firm locations in Exhibit 4.6.1.5 have been involved in developing or manufacturing plant-based meat substitutes. They may consider Missouri soybeans as ingredients in the food items they make.

Exhibit 4.6.1.5. Plant-based meat substitute manufacturing locations in Missouri

Firm	Products	Location	Website
Beyond Meat	Plant-based meat	Columbia, Missouri	beyondmeat.com
Deli Star	Plant-based proteins	St. Louis, Missouri	delistarcorp.com
Hungry Planet	Plant-based meats	St. Louis, Missouri	hungryplanetfoods.com
ICL Specialty Products	Plant-based meat substitutes	St. Louis, Missouri	bwnews.pr/3rYrJnU
IFF Nutrition and Biosciences	Meat alternatives	St. Louis, Missouri	dupontnutritionandbiosciences.com
Jake's Burgers	Vegan substitutes	Springfield, Missouri	facebook.com/JakesVeganBurgers
PFSbrands	BluTaco restaurant	Holt's Summit, Missouri	theblutaco.com
Rootberry	Meat alternatives	St. Louis, Missouri	rootberry.com

4.6.2 Snack bars

When snack bars first entered the marketplace, they tended to appeal to two audiences. One — bodybuilders — sought out protein, and second, children and adults turned to bars as a sweet treat. The momentum toward protein has continued, and more mainstream consumers have looked for protein in the snack bars they consume. Cargill conducted research in 2019 to understand preferences and perceptions for bar products. Protein ranked as the top attribute adults wanted in snack bars. Fiber ranked second and was followed by naturalness, whole grain ingredients and organic ingredients. For bars marketed to children, protein content was less important than naturalness and organic ingredients (cargill.com/doc/1432184945514/breaking-the-boundaries-in-new-bar-development.pdf).

Kerry, an ingredients company, listed the top protein food applications in a 2021 report. For North America, granola and cereal bars ranked as the top protein application (https://www.kerry.com/insights/resources/protein-mindset-consumer-research). Within the U.S. bar market, high-protein, high-fiber rank in the top six trends shaping the marketplace, according to Glanbia Nutritionals. The list also includes plant protein as another trend (glanbianutritionals.com/sites/default/files/2020-03/gn-us-bar-market-infographic.pdf). However, other recently launched bars features animal protein from meat, including grass-fed beef and poultry foodbeverageinsider.com/bakery/crowded-market-forcing-new-innovations-nutrition-bars). Manufacturers may have an opportunity to blend protein sources — plant and animal. According to FMCG Gurus research conducted in June 2020, 45% of U.S. consumers who have interest in products made from plant and animal protein (kerry.com/insights/resources/protein-snack-bar-whitepaper-download). Another niche introduced in recent years has been allergen-free bars to appeal to clean label demands (foodbeverageinsider.com/bakery/crowded-market-forcing-new-innovations-nutrition-bars).

Given the protein trend, snack bars launched in recent years have increasingly added protein or a high-protein claim. Mintel found 17% of snack bars launched globally in 2015

had high-protein content or added protein. By 2019, one-third of snack bars released globally included these attributes. North America represents the bulk of the world's protein bar market. Manufacturers may incorporate protein into various snack bar components, such as the dough, coating, filling and mix-ins. In a bar, soy protein can promote cohesiveness and add chewiness. When formatted as a crisp, soy protein may be included as a mix-in (kerry.com/insights/resources/protein-snack-bar-whitepaper-download).

From 2018 to 2019, sales increased most for bars that featured at least 20% protein. Exhibit 4.6.2.1 reports bar sales by protein content. Products containing at least 20% protein saw sales increase by 8%. Sales of bars that had less than 10% protein dropped by 2%, though this latter category still captured the largest sales of all U.S. bar sales — nearly half of all sales (glanbianutritionals.com/sites/default/files/2020-03/gn-us-bar-market-infographic.pdf). 2019 SPINS sales data reported by Cargill suggest that U.S. protein bar sales exceeded $4.6 billion (cargill.com/doc/1432184945514/breaking-the-boundaries-in-new-bar-development.pdf).

Exhibit 4.6.2.1. U.S. bar sales by protein content

	<10% protein	10%-19% protein	>20% protein
Share of U.S. bar sales	46%	22%	32%
Year-over-year sales change	-2%	6%	8%

Source: SPINS via Glanbia Nutritionals (glanbianutritionals.com/sites/default/files/2020-03/gn-us-bar-market-infographic.pdf)

When the COVID-19 pandemic forced consumers to stay home, the bar market suffered. In the year preceding Oct. 4, 2020, sales of snack and granola bars dropped by 5.2%. Exhibit 4.6.2.2 summarizes how various product categories performed during this time. Nutritional and intrinsic health value bars — the largest category by dollar sales — experienced a sales decline by 8%. Granola bar sales also dropped, but sales improved for breakfast, cereal and snack bars. The "other" category, though small, performed exceptionally well compared with the other bars categories (snackandbakery.com/articles/95934-in-quarantine-the-role-of-snack-and-granola-bars-is-shifting).

Exhibit 4.6.2.2. Bar sales by category, year preceding Oct. 4, 2020

	Sales	Sales change
Nutritional and intrinsic health value bars	$3.1 billion	-8.0%
Granola bars	$1.4 billion	-6.5%
Breakfast, cereal, snack bars	$1.5 billion	2.0%
Other	$0.0248 billion	37.6%

Source: IRI via Snack and Wholesale Bakery (snackandbakery.com/articles/95934-in-quarantine-the-role-of-snack-and-granola-bars-is-shifting)

The protein content in a bar tends to shape the market for that product. Exhibit 4.6.2.3 summarizes how bars with three protein tiers serve various audiences. A high-protein, low-sugar, low-fat bar meant for sports nutrition applications delivers the most protein, and a general wellness bar offers the least (kerry.com/insights/resources/protein-snack-bar-whitepaper-download).

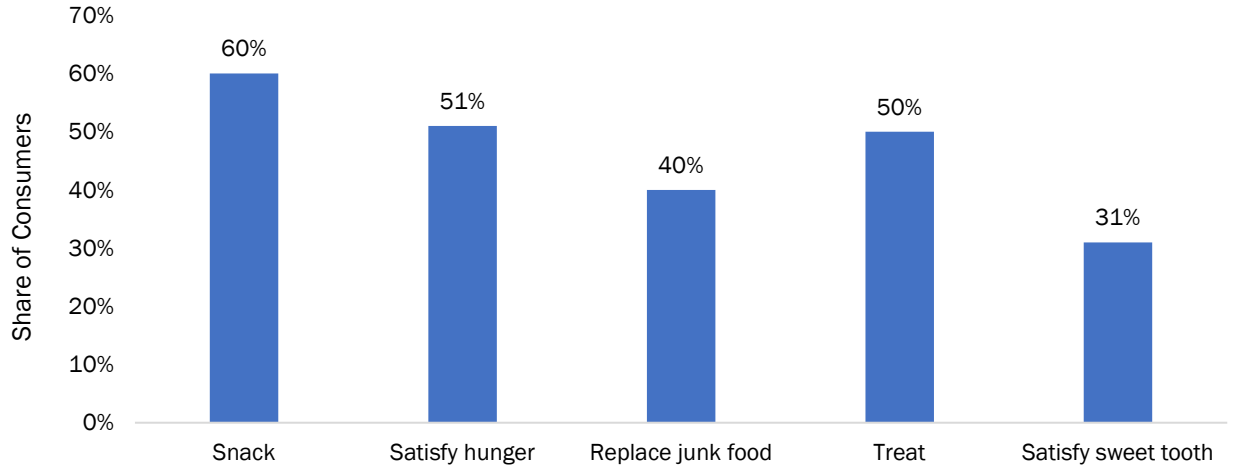
Exhibit 4.6.2.3. U.S. bar sales by protein content

	Sports nutrition	Dietary products	General wellness
Characteristics	High protein, low sugar, low fat	High protein, high fiber, low sugar, fat level, type variable	Moderate protein, low or high sugar, high fat
Typical protein/serving	>20%	10-20%	5-10%
Key factors	Digestive tolerance (laxative effect of polyols/fiber)	Diet target (e.g., keto, Atkins), fat oxidation and melting point	Good sensory experience

Source: Kerry (kerry.com/insights/resources/protein-snack-bar-whitepaper-download)

In consumer research conducted during October 2019, Cargill studied why consumers chose bar products. Exhibit 4.6.2.4 shares the results. Six in 10 respondents ate bars as a snack, and half said bars satisfy hunger. Of the respondents, 40% would chose a bar product instead of junk food. For a smaller share of consumers, bars served as a type of treat — in some cases, a sweet one (cargill.com/doc/1432184945514/breaking-the-boundaries-in-new-bar-development.pdf).

Exhibit 4.6.2.4. Bar purchase drivers, 2019



Source: Cargill (cargill.com/doc/1432184945514/breaking-the-boundaries-in-new-bar-development.pdf)

Given that snack bars are a mature product category, many manufacturers compete for market share. To differentiate their products, manufacturers seek to innovate through the ingredients they choose to feature and the benefits their products provide. Social impact has also been a priority for some bar brands to make their businesses appeal to buyers (foodbeverageinsider.com/bakery/crowded-market-forcing-new-innovations-nutrition-bars). For the year ending Oct. 4, 2020, the firms listed in Exhibit 4.6.2.5 captured the greatest market share in two particular bar product categories. Clif Bar led the nutritional and intrinsic health value bars category. Kellogg held the top spot for breakfast, cereal and snack bars (snackandbakery.com/articles/95934-in-quarantine-the-role-of-snack-and-granola-bars-is-shifting).

Exhibit 4.6.2.5. Bar product category leaders in dollar sales, year ending Oct. 4, 2020

	Nutritional/intrinsic health value bars	Breakfast, cereal and snack bars
1	Clif Bar	Kellogg
2	The Simply Good Foods	Kind LLC
3	General Mills Inc.	Private label
4	Kind LLC	General Mills Inc.
5	Quest Nutrition LLC	Small Planet Foods Inc.

Source: IRI via Snack Food & Wholesale Bakery (snackandbakery.com/articles/95934-in-quarantine-the-role-of-snack-and-granola-bars-is-shifting)

In a 2021 white paper, Cargill outlined several projections for how the bar market may evolve in the future. The following points summarize the Cargill outlook (cargill.com/doc/1432184945514/breaking-the-boundaries-in-new-bar-development.pdf):

- Consumers want to know a bar product's protein source. Traditionally, manufacturers chose soy and whey. Acceptance of plant-based protein sources has grown. Emerging options have included peas, lentils and beans.
- Consumers care about a bar's sugar content. According to Cargill, a quarter want low-sugar products. If replacing sugar, then manufacturers find alternatives that offer sweetness and the functional benefits sugar adds (e.g., binding, bulking).
- Consumers seek products that promote other health benefits (e.g., gut health, energy, heart health, cognitive function).
- Consumers choose to eat bars at different points in the day. Bars have often satisfied snack cravings. Depending on the consumer, these products may make a convenient breakfast or meal replacement or fill another eating occasion during the day.

Snack & Wholesale Bakery in December 2020 reported several emerging trends within the bars category. The following points are highlights (snackandbakery.com/articles/95934-in-quarantine-the-role-of-snack-and-granola-bars-is-shifting):

- Protein bars have an opportunity to tap into savory flavors.
- Refrigerated options may emerge.
- Product format may evolve from traditional bars. Cubes, bites, balls and other formats may emerge.
- Manufacturers may try new taste and texture combinations.

The following firms in Exhibit 4.6.2.6 have a Missouri presence and may have interest in using soy protein in snack bar applications.

Exhibit 4.6.2.6. Snack bar manufacturing locations in Missouri

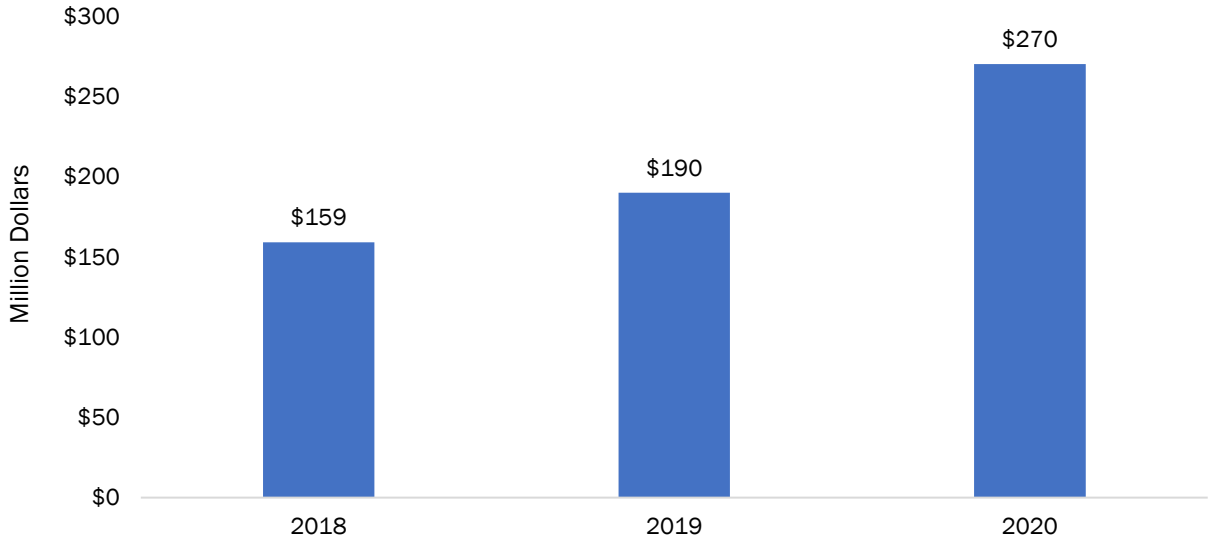
Firm	Products	Location	Website
Bellring Brands	PowerBar	St. Louis, Missouri	bellring.com
Darlington Snacks	Oatmeal bars, snack squares	Joplin, Missouri	darlingtonsnacks.com
IFF Nutrition and Biosciences	Supro soy protein for nutrition bars and snacks	St. Louis, Missouri	dupontnutritionandbiosciences.com
J&J Snack Foods	Corazonas Heartbar, Daddy Ray's fig bars	Moscow Mills, Missouri	jjsnack.com
Nature's Bakery	Fig bars, oatmeal bars, baked-ins, brownie bars	Hazelwood, Missouri	naturesbakery.com
Parker Products	Snack bar inclusions	Mexico, Missouri	parkerproducts.com

4.6.3 Cheese

A relatively small product category, plant-based cheese sales totaled $270 million in 2020, according to SPINS. See Exhibit 4.6.3.1. Sales increased 42% between 2019 and 2020 after having grown 19% from 2018 to 2019 (gfi.org/marketresearch/#cheese). Compared with all cheese sales, plant-based options have captured roughly a 3% share, according to SPINS estimations (fooddive.com/news/plant-based-cheese-is-full-of-startups-will-dairy-providers-get-into-the-s/596145).

Globally, Wise Guys Reports, a market research company, estimates that global plant-based cheese sales totaled $1.01 billion in 2019. Between 2020 and 2027, the firm projects a more than 12.8% growth rate for the category (foodinstitute.com/focus/plant-based-dairy-market-gathering-significant-momentum).

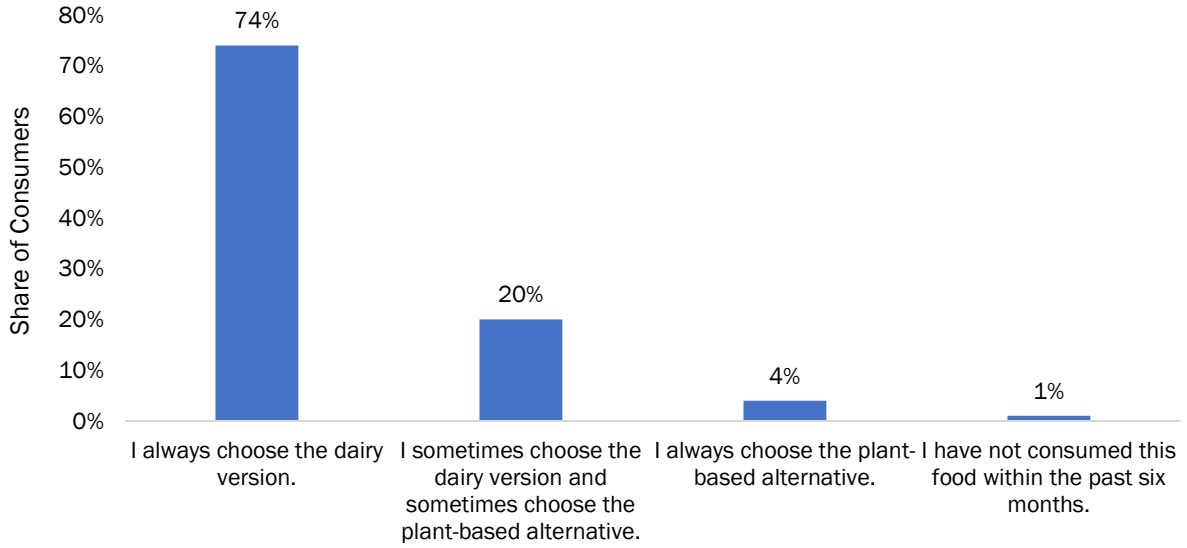
Exhibit 4.6.3.1. U.S. plant-based cheese sales, 2020



Source: SPINS via Good Food Institute (gfi.org/marketresearch/#cheese)

When deciding the cheese to consume, consumers still largely choose dairy-based options. The International Food Information Council surveyed more than 1,000 adult Americans in April 2021 about dairy products they had purchased in the preceding six months. It found nearly three-quarters of those responding always chose dairy cheese — a higher share for all-dairy consumption than any of the other product categories, including butter, ice cream, milk and yogurt. Exhibit 4.6.3.2 illustrates that one-fifth of responding consumers said they chose dairy and plant-based cheeses. Just 4% selected always consumed plant-based cheese (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf).

Exhibit 4.6.3.2. U.S. dairy-consuming adults cheese consumption*



* Data represent consumption in six months preceding April 2021
Source: International Food Information Council (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf)

Dairy and plant-based cheese consumption did vary somewhat by demographic characteristics. Exhibit 4.6.3.3 reports that women were slightly more likely than men to always choose dairy-based cheese. Younger consumers indicated a greater likelihood to sometimes consume dairy and plant-based cheese or always choose plant-based cheese than their older counterparts. Educational attainment had a minimal effect. A slightly greater share of college graduates said they chose dairy and plant-based cheese relative to noncollege adults. However, the noncollege adults noted a slightly greater likelihood to always choose plant-based cheese (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf).

Exhibit 4.6.3.3. U.S. dairy-consuming adults cheese purchase preferences and associated demographic characteristics*

	I always choose the dairy version.	I sometimes choose both — dairy and plant-based.	I always choose the plant-based (nondairy alternative).
Men	71.5%	21.9%	4.9%
Women	76.3%	18.7%	4.0%
18-34 years old	59.8%	31.1%	7.6%
35-54 years old	76.9%	18.5%	3.8%
55+ years old	89.7%	6.9%	1.0%
Noncollege	74.1%	18.9%	5.7%
College	73.7%	21.2%	3.6%

* Data represent consumption in six months preceding April 2021
Source: International Food Information Council (foodinsight.org/wp-content/uploads/2021/06/IFIC-Dairy-Consumers-Survey.pdf)

Expectations for plant-based cheese include the following: yellow or white color, fatty and creamy, indulgent and source of protein and calcium (gfi.org/wp-content/uploads/2021/02/2021-02-23_Plant_Protein_Primer_GFI.pdf). From cheese products, consumers demand certain functional characteristics that are difficult to replicate in plant-based options. For example, depending on the application, they expect cheese to have the right stretch, melt characteristics, mouthfeel and slicing or shredding abilities. To deliver on functionality, vegan cheese manufacturers have included carrageenan as an ingredient, but consumers would rather not see this ingredient on their labels (foodnavigator-usa.com/Article/2021/03/30/Plant-based-dairy-in-focus-Cheese-is-the-most-technically-challenging-space-in-dairy-alternatives). Carrageenan has been said to trigger inflammation. Some have claimed a link between it and conditions such as rheumatoid arthritis and colon cancer (scientificamerican.com/article/the-carrageenan-controversy). Plant-based cheese also hasn't always delivered on consumer expectations for taste (dairyfoods.com/articles/94524-giving-consumers-plant-based-alternatives-to-dairy). Roughly one-fifth of potential plant-based cheese consumers view taste as an impediment, according to research conducted by Numerator, a consumer insights company (fooddive.com/news/plant-based-cheese-is-full-of-startups-will-dairy-providers-get-into-the-s/596145). Adding to the challenge are the types of cheese manufacturers may produce. Depending on the starch used, manufacturers may create a soft cheese or hard cheese. They must adapt their formulations, depending on the desired final product characteristics (foodbusinessnews.net/articles/17847-unlocking-opportunities-in-cheese-alternatives).

When choosing ingredients to use in plant-based cheese, manufacturers prefer those with a mild flavor and white color. These attributes allow the end product to more closely resemble dairy-based cheese (foodbusinessnews.net/articles/17847-unlocking-opportunities-in-cheese-alternatives). To make plant-based cheese, manufacturers use ingredients such as pea protein, soy protein isolate, mung beans (foodbusinessnews.net/articles/17847-unlocking-opportunities-in-cheese-alternatives), coconut oil and nuts such as cashews and almonds. Fact.MR, a market research company, estimates that soy-based cheese

commands a 40% market share (foodmatterslive.com/discover/article/plant-based-cheese-market-expected-to-have-value-of-3-9b-by-2031).

Startup Nobell Foods has raised millions of dollars to fund its work in using bioengineered soybeans to create a plant-based casein protein. Only found in dairy, casein gives cheese its characteristic stretch. With the plant-based casein, Nobell Foods plans to make alternatives to mozzarella and cheddar cheese. Because soybeans can be grown on a wide scale, Nobell views its innovation as an option for plant-based and dairy-based cheeses to have price parity. Including soybeans in the process is novel compared with efforts of other firms that have focused on using microbial fermentation to make casein (fooddive.com/news/plant-based-cheese-maker-nobell-foods-raises-75m-for-expansion/603803).

Exhibit 4.6.3.4 details firms involved in making cheese alternatives. These firms have a presence in Missouri.

Exhibit 4.6.3.4. Cheese alternatives firms with locations in Missouri

Firm	Products	Location	Website
Allied Blending and Ingredients	PlantWise solution for vegan cheese	St. Louis, Missouri	alliedblending.com
Core & Rind	Plant-based cheesy sauce	St. Louis, Missouri	coreandrind.com
Kraft Heinz	Kraft singles, macaroni and cheese	Springfield, Missouri	kraftheinzcompany.com
Mattie's Foods	Vegan queso	Kansas City, Missouri	mattiesfoods.com
Osage Food Products	Vegan cheese	Washington, Missouri	osagefood.com
Schreiber Foods	Processed plant-based slices, shreds	Carthage, Monett, Mount Vernon, Missouri	schreiberfoods.com

4.6.4 Breakfast cereal

Hot and cold cereals may have added protein. Kerry released a consumer research report in 2021, and it shared product categories where consumers showed the most interest in seeing protein fortification. Globally and in North America, breakfast cereals ranked third — only behind granola and cereal bars and yogurt — for consumer interest in protein fortification (kerry.com/na-en/latest-news/2021/the-protein-mindset-report-finds-protein).

In cereal, protein fortification represents a relatively new approach to product development — spurred by consumer nutritional preferences. Three decades ago, consumers turned to cereal as a breakfast food that enabled them to consume less fat. Today, however, those high-sugar and -carbohydrate cereals don't mesh with the trend toward reducing sugar and carbohydrates in diets and increasing protein content (npd.com/news/thought-leadership/2020/food-and-drink-through-the-decades). Competition has also affected breakfast cereal sales. Some consumers switched to eating Greek yogurt or eggs — both high-protein foods — at breakfast instead of cereal (npd.com/news/thought-leadership/2020/food-and-drink-through-the-decades).

Therefore, multiple factors contributed to the breakfast cereal sales declines in the 2010s. Packaged Facts research found that North American breakfast sales decreased by roughly 2.7% year-over-year from 2013 to 2018 (foodnavigator-usa.com/Article/2019/10/18/Tips-from-Packaged-Facts-to-boost-cereal-sales-from-reformulating-to-repositioning). The pandemic did lead to a resurgence in breakfast cereal popularity, however. As consumers stayed home, they could more easily make cereal part of their meals. Plus, cereal's familiarity may have reassured consumers during a time of uncertainty (foodbusinessnews.net/articles/18381-slideshow-a-year-in-breakfast-cereal-innovation). Nielsen found ready-to-eat cereal dollar sales improved by 9% in 2020 compared with 2019 (winsightgrocerybusiness.com/center-store/retailers-seek-hold-consumer-interest-breakfast-foods). In 2021, consumers continued to choose cereal more often than they did before the pandemic; however, cereal consumption had receded somewhat since 2020. Compared with cold cereal, hot cereal performed better in terms of dollar sales growth in 2021 (progressivegrocer.com/how-can-cereal-aisle-reclaim-breakfast).

Research from Mintel points to three characteristics most likely to motivate cereal product trial: reduced sugar, added protein and added fiber. These factors ranked more highly than indulgent mix-ins, co-branded flavors and limited-time flavors in incentivizing new product trial (progressivegrocer.com/how-can-cereal-aisle-reclaim-breakfast). More protein in cereal may help to fill a protein consumption gap. Kerry, an ingredients business, has said that consumers tend to eat too little protein in the morning and that eating protein at different times during the day supports health. Protein fortification in breakfast foods, therefore, may encourage more balanced protein consumption each day (kerry.com/insights/kerrydigest/2019/4-trends-revitalizing-the-breakfast-cereal-market).

Several new protein-fortified cereals launched in recent months, and the following list highlights a few that use plant-based protein sources:

- *RX Cereal*: Made using pea protein, almonds and brown rice, the cereal has three flavor options and delivers 11 grams to 12 grams of protein per serving. Kellogg's promotes the product as a breakfast cereal and snack (fooddive.com/news/kelloggs-rx-brand-launches-protein-rich-cereals/603598/).
- *HighKey Plant-Based Protein Cereal*: In March 2021, HighKey introduced its plant-based protein cereal made using soy protein. Other ingredients include coconut oil, rice flour, inulin, oat fiber and stevia. A serving would provide 16 grams of protein (foodbusinessnews.net/articles/18052-highkey-pumps-up-cereal-portfolio-with-plant-based-protein-lineup).
- *Kashi GO*: Formulated for consumers following a keto diet, Kashi GO Keto-Friendly Cereal features no grain. Its ingredients include pea protein, lentil protein and chickpea flour. Protein content per serving totals 12 grams (foodbusinessnews.net/articles/17688-kashi-goes-keto).

In 2019, Packaged Facts recommended breakfast cereal manufacturers consider several opportunities to grow their businesses (foodnavigator-usa.com/Article/2019/10/18/Tips-from-Packaged-Facts-to-boost-cereal-sales-from-reformulating-to-repositioning).

- Add whole grains, protein or fiber to enhance a cereal product's nutrition.
- Find alternatives to sugar sweeteners. Examples include agave and dates.
- Align ingredient choices with dietary preferences, such as keto and gluten-free.

- Use novel or nostalgic flavors.
- Shift cereal use to different eating occasions, such as snacks or dessert.
- Make cereal consumption more convenient.

With respect to snacking, many consumers already treat cereal as a snack. Of all cereal consumers, 35% and 33% consume cereal as morning and evening snacks, respectively, according to Mintel. Certain packaging configurations may better promote cereal as a snack. A story from *Progressive Grocer* suggests that snack-size, resealable and stand-up packaging may all make cereal easier to consume as snacks (progressivegrocer.com/how-can-cereal-aisle-reclaim-breakfast). For some consumers, cereal has a health halo related to snacking. In the U.S., 35% of cereal consumers said they considered cereal as a healthier alternative than other snacks, according to Mintel (winsightgrocerybusiness.com/center-store/retailers-seek-hold-consumer-interest-breakfast-foods).

The firms listed in Exhibit 4.6.4.1 produce cereal products and have Missouri locations. These may represent potential buyers for soy protein ingredients formatted for cereal product applications.

Exhibit 4.6.4.1. Cereal manufacturers with locations in Missouri

Firm	Products	Location	Website
Cereal Ingredients	Granola, clusters	St. Joseph, Missouri	ciifoods.com
Gilster-Mary Lee	Cereal	McBride, Perryville and Joplin, Missouri	gilstermarylee.com
IFF Nutrition and Biosciences	Supro soy protein for cereal	St. Louis, Missouri	dupontnutritionandbiosciences.com
Post	Cereal	St. Louis, Missouri	postholdings.com

4.6.5 Bread

In its 2021 consumer research-based report about protein fortification in food, Kerry identified bread to rank fifth for protein fortification interest among North American consumers. Bread also ranked fifth globally for protein fortification appeal in food products. It followed granola and cereal bars, yogurt, breakfast cereals and breakfast granola (kerry.com/na-en/latest-news/2021/the-protein-mindset-report-finds-protein).

In 2020, bread sales increased — triggered by behavioral changes related to the COVID-19 pandemic. Exhibit 4.6.5.1 highlights how sales in five bread categories changed in the year ending Jan. 21, 2021. These IRI data suggest bagel sales improved the most on a percentage basis. Bagels also represented the smallest of these five categories. The largest — fresh bread — also saw sales increase in 2020. Relative to the year prior, fresh bread sales grew by 10.4% in the year ending Jan. 21, 2021, according to IRI. Hamburger and hot dog buns ranked second in terms of dollar sales and sales growth from 2019 to 2020 (foodbusinessnews.net/articles/18685-bread-is-on-a-roll).

Exhibit 4.6.5.1. Bakery staples sales for year ending Jan. 24, 2021

	Dollar sales	Growth from year ago
Fresh bread	$10.1 billion	10.4%
Hamburger and hot dog buns	$2.6 billion	18.6%
Other fresh rolls, buns, croissants	$2.4 billion	15.7%
Bagels	$1.2 billion	24.6%
English muffins	$835 million	16.5%

Source: IRI via Food Business News (foodbusinessnews.net/articles/18685-bread-is-on-a-roll)

The pandemic not only increased bread demand, but consumers also during this time showed more interest in breads they considered healthier or indulgent. Healthier options include low-carb, high-protein and high-fiber products. Young people in particular have shown interest in healthier bread choices (foodbusinessnews.net/articles/18685-bread-is-on-a-roll). At the same time, bakers resorted to producing fewer SKUs. Simplified product portfolios added efficiency to their businesses and enabled them to continue filling orders while maximizing production (bakingbusiness.com/articles/53287-bread-industry-preps-for-future-after-covid). One industry expert quoted in August 2021 by *Food Business News* predicted fewer SKUs into the future (foodbusinessnews.net/articles/18685-bread-is-on-a-roll). Top bakers featured in a March 2021 piece from *Baking Business*, however, shared plans to introduce new products or extend existing brands (bakingbusiness.com/articles/53287-bread-industry-preps-for-future-after-covid).

Elevating a baked good's protein content does present some formulation challenges. For example, the added protein affects the gluten network. Without additional formulation changes, high-protein bread may have volume and grain structure problems. Protein also influences water management in baked goods. If formulating a plant-based, high-protein bread, then bakers may blend proteins such as wheat, soy, flax or pea and displace the eggs or dairy often used in bread recipes (ift.org/news-and-publications/food-technology-magazine/issues/2021/august/columns/ingredients-7-top-bakery-product-trends). In addition to dairy and egg protein, soy protein has been a traditional ingredient used in baked products. Although soy is a complete protein — like dairy and egg protein — formulations may combine soy with other protein sources such as ancient grains or other legumes. Using blends may also control for any strong flavors associated with a single protein ingredient. Soy protein isolate represents a good option because it has less flavor (foodbusinessnews.net/articles/15420-blending-protein-sources-in-baked-goods).

A February 2021 story from *Snack Food & Wholesale Bakery* outlined several future trends and opportunities for the bread category to consider (snackandbakery.com/articles/96348-sustaining-bread-category-growth-during-2021):

- Consumers prioritize taste more than any attribute when purchasing breads and bakery products. Any changes to recipes should ensure the final product offers the taste that consumers will accept and enjoy.
- The pandemic ignited interest in at-home baking. As behaviors shift back to those more common before the pandemic, consumers may prefer shopping for unique bread products — particularly those that may be difficult to make such as croissants or brioche — rather than prepare them at home.

- Consumers show increasing interest in artisan and rustic options. These products' features include complex flavors, an "artisan" appearance and compelling story.
- Bakers may package bread in more "half loaf" styles to accommodate smaller households and minimize food waste.
- Buyers appear poised to find staple goods such as bread with varying nutritional profiles. The following attributes are examples of those that have been of interest: low-carbohydrate, keto, gluten-free, high-fiber, high-protein, whole grains and sprouted grains. They're also interested in benefits such as immune support, weight management, satiety and better digestion.
- Ingredient provenance also matters to some consumers. This trend includes a growing appreciation for how ingredients are produced, environmental stewardship and farmer welfare.

The following bread manufacturers with Missouri locations in Exhibit 4.6.5.2 may have interest in using soy ingredients in their recipes.

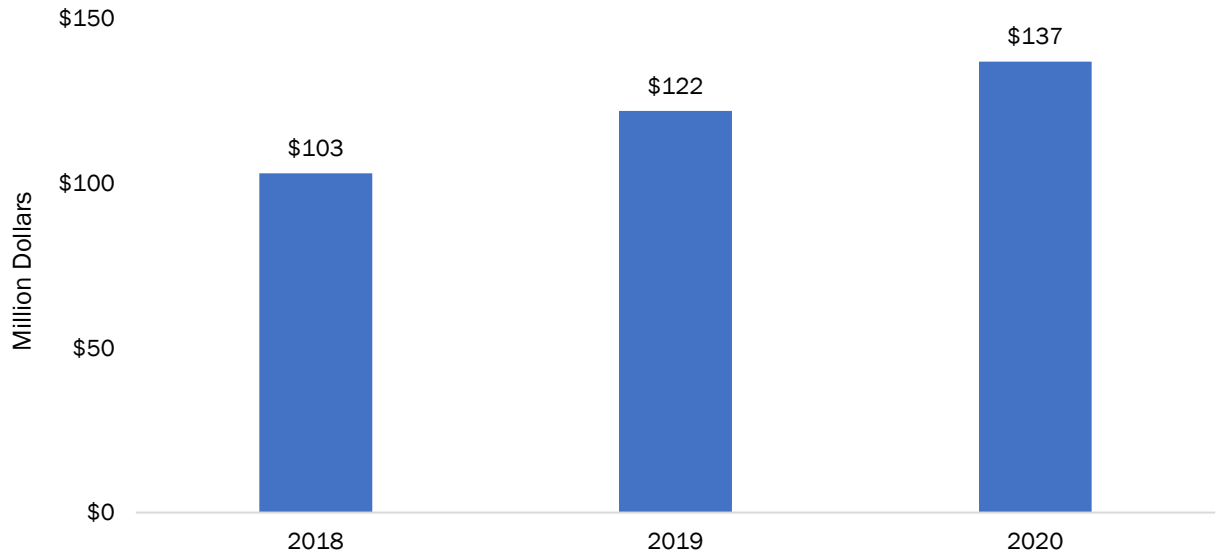
Exhibit 4.6.5.2. Bakeries or bakery suppliers with locations in Missouri

Firm	Products	Location	Website
Bimbo Bakeries	Bread, sweet baked goods	Kansas City, Sedalia, Springfield, Maryland Heights, Missouri	bimbobakeriesusa.com
Companion	Customized bread programs	St. Louis, Missouri	companionbaking.com
Dakota Blenders	Baking blends	St. Louis, Missouri	dakotablenders.net
Farm to Market Bread Company	Sliced, hearth, other breads	Kansas City, Kansas	farmtomarketbread.com
Fazio's Bakery	Fresh bread, frozen Italian specialty goods	St. Louis, Missouri	faziosbakery.com
J&J Snack Foods	County Home, READI-BAKE, Labriola breads	Moscow Mills, Missouri	jjsnack.com
Panera Bread	Sandwich breads	St. Louis, Missouri	panerabread.com
Pizza Blend	Custom flour blends	Kansas City, Missouri	pizzablends.com
Planet Sub	Sub shop	Kansas City, Missouri	planetsub.com
TNT Crust	Pizza crusts	St. Charles, Missouri	tntcrust.com

4.6.6 Beverages

Beverages represent another category where plant-based has made an impact. SPINS data reported by the Good Food Institute — see Exhibit 4.6.6.1 — suggest that sales of plant-based ready-to-drink beverages increased by 12% between 2019 and 2020 to total $137 million in 2020. Sales growth from 2018 to 2020 exceeded 30%. Consumers purchased more than 41 million units of plant-based ready-to-drink beverages in 2020. Note, the products included in this category are those that may replace dairy products. Plant-based milk sales are reported separately, however (gfi.org/marketresearch/#ready-to-drink-beverages).

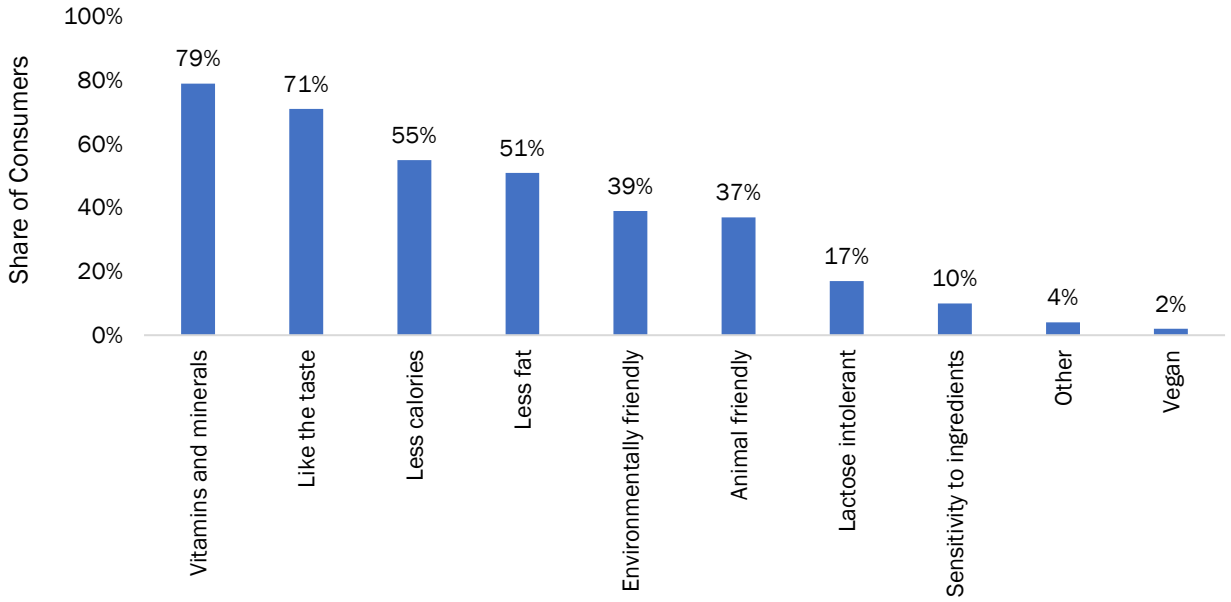
Exhibit 4.6.6.1. Plant-based ready-to-drink beverage sales



Source: SPINS via Good Food Institute (gfi.org/marketresearch/#ready-to-drink-beverages)

Ready-to-drink beverages may offer health benefits related to energy, weight loss or management, digestive health, inflammation or immunity (naturalproductsinsider.com/beverages/functional-ready-drink-rtd-beverage-marketplace-thrives). Plant-based beverage formats include juices, wellness shots, energy drinks, fortified water, teas and sports drinks (nutraingredients.com/News/Promotional-Features/Why-plant-based-functional-beverages-are-perfect-for-the-modern-market). Protein, fiber, botanicals or other compounds in these beverages may originate from plant sources (naturalproductsinsider.com/beverages/functional-ready-drink-rtd-beverage-marketplace-thrives). Exhibit 4.6.6.2 illustrates the reasons why consumers participating in a Brisan Group study during December 2019 said they purchased plant-based beverages. Note, the Brisan Group provides product development support to food businesses. Of the consumers participating in the research, nearly 80% said the vitamins and minerals in plant-based beverages contributed to their purchase decisions, and 71% said they liked how those beverages taste. The share of consumers citing less calories and less fat as reasons why they purchase plant-based beverages totaled 55% and 51%, respectively (brisangroup.com/food-industry-thoughts-articles/the-future-of-plant-based-beverages).

Exhibit 4.6.6.2. Reasons why consumers buy plant-based beverages



Source: Brisan Group (brisangroup.com/food-industry-thoughts-articles/the-future-of-plant-based-beverages)

Beverages often include added protein ingredients to enhance nutritional value. North American consumers participating in a 2021 study from Kerry, an ingredients business, identified the following beverage products as those where protein fortification would be most appealing: smoothies, milkshakes, nutritional beverages, drinkable yogurt and dairy-based milk (kerry.com/na-en/latest-news/2021/the-protein-mindset-report-finds-protein). Ready-to-drink beverages have incorporated several "trending" plant proteins, according to an October 2020 story from *Natural Products Insider*. Examples include fava beans, pumpkin seeds and lentils. To promote satiety, high-protein drinks may have added fiber, such as that from carrots, apples or oats (naturalproductsinsider.com/beverages/functional-ready-drink-rtd-beverage-marketplace-thrives).

Alone, a plant protein may not offer the "complete" or "whole" protein profile that consumers expect to see on a label. To provide the appropriate protein content, manufacturers often blend protein sources. That includes blending one plant protein with other plant-based proteins or combining dairy and plant proteins. The blend's composition not only affects its protein content but also the product's taste, texture and functionality (foodbusinessnews.net/articles/17387-protein-blends-creating-new-beverage-opportunities). In dairy substitutes, soy has often served as a protein ingredient of choice because it offers all of the essential amino acids. Its beany flavor, however, has been an impediment and motivated manufacturers to consider other plant-based proteins for their products (foodbusinessnews.net/articles/15729-slideshow-plant-protein-blends-driving-beverage-innovation). Pea has captured attention, but because it isn't a complete protein, it's often blended with plant-based proteins including soy (foodbusinessnews.net/articles/13460-plant-protein-is-growing-in-beverage-applications).

With respect to plant-dairy blends, pea protein has been a popular plant-based ingredient in these products. If blending soy and dairy, then products may need undergo additional

processing steps or use different ingredients. For example, in a fermented soy-dairy blend, the soy ingredient would need acid tolerance. A dairy-plant blend may appeal to flexitarians who continue to consume animal proteins but like incorporating more plant-based proteins into their diets. Roughly one-quarter of Americans consume dairy milk and plant-based alternatives, so a few manufacturers have tried formulating products that offer both dairy and plant proteins in one SKU. Examples include Dairy Farmers of America and Premier Nutrition Company (foodbusinessnews.net/articles/17387-protein-blends-creating-new-beverage-opportunities).

The firms in Exhibit 4.6.6.3 with a Missouri presence may have interest in using soy protein in functional beverage applications. Note, Soylent appears to not disclose the city where its manufacturing facility is located (lamag.com/lafood/soylent-moving-to-arts-district). The brand has also partnered with the United Soybean Board to place a "Sustainably Grown U.S. Soy" logo on its products as part of a pilot program (foodnavigator-usa.com/Article/2021/01/28/Soylent-first-to-test-Sustainably-Grown-US-Soy-mark-Companies-should-not-fear-alignment-with-a-GMO-crop-says-soybean-board).

Exhibit 4.6.6.3. Beverage manufacturers with locations in Missouri

Firm	Products	Location	Website
Bellring Blends	Premier Protein drinks	St. Louis, Missouri	bellring.com
IFF Nutrition and Biosciences	Soy protein isolate for beverages	St. Louis, Missouri	dupontnutritionandbiosciences.com
Jasper Products	Sports nutrition beverages	Joplin, Missouri	heritage-foods.com/jasper
Refresco	Fruit juice, hot-filled beverages	Joplin, Missouri	refresco.com
Soylent	Complete Meal, Complete Protein, Complete Energy drinks	Missouri*	soylent.com

* City in Missouri not known

4.6.7 Supplements

The Council for Responsible Nutrition annually surveys consumers about their dietary supplement use. Data from the 2019 survey suggest that roughly one-quarter of supplement users that year chose protein supplements, according to reporting from the Institute of Food Technologists. More than 40% of protein supplement consumers said they used plant protein options. Men were slightly more likely than women to take protein supplements — 30% and 24%, respectively. In terms of age, protein supplement use was most common among 18- to 24-year-olds (ift.org/news-and-publications/food-technology-magazine/issues/2020/april/features/the-top-10-functional-food-trends).

Several types of supplements incorporate protein as an ingredient. SPINS, a market researcher, tracked protein supplement sales for the year ending Nov. 29, 2020. Exhibit 4.6.30 presents sales for the bestselling U.S. protein product categories in the mainstream supplements channel, which represents grocery stores, drug stores, Walmart locations,

mass retailers, dollar stores, military commissaries and club stores (cdn.sanity.io/files/0vv8moc6/nutrioutlook/bbffd7b86714d9459658ad2376cc2cbb6fb640a5.pdf/NO2101_issue.pdf).

Sales of animal-plant protein combinations topped sales of other proteins. Plus, animal-plant protein combinations ranked as the overall top bestselling ingredient in the conventional multioutlet channel. See Exhibit 4.6.7.1. Of the four protein categories that ranked in the bestselling list for the conventional multioutlet channel, all but one — protein, animal-multi — recorded sales growth in the year ending on Nov. 29, 2020. By health condition, energy support and weight management products sold in the conventional multioutlet channel tended to incorporate protein. In the energy support category, common ingredients included animal protein and animal and plant protein combinations. Weight management products included a variety of animal proteins; plus, animal and plant protein combinations ranked third in terms of ingredient sales for weight management supplements (cdn.sanity.io/files/0vv8moc6/nutrioutlook/bbffd7b86714d9459658ad2376cc2cbb6fb640a5.pdf/NO2101_issue.pdf)

Plant-based protein alone did not rank as one of the 25 bestselling ingredients in the conventional multioutlet channel. Of the ingredients incorporated in brain health products, plant-based protein was the only protein source to rank in the top 10 for ingredient sales (cdn.sanity.io/files/0vv8moc6/nutrioutlook/bbffd7b86714d9459658ad2376cc2cbb6fb640a5.pdf/NO2101_issue.pdf).

Exhibit 4.6.7.1. Bestselling protein ingredients sold in dietary supplements, conventional multioutlet channel for year ending Nov. 29, 2020

	Sales	Sales change
Protein, animal and plant combo	$1.47 billion	3.4%
Protein, animal-multi	$759 million	(4.0%)
Protein, animal-general	$482.6 million	9.4%
Protein, animal-whey	$269 million	4.0%

Source: SPINS via Nutritional Outlook (cdn.sanity.io/files/0vv8moc6/nutrioutlook/bbffd7b86714d9459658ad2376cc2cbb6fb640a5.pdf/NO2101_issue.pdf)

Protein sales in the natural channel, which represents sales made at natural supermarkets except Whole Foods Market and Trader Joe's, skewed more toward plant-based products. Exhibit 4.6.7.2 reports that "protein, plant-multi" ingredient sales exceeded $65.5 million in the year ending Nov. 29, 2020. Overall, this category ranked second in the list of bestselling ingredients in the natural channel. However, sales did drop by 5.5% compared with the previous year. "Protein, animal-whey" also ranked in the top 25 list. Its sales declined even more substantially — 14.7% sales reduction in the natural channel (cdn.sanity.io/files/0vv8moc6/nutrioutlook/bbffd7b86714d9459658ad2376cc2cbb6fb640a5.pdf/NO2101_issue.pdf).

Of the health conditions targeted by supplements sold in the natural channel, energy support products tended to use plant-based protein most. Plant-based product ranked as the top ingredient in energy support products sold in the natural channel

(cdn.sanity.io/files/0vv8moc6/nutrioutlook/bbffd7b86714d9459658ad2376cc2cbb6fb640a5.pdf/NO2101_issue.pdf).

Exhibit 4.6.7.2. Bestselling protein ingredients sold in dietary supplements, conventional multioutlet channel for year ending Nov. 29, 2020

	Sales	Sales change
Protein, plant-multi	$65.5 million	(5.5%)
Protein, animal-whey	$17.4 million	(14.7%)

Source: SPINS via Nutritional Outlook (cdn.sanity.io/files/0vv8moc6/nutrioutlook/bbffd7b86714d9459658ad2376cc2cbb6fb640a5.pdf/NO2101_issue.pdf)

The firms in Exhibit 4.6.7.3 have a Missouri presence and may have interest in using soy protein in supplement applications:

Exhibit 4.6.7.3. Supplement manufacturers with locations in Missouri

Firm	Products	Location	Website
Bellring Blends	Dynamtize sports nutrition	St. Louis, Missouri	bellring.com
Osage Food Products	Plant-based protein for food and nutritional supplements	Washington, Missouri	osagefood.com
Syntrax	Protein powder, dietary supplement	Cape Girardeau, Missouri	si03.com

5. Alternative soybean food product opportunities

The companies in Exhibit 5.1 have a Missouri presence and produce soy products not covered in the previous section, or they produce intermediate soy products that would undergo further processing into final goods. These firms may have interest in sourcing Missouri-grown soybeans to use in their products.

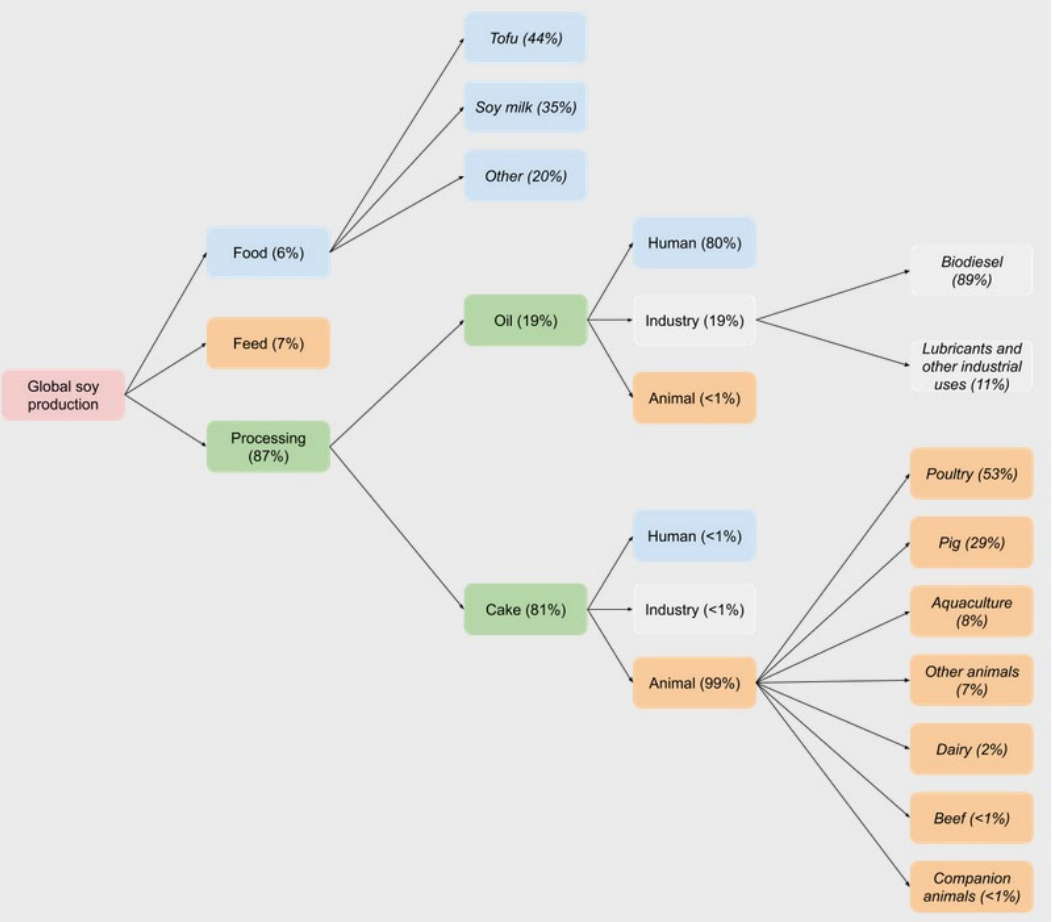
Exhibit 5.1. Other soy product manufacturers

Firm	Products	Location	Website
Tiger Soy	Soy flour	Mexico, Missouri	tigersoyllc.com
Yibo Inc.	Soy sauce	Warrenton, Missouri	yiboinc.com

6. Soybean use projections in food

In a 2020 publication, the Food Climate Research Network used data from the USDA and United Soybean Board to estimate how global soybean production was allocated to various uses. The flowchart in Exhibit 6.1 summarizes these estimates. Globally, soybeans largely undergo further processing into oil and meal. Feed captures 7% of global soybean production. An estimated 6% of the soybeans produced globally have food uses (tabledebates.org/building-blocks/soy-food-feed-and-land-use-change#SOYBB2).

Exhibit 6.1. Global soybean use estimates



Source: Food Climate Research Network using data from USDA (data in plain text from 2018-19) and United Soybean Board (data in italics from 2017-18) (tabledebates.org/building-blocks/soy-food-feed-and-land-use-change#SOYBB2)

Whole food uses

Within the food use category, tofu and soy milk represent the most common whole soy food uses. According to the Food Climate Research Network reporting, of the 6% of global soybean production directed to these uses, tofu consumes 44% of the food-use soybeans. Soy milk requires about one-third of the food-use soybeans. The other category may include uses such as tempeh and natto.

Within this food category, tofu possibly has the greatest chance to drive future soybean demand. During the pandemic, tofu sales improved — perhaps because supply chain constraints encouraged consumers to consider different protein sources and some consumers experimented with trying new foods at home.

To project how tofu demand changes would shape overall soybean demand, Exhibit 6.2 presents rough estimates for how 5%, 10% and 20% growth in tofu volume sales would change U.S. soybean demand in bushels and acres. Missouri could participate in capturing some of this added demand. As noted, a 5% increase in tofu demand would add 5.6 million bushels of soybean demand and require about 116,000 more acres. If tofu demand increases to a greater extent at 20%, then soybean demand would grow by an estimated 22.2 million bushels or nearly 463,000 acres. Note, any increase in tofu production would also increase okara production by roughly the same amount. Okara would need to find valuable uses — section 4.4 details more about okara market opportunities — or otherwise be discarded.

Exhibit 6.2. Tofu sales growth scenarios and effect on soybean demand*

Sales growth	Bushels	Acres
5% increase	5,555,411	115,738
10% increase	11,110,823	231,475
15% increase	16,666,234	347,213
20% increase	22,221,646	462,951

* Estimates assume 6% of soybean production used for food, 44% of the food-use soybeans are used to make tofu, 0.4 pounds of dried soybeans make 1 pound of tofu, baseline U.S. soybean production totals 126,259,350 tons (2017-21 average), U.S. soybean yields average 49.94 bushels per acre (2017-21 average); note, these estimates assume that U.S. soybean use is similar to global soybean use

<u>Oil uses</u>

Globally, 87% of soybeans undergo processing into oil and meal. Of the oil generated, roughly 80% finds use in human food. As noted earlier, soybean oil consumption has declined in recent years. Data from the United Soybean Board's Market View Database suggests that soybean oil use for food applications declined by more than 1.5 million metric tons from the early 2000s to 2019. Driving the decline was concerns about partial hydrogenation, a process that would give soybean oil the stability it needs for high-heat, long shelf-life applications. Despite adding functionality to the oil, partial hydrogenation also created trans fats. Some buyers who used partially hydrogenated soybean oil as a baking or frying fat or margarine ingredient transitioned to alternatives other than soybean oil.

High-oleic soybean oil's fatty acid profile offers natural stability. Therefore, the oil doesn't require partial hydrogenation, and it has the potential to regain some of the oil demand lost in recent years. Exhibit 6.3 illustrates how many more soybean bushels and acres the U.S. would require to satisfy several scenarios of regained soybean oil demand. If soybean oil demand for food use were to improve by 250,000 metric tons, then U.S. soybean production would need to expand by 1 million acres — assuming no change in other supply and demand factors. If soybean oil demand were to improve by 1 million metric tons, then the U.S. would need an additional 4 million soybean acres.

Exhibit 6.3. Soybean oil growth and effect on soybean demand*

Oil use growth (metric tons)	Bushels	Acres
250,000	50,090,909	1,003,022
500,000	100,181,818	2,006,044
750,000	150,272,727	3,009,065
1,000,000	200,363,636	4,012,087

* Assumes 11 pounds of oil per bushel and U.S. soybean yields average 49.94 bushels per acre (2017-21 average)

Meal uses

Of the soybean meal produced globally, most is used for animal feed — predominantly in poultry and pig rations, according to the data reported by the Food Climate Research Network. Less than 1% of the soybean meal produced has had human food applications.

If high-oleic soybean oil regains market share in the food use space, then the U.S. will have significantly more soy protein to use in applications, including food. Exhibit 6.4 summarizes the amount of soy flour, soy protein concentrate or soy protein isolate generated from processing soybeans to yield the amount of oil outlined in Exhibit 6.3's scenarios.

Exhibit 6.4. Soy protein produced in four scenarios stemming from increased oil demand*

Bushels	Soy flour	Soy protein concentrate	Soy protein isolate
50,090,909	1,953,545,455	1,001,818,182	591,072,727
100,181,818	3,907,090,909	2,003,636,364	1,182,145,455
150,272,727	5,860,636,364	3,005,454,545	1,773,218,182
200,363,636	7,814,181,818	4,007,272,727	2,364,290,909

* Assumes 39 pounds of soy flour per bushel, 20 pounds of soy protein concentrate per bushel or 11.8 pounds of soy protein isolate per bushel

The plant-based meat category represents one potential market to use soy protein supplies. In 2021, the Good Food Institute released a report meant to gauge the potential for plant-based meat consumption to grow through 2030. By 2030, the Food and Agriculture Organization of the United Nations projects that worldwide meat demand — on a retail weight basis — will total 398 million metric tons. The Good Food Institute predicts plant-based meat will capture a 6% market share. Thus, to satisfy worldwide demand in 2030, manufacturers must produce an estimated 25 million metric tons of plant-based meat (gfi.org/resource/anticipating-plant-based-meat-production-requirements-2030).

In its report, the Good Food Institute assumes 62% of plant-based meat products will have a wheat-soy formulation that blends soy protein concentrate and wheat gluten as major ingredients. It projects soy-based meat alternative products — those that include soy protein concentrate, coconut oil and sunflower oil as major ingredients and soy protein isolate as a minor ingredient — to represent 14% of the plant-based meat produced in 2030. Given these projections and estimates about how much soy these formulas would include, the Good Food Institute shared the ingredient demand estimates in Exhibit 6.5. To meet these projected demands, the institute estimates that 2% of soybean production would be needed

for plant-based alternatives (gfi.org/resource/anticipating-plant-based-meat-production-requirements-2030).

Exhibit 6.5. Estimated soy protein ingredient demand for plant-based meat, 2030

	Projected demand (million metric tons)
Soy protein concentrate	2.43
Soy protein isolate	0.01

Source: Good Food Institute (gfi.org/resource/anticipating-plant-based-meat-production-requirements-2030)

To further illustrate the need, the institute projects this 2030 demand would require three times the globe's projected soy protein concentrate supply. Therefore, the industry would need to invest in more intermediary product processing capacity that could prepare that much concentrate ingredient. To meet plant-based meat demand, the institute estimates the industry would use 1% of the world's soy protein isolate (gfi.org/resource/anticipating-plant-based-meat-production-requirements-2030).

7. Recommendations

Based on the food market research conducted for this project, Exhibit 7.1 identifies strengths, weaknesses, opportunities and threats related to expanding Missouri food manufacturers' use of Missouri-produced soybean ingredients.

Exhibit 7.1. SWOT analysis for Missouri soybean industry increasing in-state use of soybean-derived food ingredients

Strengths	Weaknesses
• Several industries with the potential to use soy ingredients concentrate in Missouri, based on jobs data. Those include breakfast manufacturing; pasta, dough and flour mixes; ice cream and frozen dessert manufacturing; fats and oils refining and blending; and flour milling. • Soyleic oil allows high-oleic oil users to make non-GMO claims on packaged goods. • Soy protein derived from Soyleic soybeans has some advantages relative to commodity soy protein. Those include desirable color, blending potential and shelf life. • With widespread production, soybean ingredients represent an economical ingredient option.	• The premium associated with Soyleic non-GMO soybean oil may make the ingredient cost-prohibitive for some food companies. • Unlike in other states, Missouri firms have made minimal investments in processing capacity to produce whole soy foods (e.g., soy milk, tofu). • Protein products made from soy may have consumer acceptance problems because of the ingredient's allergen risk and flavor.
Opportunities	**Threats**
• Soyleic's non-GMO attribute especially appeals to consumers purchasing food to eat at home — a category that grew during the pandemic. • Supply chain constraints caused by the pandemic led some consumers to choose products, such as tofu, they hadn't used consistently. Those buyers may be maintained in the long term. • MSMC-funded research into fortifying soy foods with vitamin B12 has the potential to make a plant-based product fortification standard — just as dairy milk is typically fortified with vitamin D. • The Show-Me Food, Beverage and Forest Products Manufacturing Initiative may recruit more processors that could use Missouri-produced soy. • The St. Louis region has been identified as a hub for plant-based food manufacturing. • Blending soy with other proteins may improve the "completeness" of those other proteins while balancing some of soy's drawbacks, such as flavor.	• Soy ingredients face competitive threats from alternative ingredients. For example, in the alternative milk category, soy milk has lost significant share to almond and oat options. • Because plant-based product manufacturers are relatively new, they may be more open to choosing novel ingredients and scaling their supply chains over time to provide enough of those novel ingredients. • Although an opportunity, plant-based foods (e.g., meat alternatives) may be perceived as highly processed compared with traditional alternatives (e.g., animal meat). Consumers interested in minimal ingredients may choose not to switch to plant-based options.

To increase Missouri soybean demand for food applications, Exhibit 7.2 reports multiple recommendations and organizes those recommendations by ingredient — oil and protein — that food manufacturers may use in their formulations.

Exhibit 7.2. Recommendations to increase soybean demand by soy ingredient

Product	Category	Recommendations
Oil	Goal	• Open new in-state markets for Soyleic non-GMO, high-oleic soybean oil. • Increase sales of Missouri-grown soybean oil to Missouri food manufacturers.
	Strategies	• Educate Missouri food businesses about the advantages of Soyleic oil. • Engage an industry liaison or third-party business to champion Missouri-produced soybean oil as an ingredient option. • Introduce soybean oil to emerging food businesses.
	Tactics	• Invest in Soyleic use trials that demonstrate fry life or shelf life improvements attributed to the high-oleic trait. • Contact Missouri manufacturers in key categories that may use soybean oil. (This report lists Missouri manufacturers by product category.) • Communicate with foodservice establishments (e.g., restaurants) based in Missouri to identify potential markets for soybean oil. • Reach out to Bright Future Foods, a St. Louis food incubator that operates as a subsidiary of Post Holdings. The incubator has invested in two climate-friendly food brands: Airly Oat Clouds and EverGrain. • Build awareness of soy ingredient applications through the Missouri Food Entrepreneur Network (MO-FEN). • Support value chain stakeholders such as Tiger Soy, Moberly Natural Crush and Benson Hill as they grow and add value to Missouri-produced soybeans.
Protein	Goals	• Open new in-state markets for Soyleic soy protein. • Increase sales of Missouri-grown soy protein to Missouri food manufacturers.
	Strategies	• Educate Missouri food businesses about Soyleic soy protein's advantages. • Engage an industry liaison to build relationships with Missouri food manufacturers. • Participate in industry conversations to raise soy protein's profile as a food ingredient.
	Tactics	• Aggregate research findings that show how Soyleic protein's attributes (e.g., color, blending potential, shelf life) offer advantages. • Package those findings into promotional materials. • Contact Missouri firms that manufacture foods that list soy protein as an ingredient. (This report lists Missouri manufacturers by product category.) • Reach out to Bright Future Foods, a St. Louis food incubator that operates as a subsidiary of Post Holdings. The incubator has invested in two climate-friendly food brands: Airly Oat Clouds and EverGrain. • Build awareness of soy protein applications through the Missouri Food Entrepreneur Network (MO-FEN). • Assess whether to support the University of Minnesota's Plant Protein Innovation Center or replicate the effort with Midwest soy centers at the University of Missouri, Purdue University and Iowa State University. • Collaborate with soybean checkoff organizations in neighboring states to create a program modeled after the Plant Protein Highway formed in the Upper Midwest and Canada. • Support value chain stakeholders such as Tiger Soy, Moberly Natural Crush and Benson Hill as they grow and add value to Missouri-produced soybeans.w

Growing Missouri Soybean Demand: Industrial Product Manufacturing

Commissioned by the Missouri Soybean Merchandising Council

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Missouri Soybeans

Extension
University of Missouri

MASBDA
Missouri Agricultural and Small Business Development Authority

Growing Missouri Soybean Demand: Industrial Product Manufacturing

This report explores opportunities to supply soybean components to Missouri industrial products manufacturers. Soy-based raw materials have multiple potential industrial applications, including fuels, adhesives, coatings, fibers, lubricants and plastics. The report emphasizes market opportunities for several Missouri Soybean Merchandising Council-funded technologies, and it lists nearby firms that may have interest in adopting them.

The report also discusses other alternative soybean industrial product opportunities that could influence Missouri soybean demand, and it shares ideas for how to reach Missouri buyers who could use these technologies.

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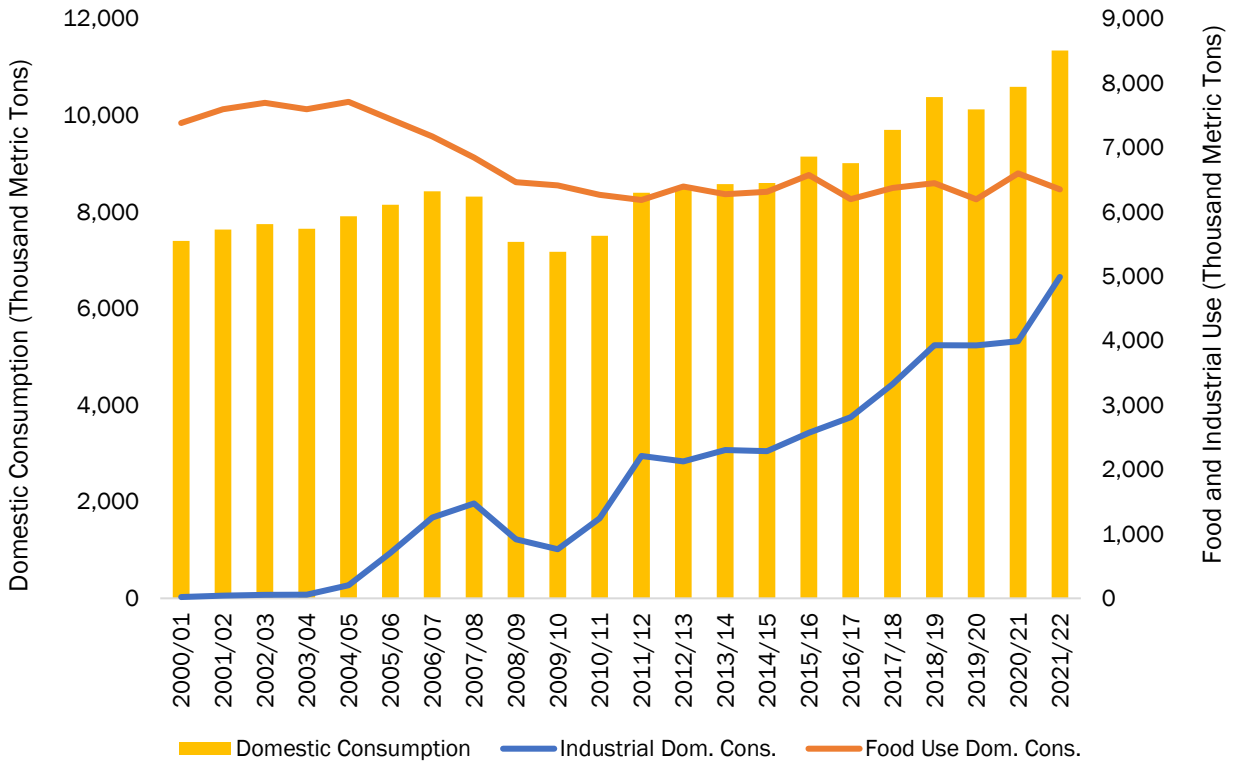
Contents

1. Summary

Industrial products have the potential to demand soybean components — oil, meal and hulls — as inputs. The USDA Foreign Agricultural Service tracks domestic soybean oil consumption over time. From 2000/01 to 2021/22, industrial soybean oil use increased substantially. See Exhibit 1.1. Industrial applications demanded 44% of all soybean oil consumed in the U.S. during 2021/22 (apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery).

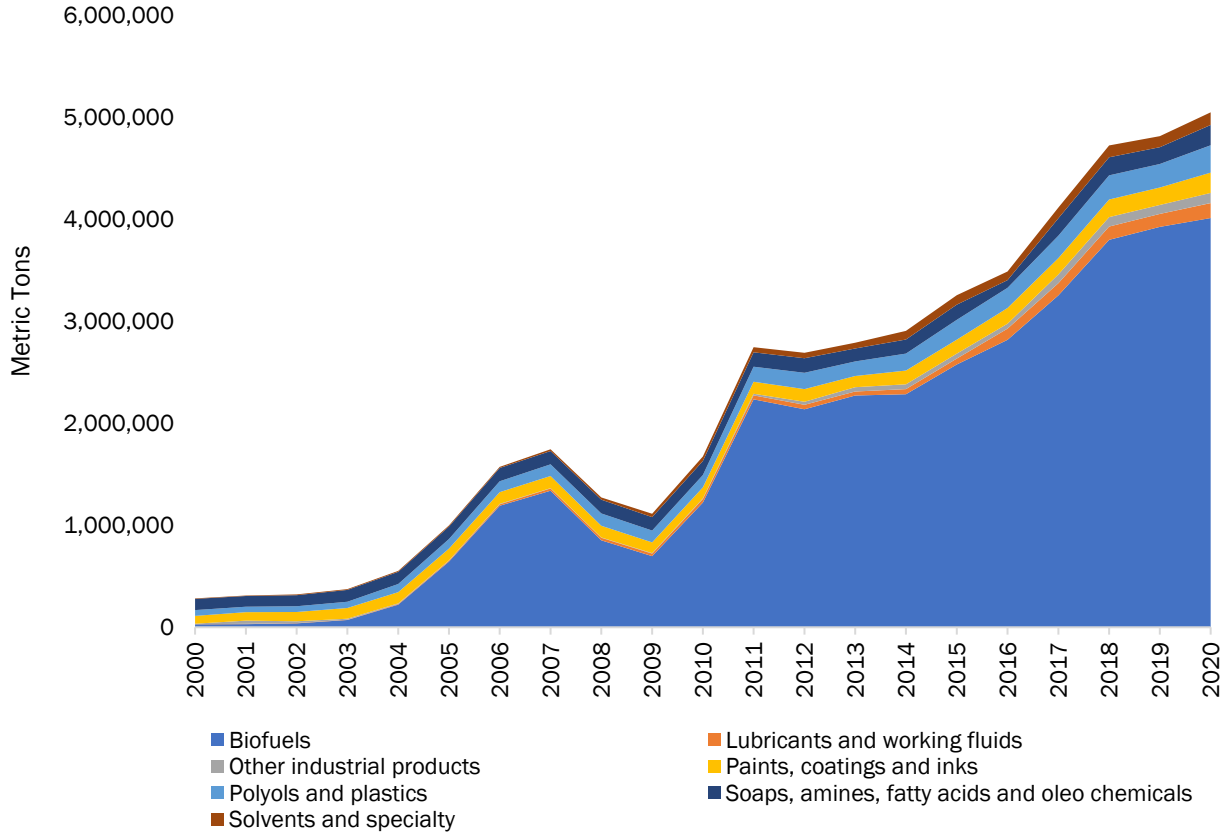
Exhibit 1.1. U.S. domestic soybean oil use, 2000/01 to 2021/22



Source: USDA Foreign Agricultural Service Production, Supply and Distribution (apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery)

In the past 20 years, biofuel producers have used more soybean oil for industrial purposes than other industrial products manufacturers, according to Centrec and the United Soybean Board. Exhibit 1.2 reports industrial soybean oil consumption data from 2000 to 2020. In 2020, 79% of all soybean oil used to make industrial products was directed to biofuel production. Polyols and plastics ranked second for the amount of soybean oil these uses demanded (marketviewdb.centrec.com).

Exhibit 1.2. U.S. soybean oil industrial use by category, 2000 to 2020



Source: Centrec and the United Soybean Board (marketviewdb.centrec.com)

Understanding the state's industrial manufacturing activity may uncover new opportunities to develop soy-based inputs that these manufacturers can use in their products. A location quotient conveys the extent to which an industry concentrates in a particular geography compared with the U.S. overall based on number of jobs supported. A location quotient greater than 1.0 indicates a state or region depends more on a particular industry for jobs than the U.S. does overall. In Missouri, four types of industrial manufacturing had location quotients that exceeded 2.0 in 2020, based on data available from Emsi: *storage battery manufacturing*; *power, distribution and specialty transformer manufacturing*; *explosives manufacturing*; and *unlaminated plastics film and sheet, except packaging, manufacturing*. Industries with a location quotient between 1.0 and 2.0 were *sporting and athletic goods manufacturing*, *all other miscellaneous chemical product and preparation manufacturing* and *all other basic organic chemical manufacturing*.

The Missouri Soybean Merchandising Council has invested in several technologies that may open new markets for using soybeans in Missouri-produced industrial products. Exhibit 1.3 summarizes the various end markets where these innovations have market potential and the trends shaping these markets.

Exhibit 1.3. Opportunities to expand soy demand to make industrial products

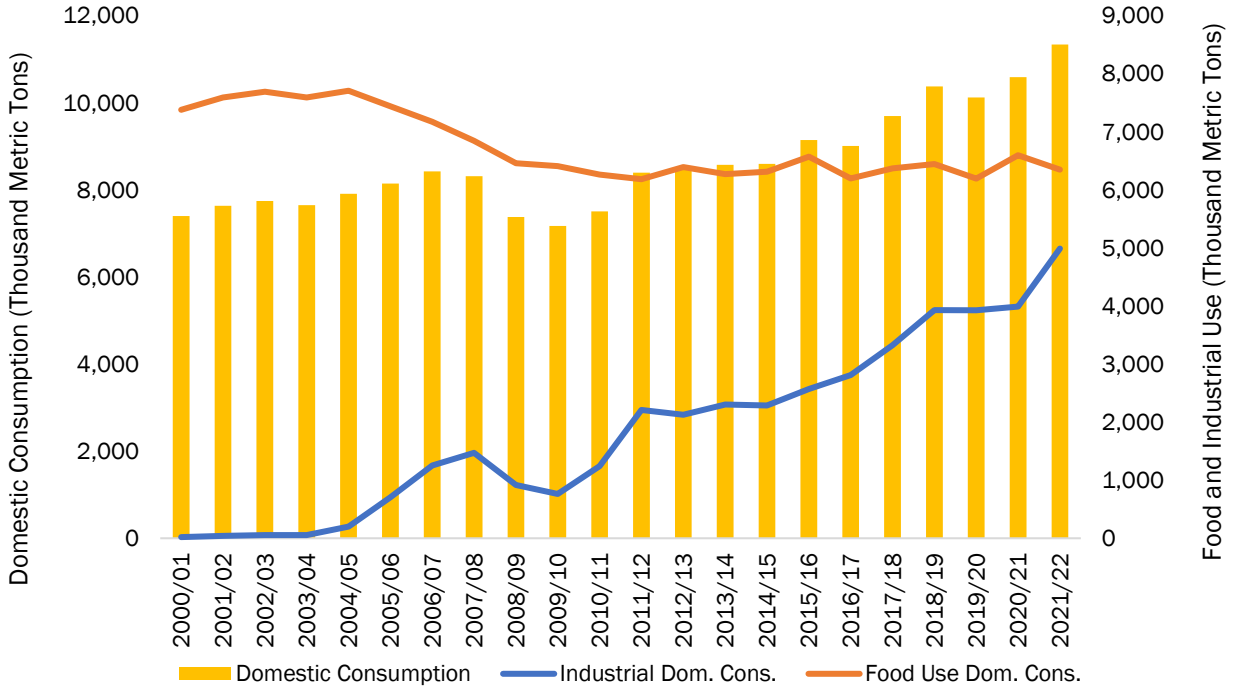
Sector	Discussion
Batteries	Soy carbon may be used in batteries that would compete with lithium-ion options. Lithium-ion batteries have become less expensive over time, so new technologies must compete at a similar cost or yield more value. Manufacturing capacity for lithium-ion batteries has concentrated, and the U.S. has had a limited presence. Lithium-ion battery demand for ***electric vehicles*** and ***energy storage*** is projected to increase significantly in the next decade. U.S. consumers have stated more hesitancy about adopting battery-powered vehicles than consumers in other counties. Stationary storage at large-scale battery sites predominantly provides frequency regulation and system peak shaving benefits to the power grid. Stationary storage also refers to industrial used to power forklifts, data centers and telecom backups. Looking forward, more battery capacity is expected to co-locate with other generation facilities — namely, solar facilities adding battery storage capacity.
Explosives	Soybean oil biodiesel may serve as an alternative fuel source in mining explosives. In the U.S., more than half of the blasting agents and oxidizers — explosives that use ammonium nitrate-fuel oil — sold in recent years have been used for ***coal mining***. Coal mining's share has declined, however, the share for ***construction work*** has increased. Looking forward, the U.S. Energy Information Administration projects U.S. coal production will grow slightly through 2023 — suggesting that this category may at least hold its explosives demand. Construction firms, which use explosives to form tunnels and destroy old infrastructure, may represent a long-term market for explosives as federal infrastructure investments get underway to improve roads, bridges, airports, waterways and public transit.
Polyurethanes	Created from a polyol and isocyanate, polyurethanes take multiple formats — ranging from foams to coatings to binders to sealants — depending on the production method used. Each format offers specific characteristics that make it well-suited for certain applications. Multiple markets demand polyurethanes. During 2018, however, three drove more than three-quarters of U.S. polyurethane production: ***building and construction***, ***transportation and marine*** and ***furniture and bedding***.
Fuel	Soybean oil represents an important feedstock for the U.S. biodiesel industry. Used in blends with petroleum diesel, ***biodiesel*** may represent as much as 20% of those blends. Unlike biodiesel, ***renewable diesel*** may completely replace petroleum diesel, or it may be added to blends. If all announced renewable diesel capacity were built and soybean oil serves as the sole feedstock, then renewable diesel manufacturers could utilize approximately 85 million acres of soybeans. Made from sustainable feedstocks, ***sustainable aviation fuel*** can represent up to half of a jet fuel blend. Airlines and airports have entertained options such as sustainable aviation fuel as they seek to meet sustainability and environmental goals or mandates.
Road care	Several road care innovations have used soybean oil as an input. Made from soybean oil and glycerin, ***EPIC EL*** suppresses dust on gravel roads, construction sites and wind farms. ***PoreShield*** treats concrete to help the treated surface resist breakdown. It's made from soy methyl ester-polystyrene. When applied to asphalt, ***RePlay*** prevents asphalt oxidation and erosion, and it uses agricultural oil as an input. Missouri is home to several professional organizations of engineers and roadway surface managers. Reaching those organizations would provide direct access to road care product decision makers.
Other uses	Multiple Missouri industrial products manufacturers create products using soy-based inputs. For example, ***Express Chem***, a mastic remover manufacturer, uses soybean-oil derived methyl ester in its products, which can remove mastic adhesives such as black mastic and yellow carpet glue. ***Soya System*** hair care products features hydrolyzed soy protein in three of its shampoo products and one conditioner product. Other soy-based products developed outside of Missouri that have use potential in Missouri include ***Roof Maxx*** shingle rejuvenator and ***SYNlawn*** artificial turf.

2. Soybean use in industrial products manufacturing

Industrial product applications have the potential to demand soybean components — oil, meal and hulls — as inputs. This section details soybean oil use in industrial products. No data are available to indicate soybean meal or soybean hull use in industrial products.

The USDA Foreign Agricultural Service's Production, Supply and Distribution database tracks domestic soybean oil consumption over time. Exhibit 2.1 shares the domestic consumption trend. Plus, it breaks down total consumption into industrial and food uses. During the observed period — 2000/01 to 2021/22 — industrial soybean oil consumption increased substantially. It totaled 20,000 metric tons in 2000/01 but grew to 4.99 million metric tons by 2021/22. Industrial applications demanded 44% of all domestic soybean oil consumed in 2021/22 (apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery).

Exhibit 2.1. U.S. domestic soybean oil use, 2000/01 to 2021/22

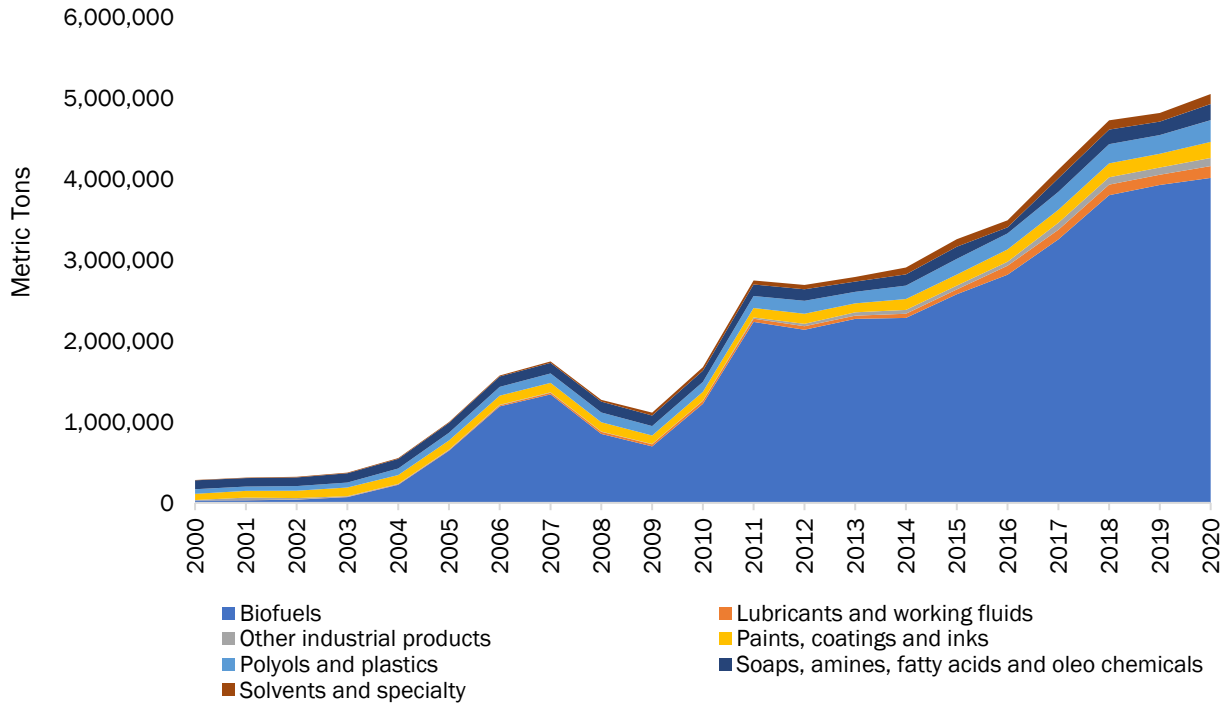


Source: USDA Foreign Agricultural Service Production, Supply and Distribution (apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery)

Centrec and the United Soybean Board have quantified how industrial soybean oil use has varied over time by product category. See Exhibit 2.2 for data from 2000 to 2020. During this time, biofuels consumed more soybean oil than other industrial products, and polyols and plastics ranked second for the amount of soybean oil demanded. Of all application categories, the biofuels category[1] most grew its soybean oil consumption during the 20-year period. The following two categories also recorded significant growth in soybean oil used: lubricants and working fluids and solvents and specialty uses (marketviewdb.centrec.com).

[1] Could include soybean oil use in biodiesel and renewable diesel.

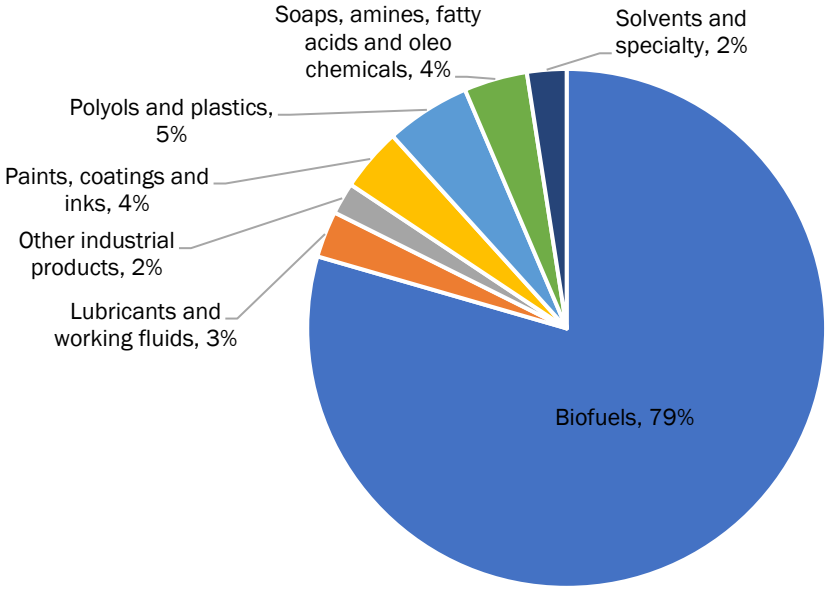
Exhibit 2.2. U.S. soybean oil industrial use by category, 2000 to 2020



Source: Centrec and the United Soybean Board (marketviewdb.centrec.com)

Of all soybean oil directed to industrial uses, Exhibit 2.3 describes the percentage used in varying industrial products during 2020. Of the soybean oil used to make industrial products, 80% found use in biodiesel. Other categories captured relatively minor shares of total soybean oil used for industrial purposes

Exhibit 2.3. Share of U.S. soybean oil industrial use by category, 2020



Source: Centrec and the United Soybean Board (marketviewdb.centrec.com)

3. Missouri industrial products manufacturing

Understanding the state's industrial manufacturing activity may uncover new opportunities to develop soy-based materials that these manufacturers can use in their products. That would ultimately drive in-state soybean demand.

The location quotient conveys the extent to which an industry concentrates in a particular geography compared with the U.S. overall based on number of jobs supported. A location quotient greater than 1.0 indicates a state or region depends more on a particular industry for jobs than the U.S. does overall.

Exhibit 3.1 lists four Missouri industries with location quotients that exceeded 2.0 in 2020, based on data available from Emsi. It also reports business location and jobs data for these industries. Of these four industries, *storage battery manufacturing* had the highest 2020 location quotient at 4.6. In 2019, 12 of these manufacturers operated in Missouri. Their employment exceeded 2,300 people in 2020 — a 24% increase compared with 2015. *Power, distribution and specialty transformer manufacturing* had a location quotient that topped 3.0 in 2020, but the 12 Missouri establishments operating in this industry recorded small job growth between 2015 and 2020. A smaller industry when measured by total jobs, *explosives manufacturing* had a 2020 location quotient that totaled 2.92, and its employment grew 6% between 2015 and 2020. Of these four industries, *unlaminated plastics film and sheet, except packaging, manufacturing* had the smallest 2020 location quotient, but it notably grew employment by 55% between 2015 and 2020.

Exhibit 3.1. Missouri industrial products manufacturing industries with location quotients that exceed 2.0, 2020

	2019 payrolled business locations	2020 jobs	% change in jobs, 2015-20	2020 location quotient
Storage battery manufacturing	12	2,330	24%	4.60
Power, distribution and specialty transformer manufacturing	12	1,646	2%	3.22
Explosives manufacturing	4	418	6%	2.92
Unlaminated plastics film and sheet, except packaging, manufacturing	19	1,601	55%	2.23

Source: Emsi

Exhibit 3.2 lists a different subset of Missouri's industrial products manufacturing industries. These industries had a 2020 location quotient between 1.0 and 2.0, and they employed at least 1,000 workers in 2020. Their location quotients suggest Missouri depends more on these industries for jobs than the U.S. overall. Of these three industries, *sporting and*

athletic goods manufacturing had the greater number of payrolled business locations in 2019, and it slightly beat *all other miscellaneous chemical product and preparation manufacturing* for employment growth between 2015 and 2020. Compared with these two industries, *all other basic organic chemical manufacturing* had a slightly greater 2020 location quotient and total number of jobs.

Exhibit 3.2. Missouri industrial products manufacturing industries with location quotients between 1.0 and 2.0 and employment totaling at least 1,000 workers, 2020

	2019 payrolled business locations	2020 jobs	% change in jobs, 2015-20	2020 location quotient
All other basic organic chemical manufacturing	22	1,524	6%	1.99
Sporting and athletic goods manufacturing	44	1,335	14%	1.49
All other miscellaneous chemical product and preparation manufacturing	33	1,109	13%	1.45

Source: Emsi

4. MSMC commercialization opportunities

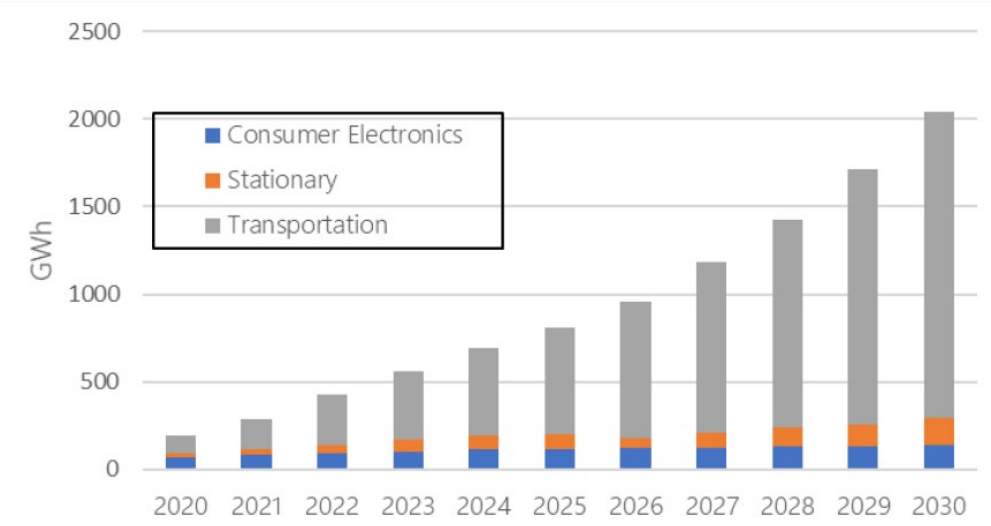
The Missouri Soybean Merchandising Council has financially supported research into several industrial products that would use soy components. The following discussion summarizes these technologies, the markets for them and the Missouri firms that may use these technologies in their businesses.

4.1 Batteries

MSMC-funded research has developed battery technology capable of competing in the lithium-ion batteries space. Lithium-ion batteries may power electric vehicles, stationary energy storage and consumer electronic devices (energy.gov/sites/default/files/2021-06/FCAB%20National%20Blueprint%20Lithium%20Batteries%200621_0.pdf). Alone, lithium-ion battery demand for electric vehicles and energy storage is projected to increase significantly in the next decade. Bloomberg estimates demand totaled 0.5 gigawatt-hours in 2020. By 2039, it projects demand to reach 9,300 gigawatt-hours (weforum.org/agenda/2021/09/batteries-lithium-ion-energy-storage-circular-economy).

Exhibit 4.1.1 details global projections related to lithium-ion battery deployment through 2030. As noted, the transportation sector is projected to have notable growth and represent the bulk of battery deployment through most of the projection period. By 2030, the size of the consumer electronics and stationary storage markets will be comparable, according to these projections. Of these two, the stationary storage market has the greatest growth potential in the next decade. These projections suggest roughly flat battery deployment for consumer electronics uses during the next decade (energy.gov/sites/prod/files/2020/12/f81/Energy%20Storage%20Market%20Report%202020_0.pdf).

Exhibit 4.1.1. Global projected lithium-ion battery deployment, 2020 to 2030



Source: Bloomberg New Energy Finance via U.S. Department of Energy (energy.gov/sites/prod/files/2020/12/f81/Energy%20Storage%20Market%20Report%202020_0.pdf)

MSMC Research Connection

Researchers at Pittsburg State University have studied how to use soy carbon components (e.g., hulls, meal, stover) in battery technologies that would compete with traditional lithium-ion batteries. The first phase of research focuses on introducing soy components as the battery's carbon source. Current carbon sources include graphene and carbon black. Soy-based carbons can serve as one-to-one replacements for carbon. A battery made with sulfur would have a longer life and use the same amount of materials compared with lithium-ion batteries.

On a lab scale, the cost to prepare soy carbon for battery applications may range from $3 to $4 per gram. Graphene costs on a lab scale may reach $200 per gram. Therefore, the soy carbon has a cost advantage. Production involving graphene uses chemicals. Soy carbon is environmentally friendly — no toxic chemicals involved. Graphene and soy carbon have similar properties. After testing under lab conditions for 10 years, batteries produced using soy carbon have performance that's similar to the batteries made with graphene. The batteries had stability after a 10-year period.

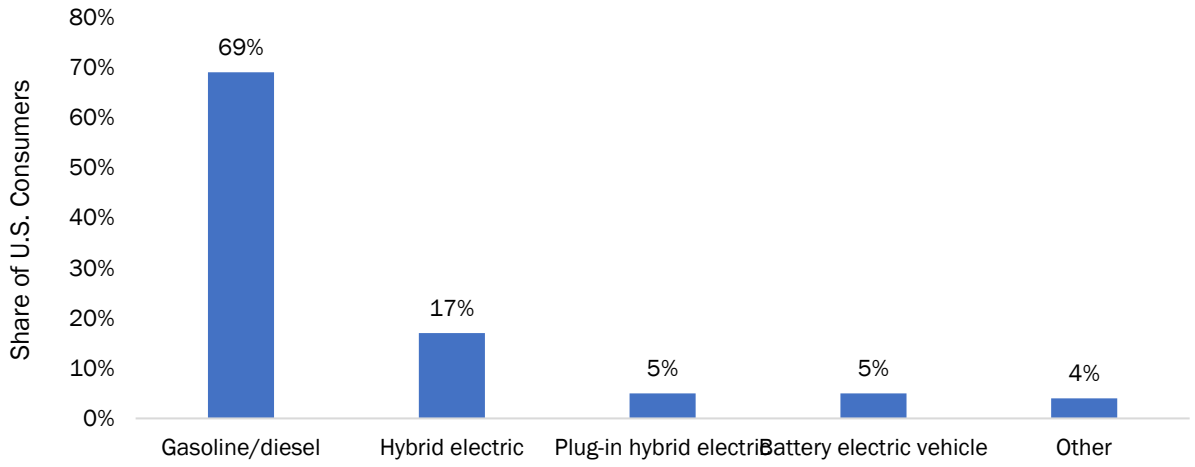
Electric vehicles

Despite Bloomberg projecting a significant increase in lithium-ion battery demand for vehicles and electric storage, U.S. consumers appear to have some hesitancy about purchasing battery-powered electric vehicles. Deloitte released an automotive consumer study in January 2022. The report details forward-looking consumer preferences for vehicles. Of the 918 U.S. respondents, just 5% said they'd prefer a battery electric vehicle when they next purchase a vehicle. See Exhibit 4.1.2. Roughly seven in 10 said they'd prefer a vehicle that uses gasoline or diesel. Fewer than one in five said they prefer to buy a hybrid electric vehicle next, and 5% selected plug-in hybrid electric vehicles as their next vehicle preference (www2.deloitte.com/content/dam/Deloitte/global/Documents/Consumer-Business/us-2022-global-automotive-consumer-study-global-focus-final.pdf).

Soybean Biowaste Production and Soil Health

To maintain organic matter levels in fields, recommendations point to leaving 2 tons of crop residue per acre. For each 30 bushels in soybean yield, the crop generates 1 ton of residue (cropwatch.unl.edu/2018/what-value-soybean-residue). Therefore, a soybean field's yield would need to top 60 bushels per acre before soil health best practices would recommend removing residue.

Exhibit 4.1.2. Powertrain preferences for U.S. consumers' next vehicle



Source: Deloitte (www2.deloitte.com/content/dam/Deloitte/global/Documents/Consumer-Business/us-2022-global-automotive-consumer-study-global-focus-final.pdf)

The U.S. Department of Energy reports that plug-in hybrid electric vehicles and all-electric vehicles generally operate on lithium-ion batteries (afdc.energy.gov/vehicles/electric_batteries.html). Hybrid vehicle manufacturers often choose between lithium-ion batteries and batteries made from nickel-metal hydride cells. A 2018 story from Green Car Reports described that hybrid vehicle brands at the time tended to choose lithium-ion batteries. However, Toyota hybrid vehicles could use lithium-ion batteries or nickel-metal hydride battery cells. The brand chooses a battery technology for a specific vehicle based on supply considerations and conditions where a vehicle may be used — for example, all-wheel drive vehicles would use a nickel-metal hydride battery technology because it better tolerates cold temperatures where all-wheel drive vehicles could be used (greencarreports.com/news/1120320_lithium-ion-vs-nickel-metal-hydride-toyota-still-likes-both-for-its-hybrids). Exhibit 4.1.3 estimates soy carbon demand for vehicle batteries.

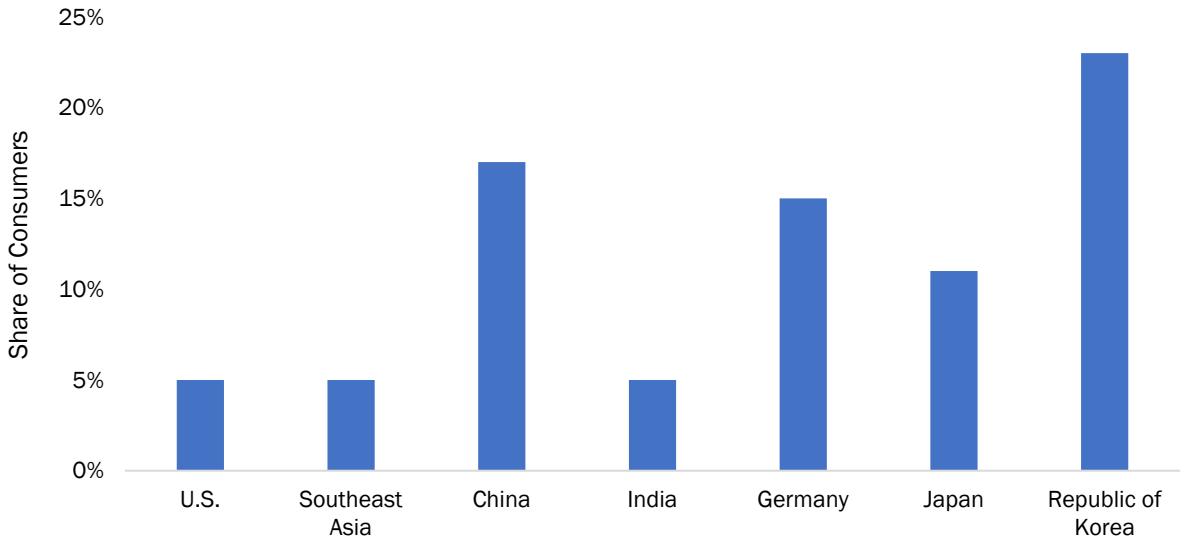
Exhibit 4.1.3. New electric vehicle demand for carbon in batteries

	Estimated annual sales (vehicle units)	Pounds of carbon potentially used in batteries	Acres needed if soy carbon replaces all carbon
Battery electric vehicles	489,321	75,513,680	23,598
Plug-in hybrid vehicles	489,321	10,787,669	3,371
Hybrid vehicles	924,273	20,376,707	6,368
Total	**1,902,915**	**106,678,056**	**33,337**

* Estimates assume the following: motor vehicle sales average units sold in past five years (U.S. Bureau of Transportation Statistics); vehicle preferences mirror data from Deloitte automotive study; 90% of battery electric vehicles use lithium-ion batteries, 90% of plug-in hybrid vehicles use lithium-ion batteries, 50% of hybrid electric vehicles use lithium-ion batteries; soy carbon replaces amount of graphite typical in battery – 70 kg in battery electric vehicle batteries, 10 kg in plug-in hybrid electric vehicle batteries and 10 kg in hybrid vehicle batteries; one-to-one replacement of graphite with soy carbon; soy carbon originates from soy field residue; average Missouri soybean acre generates 3,200 pounds of residue
Source: University of Missouri estimates

Compared with the U.S., some international markets have consumers more likely to prefer battery electric vehicles. Nearly one-fourth of consumers from the Republic of Korea and one-fifth of Chinese consumers said in the Deloitte research that they would prefer a battery electric vehicle as their next vehicle. Exhibit 4.1.4 summarizes the share of consumers in seven international markets who said they'd prefer a battery electric vehicle as their next vehicle (www2.deloitte.com/content/dam/Deloitte/global/Documents/Consumer-Business/us-2022-global-automotive-consumer-study-global-focus-final.pdf).

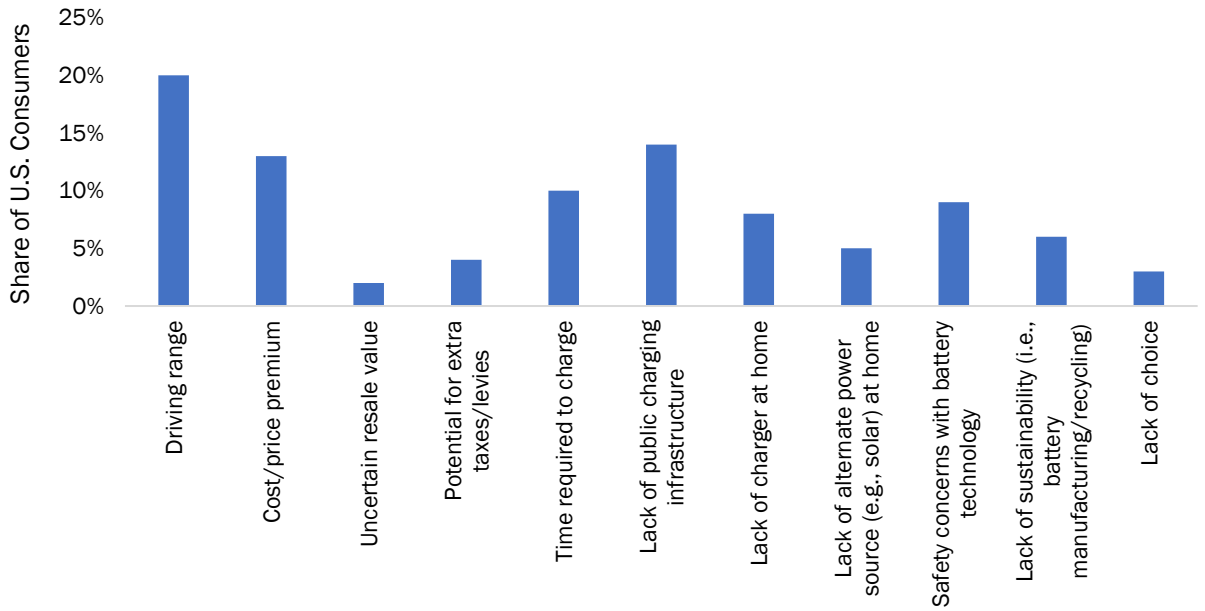
Exhibit 4.1.4. Consumers' powertrain preferences for next vehicle by market



Source: Deloitte (www2.deloitte.com/content/dam/Deloitte/global/Documents/Consumer-Business/us-2022-global-automotive-consumer-study-global-focus-final.pdf)

In terms of concerns about battery-powered electric vehicles, the U.S. consumers who Deloitte surveyed most frequently mentioned driving range as their greatest concern. On average, U.S. consumers said they expect a fully charged all-battery vehicle to have a 518-mile driving range. Consumers from the other surveyed countries said they expect driving range for an all-battery electric vehicle to range from 258 miles to 397 miles. Therefore, U.S. consumers have much higher expectations than consumers in the other studied countries. Among the U.S. consumers, their other top concerns associated with battery-powered vehicles — see Exhibit 4.1.5 — include the lack of public charging infrastructure and the vehicle cost (www2.deloitte.com/content/dam/Deloitte/global/Documents/Consumer-Business/us-2022-global-automotive-consumer-study-global-focus-final.pdf).

Exhibit 4.1.5. U.S. consumers' greatest concerns about all battery-powered electric vehicles



Source: Deloitte (www2.deloitte.com/content/dam/Deloitte/global/Documents/Consumer-Business/us-2022-global-automotive-consumer-study-global-focus-final.pdf)

Stationary storage

Two key stationary energy storage applications with growth potential are industrial and grid deployments. Industrial uses include energy storage for forklifts, data centers and telecom backups. Between 2018 and 2030, estimates suggest that energy storage for industrial applications will increase by 2.6 times to reach 167 GWh. Energy storage needs for forklifts will drive this category, according to projections. With respect to grid-related deployments, this category's growth potential exceeds that of industrial applications. Estimates suggest that the compound annual growth rate for grid applications will reach 27% through 2030 (energy.gov/sites/prod/files/2020/12/f81/Energy%20Storage%20Market%20Report%202020_0.pdf).

The U.S. had 163 operational large-scale battery storage systems at the end of 2019. The facility count grew by 28% from 2018 to 2019. These sites had 1,688 megawatt-hours in energy storage capacity. Power capacity — the most power these systems could supply to the grid at one point — summed to 1,022 megawatts, according to the U.S. Energy Information Administration. In addition to reporting historical data, the administration collects planning data to estimate how large-scale battery storage capacity may change in the future. Those projections suggest that the U.S. will add 10,000 megawatts of large-scale battery storage from 2021 to 2023 (eia.gov/analysis/studies/electricity/batterystorage).

Historically, pumped-storage hydropower served most stationary energy storage needs (energy.gov/sites/prod/files/2020/12/f81/Energy%20Storage%20Market%20Report%202020_0.pdf). At these large-scale battery storage sites, however, lithium-ion batteries have been the preferred technology since 2011. Exhibit 4.1.6 details the share of large-scale battery storage power and energy capacity stemming from various battery technologies. Note, some systems installed before 2011 have since been retrofitted to use lithium-ion

batteries. The most common power capacity application provided by large-scale U.S. battery storage installations in 2019 was frequency regulation. The top two applications served by these installations' energy capacity in 2019 were frequency regulation and system peak shaving. Frequency regulation means these systems balance supply and demand for electricity. System peak shaving refers to how the power grid can forgo constructing or buying generation capacity, particularly when demand peaks (eia.gov/analysis/studies/electricity/batterystorage).

Exhibit 4.1.6. Battery technologies used at U.S. large-scale battery storage sites

	Power capacity (megawatts)	Energy capacity (megawatt-hours)
Lithium-ion	92%	93%
Nickel-based	4%	1%
Sodium-based	2%	4%
Flow	1%	1%
Other	1%	1%

Source: U.S. Energy Information Administration (eia.gov/analysis/studies/electricity/batterystorage)

In the U.S., independent power producers owned 56% of large-scale battery storage power capacity, and 20% had ownership trace back to independent system operators. Of the energy capacity at large-scale battery storage systems, 38% and 36% was owned by independent power producers and independent system operators, respectively (eia.gov/analysis/studies/electricity/batterystorage).

The U.S. has also installed some small-scale battery storage. Commercial, residential and industrial properties use these small-scale energy storage systems. Of the 402 megawatts in small-scale power capacity available in 2019, 83% was located in California. States that followed California in their use of small-scale storage power capacity were Hawaii, Vermont and Texas. Missouri didn't rank in the top 10 for small-scale energy storage capacity in 2019 (eia.gov/analysis/studies/electricity/batterystorage).

Missouri has also had a relatively limited presence in providing battery storage capacity for the power grid. Exhibit 4.1.7 summarizes that the state's installed large-scale battery capacity didn't change from 2019 to 2020. In both years, the state had large-scale battery storage systems that provided 2 megawatts in power capacity and 3 megawatt-hours in energy capacity (eia.gov/analysis/studies/electricity/batterystorage).

Exhibit 4.1.7. Missouri large-scale battery storage system capacity

	2019	2020
Power capacity (megawatts)	2	2
Energy capacity (megawatt-hours)	3	3

Source: U.S. Energy Information Administration (eia.gov/analysis/studies/electricity/batterystorage)

Historically, large-scale battery storage systems have been constructed as standalone facilities. Of all the capacity that large-scale battery storage systems had to generate power

in December 2020, just 30% was co-located with a generation facility that used renewable resources. Another 8% of the total capacity had been co-located with generators that used fossil fuels. Looking forward, however, the U.S. Energy Information Administration projects that more battery storage capacity will co-locate with other generation facilities. Namely, solar facilities will increasingly have added battery storage capacity (eia.gov/analysis/studies/electricity/batterystorage).

Renewable energy systems pair their projects with battery technology to help balance energy supply and demand. Batteries can hold the energy that's generated and serve as an alternative to "peaker plants" that rely on fossil fuels. These plants supply energy when renewable systems fail to produce enough energy to meet needs (e.g., cloudy days, low-wind days). A December 2020 publication from Yale University described California as "the global leader in the deployment of high-capacity batteries" (e360.yale.edu/features/in-boost-for-renewables-grid-scale-battery-storage-is-on-the-rise).

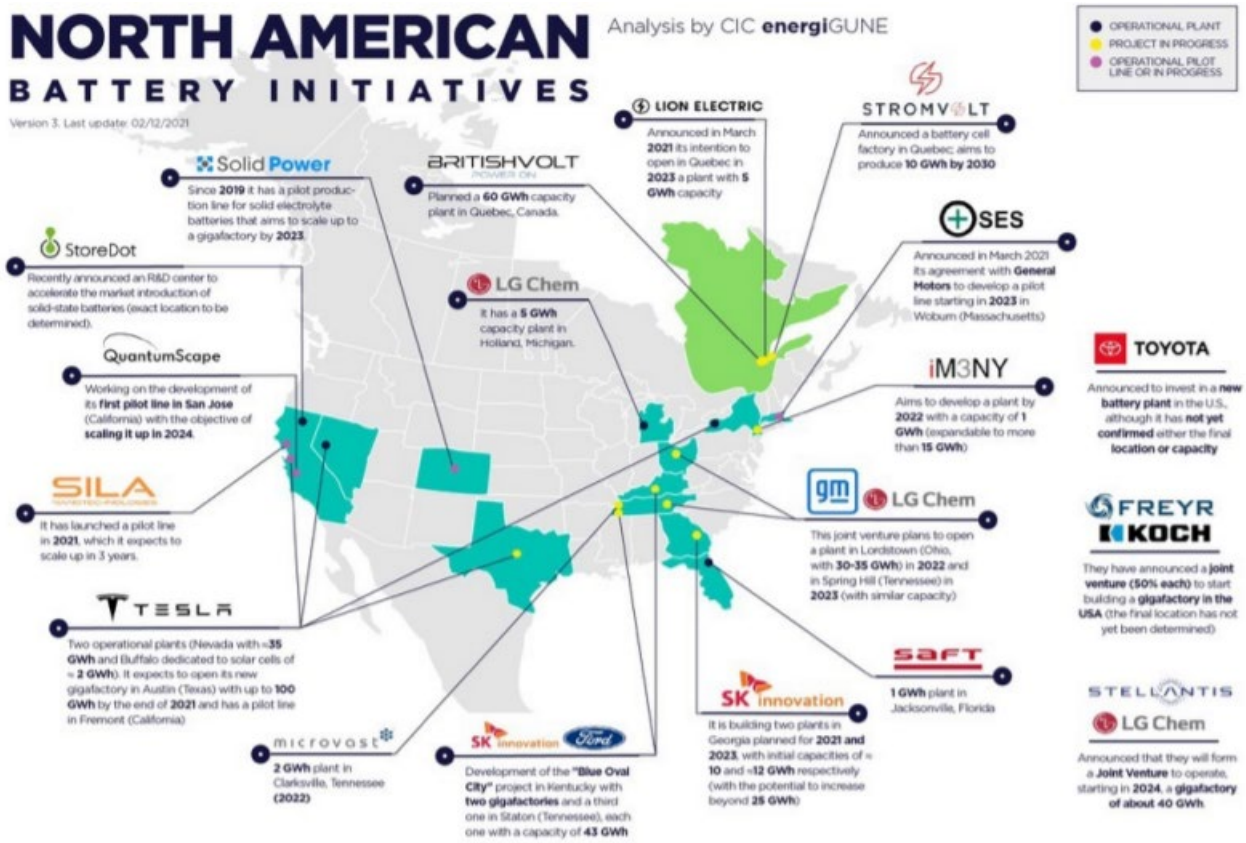
National defense projects also have a need for energy storage. Of the high-density energy storage it procures, the U.S. Department of Defense has a preference for domestic options. Each year, the Defense Logistics Agency purchases $200 million in batteries. Batteries used in military applications should withstand cold and hot weather, shocks, vibration and long storage times (energy.gov/sites/default/files/2021-06/FCAB%20National%20Blueprint%20Lithium%20Batteries%200621_0.pdf).

<u>Battery manufacturing</u>

The U.S. has historically contributed to global lithium-ion cell manufacturing on a small scale. Benchmark Mineral Intelligence estimated that U.S. manufacturing capacity tallied to 8% of the world's total capacity in 2020 (energy.gov/sites/default/files/2021-06/FCAB%20National%20Blueprint%20Lithium%20Batteries%200621_0.pdf). The Tesla-Panasonic plants in Nevada contribute significantly to U.S. battery manufacturing capacity (energy.gov/sites/prod/files/2020/12/f81/Energy%20Storage%20Market%20Report%202020_0.pdf).

To better position the U.S. to compete in battery manufacturing, the U.S. has outlined a blueprint for meeting lithium-ion battery demand through the Federal Consortium for Advanced Batteries. The blueprint envisions the U.S. and partners will rework the batteries supply chain and materials sourcing by 2030. It includes five goals. One relates to securing raw and refined materials used in battery production (energy.gov/sites/default/files/2021-06/FCAB%20National%20Blueprint%20Lithium%20Batteries%200621_0.pdf). Exhibit 4.1.8 highlights North American battery initiatives identified in a February 2021 analysis from CIC energiGUNE. Note, several in-progress projects at the time were located in states adjacent to Missouri (i.e., Tennessee, Kentucky) (americanmanganeseinc.com/wp-content/uploads/2021/12/AMY_Presentation-Dec_2021.pdf).

Exhibit 4.1.8. North American battery initiatives



Source: CIC energiGUNE (americanmanganeseinc.com/wp-content/uploads/2021/12/AMY_Presentation-Dec_2021.pdf)

Lithium-ion manufacturing capacity has concentrated in China. A December 2020 report from the U.S. Department of Energy traced 80% of the world's lithium-ion battery manufacturing capacity to China. The country also had more than 60% of the capacity in planned projects or capacity additions under construction (energy.gov/sites/prod/files/2020/12/f81/Energy%20Storage%20Market%20Report%202020_0.pdf). Therefore, U.S. efforts to increase domestic battery manufacturing capacity would compete with international suppliers who have significant experience and have likely developed and built on competitive advantages over time.

Although lithium-ion batteries have had widespread adoption, innovation has been underway to develop other battery technologies. Those alternatives to the traditional lithium-ion battery may solve challenges typical of lithium ion options, or they may provide performance improvements. In a 2019 story, the Berkeley Lab — a lab that's affiliated with the U.S. Department of Energy and based at the University of California — highlighted four technologies that have received research and development attention. Exhibit 4.1.9 summarizes how these technologies work, how they might be used and where they sit in the battery product development pipeline.

Exhibit 4.1.9. Battery product development pipeline

	How they work	How they're used	Where in the pipeline*
Sodium-ion	Made with sodium instead of lithium, sodium-ion batteries would be less expensive than lithium options.	Energy storage	Three to four years
Solid-state	Solid material — instead of liquid electrolytes found in some lithium-ion options — may be less flammable, store more energy, cost less and weigh less.	Electric vehicles, consumer electronic devices	Four to five years
Lithium-ion	Next-generation lithium-ion batteries may replace cobalt and nickel — two materials that store lithium but can be expensive or have had mining challenges — with iron or manganese.	Consumer electronics, vehicles	Five to six years
Multi-valent	Made with magnesium, calcium or aluminum, multi-valent options would hold more charge and be smaller than single-valent lithium-ion options.	Portable electronics, electric vehicles	At least 10 years

* Estimated years from December 2019
Source: Berkeley Lab (newscenter.lbl.gov/2019/12/11/a-peek-into-the-battery-technology-pipeline)

The following points summarize other trends and factors shaping battery manufacturing and sales. These may be important to consider when marketing battery technologies.

- Costs have declined for lithium-ion battery production — by roughly 90% from 2010 to 2021. Therefore, new technologies must compete at a similar cost or yield enough value to justify any price premium (energy.gov/sites/default/files/2021-06/FCAB%20National%20Blueprint%20Lithium%20Batteries%200621_0.pdf).
- States dictate much of the policy environment that affects large-scale battery installations, so the country can have a patchwork of polices related to energy storage incentives and planning (eia.gov/analysis/studies/electricity/batterystorage).
- Lithium-ion batteries may use various carbon sources that would compete with soy-derived carbons. Additionally, a report from the Environmental and Energy Study Institute describes that silicon has been explored as a substitute for graphite. Therefore, other industry players have made investments in discovering alternatives other than soy carbons (eesi.org/papers/view/energy-storage-2019).
- Flammability can present a concern for some lithium-ion battery applications. Therefore, system engineering has an opportunity to correct the flammability concerns and potentially further open market opportunities for new technologies (energy.gov/sites/prod/files/2020/12/f81/Energy%20Storage%20Market%20Report%202020_0.pdf).
- Battery manufacturing poses risks that may exceed the financial award. A report from CNBC describes how bankruptcy has affected several manufacturers. Novel battery technologies may need to reach manufacturers with solid financials in order for them to have consistent marketability (cnbc.com/2019/12/30/battery-developments-in-the-last-decade-created-a-seismic-shift-that-will-play-out-in-the-next-10-years.html).

Global Battery Alliance Battery Passport

At the World Economic Forum's annual meeting in 2020, the battery passport concept debuted. The concept suggests that each battery receive a digital record that tracks information value chain users can monitor. This information includes environmental, social and governance details and life-cycle requirements. It can be reviewed to create benchmarks related to what makes a sustainable battery (www3.weforum.org/docs/WEF_GBA_Battery_Passport_Overview_2021.pdf).

The firms listed in Exhibit 4.1.10 have a Missouri presence and manufacture batteries. These firms may have interest in incorporating MSMC-funded battery technologies into their businesses and battery products.

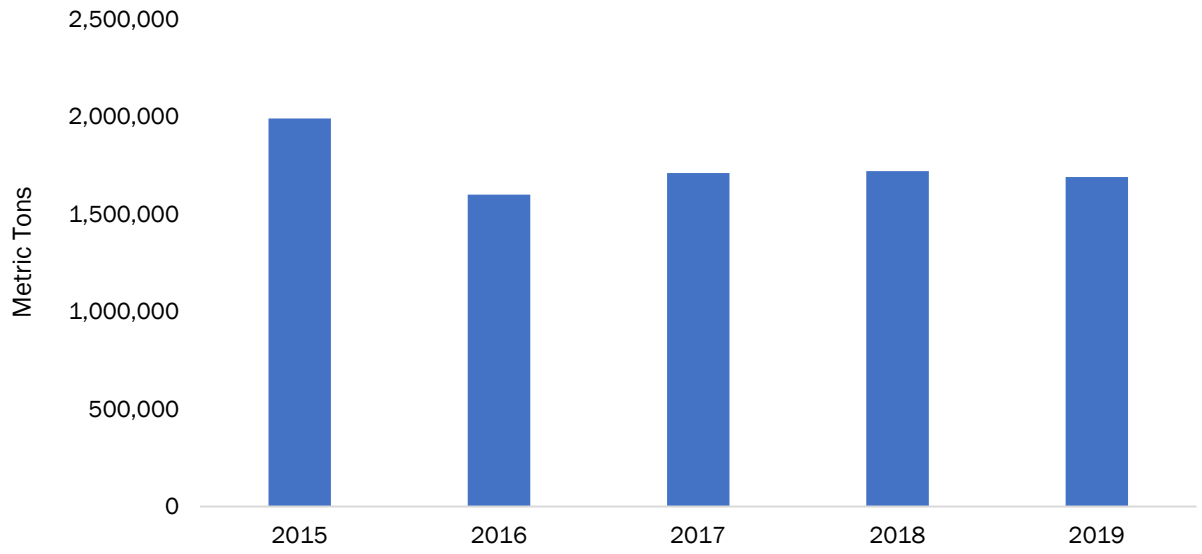
Exhibit 4.1.10. Missouri battery manufacturers

Firm	Products	Location	Website
AEsir Technologies Inc.	Nickel-zinc batteries for data centers, defense and aerospace applications	Joplin	aesirtec.com
Clarios	Lead-acid and lithium-ion batteries for vehicles	St. Joseph	clarios.com
EaglePicher	Lithium-ion Center of Excellence in Joplin; St. Louis headquarters	Joplin and St. Louis	eaglepicher.com
Energizer	Lithium, alkaline, carbon zinc, miniature, specialty photo, rechargeable batteries; St. Louis headquarters	St. Louis	energizer.com
EnerSys Battery	Thin plate pure lead and lithium-ion batteries; serves automotive, telecommunications, aerospace and defense industries	Springfield, Missouri	enersys.com
Exergonix Inc.	Lithium-ion products	Lee's Summit, Missouri	exergonix.com
Hawker Energy Products	Part of EnerSys; lead acid military vehicle battery	Warrensburg, Missouri	hawkerbattery.com
NorthStar Battery	Part of EnerSys; thin plate pure lead batteries	Springfield, Missouri	northstarbattery.com
Spear Power Systems	Lithium-ion battery storage systems for land, air and sea	Grandview, Missouri	spearpowersystems.com
Vision Battery USA	VRLA and lithium-ion batteries	Joplin, Missouri	visionbatteryusa.com

4.2 Environmentally friendly explosives

Blasting agents and oxidizers — including explosives that use ammonium nitrate-fuel oil — have had relatively stable sales in the past few years. From 2015 to 2019, Exhibit 4.2.1 shows that sales reached their highest point in 2015 at nearly 2 million metric tons. Sales levels were fairly consistent between 2017 and 2019 — averaging 1.7 million metric tons per year. Blasting agent and oxidizer sales exceeded sales of other industrial explosives, which include permissibles and other high explosives. Of the blasting agents and oxidizers sold in 2018, most — 95% — were sold in bulk. Packaged options represented a small portion of the blasting agents and oxidizers sold (usgs.gov/centers/national-minerals-information-center/explosives-statistics-and-information).

Exhibit 4.2.1. U.S. sales of blasting agents and oxidizers



Source: Institute of Makers of Explosives via USGS (usgs.gov/centers/national-minerals-information-center/explosives-statistics-and-information)

MSMC Research Connection

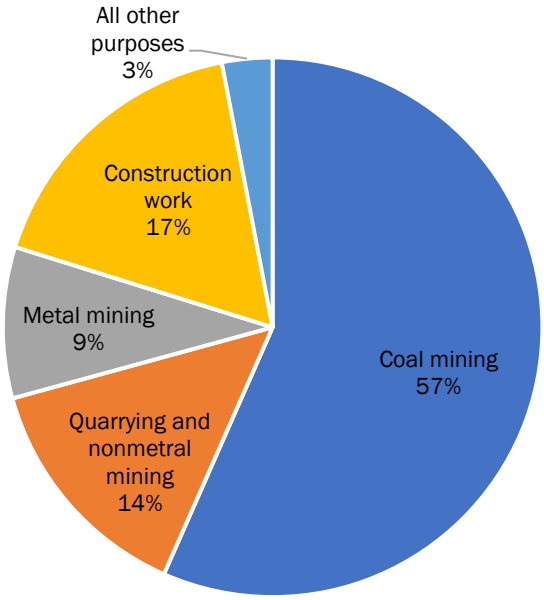
Missouri University of Science and Technology researchers are evaluating soybean oil or biodiesel as an alternative fuel source in mining explosives. Funded by MSMC, this research has documented that ammonium nitrate and soy oil (ANSOY) alternatives produce equivalent power, lower concentrations of toxic gas and gases that travel less distance than traditional ammonium nitrate and diesel fuel explosives (ANFO). Additional work is underway to study emulsified explosives that use soybean oil as fuel (soybeanresearchdata.com/Project.aspx?id=53310). Compared with ANFO explosives, emulsified options, which are water-in-oil emulsions, are more likely to resist water and have more sensitivity. Plus, they're easy to transport.

Of the blasting agents and oxidizers sold in 2019, more than half had coal mining uses. Construction work ranked as the second most common use as 17% of blasting agents and oxidizers sold had this purpose. Exhibit 4.2.2 illustrates that quarrying and nonmetal mining,

metal mining and other uses combined demanded about one-quarter of blasting agents and oxidizers sold in 2019 (usgs.gov/centers/national-minerals-information-center/explosives-statistics-and-information).

Coal mining's share of blasting agent and oxidizer consumption has declined in recent years. During 2014 and 2015, coal mining demanded 67% and 64% of the blasting agents and oxidizers that were consumed. Construction work most increased its share. In 2015, 12% of blasting agent and oxidizer use traced to construction applications compared with the 17% share this category captured in 2019 (usgs.gov/centers/national-minerals-information-center/explosives-statistics-and-information).

Exhibit 4.2.2. Blasting agents and oxidizers sales by use, 2019



Source: Institute of Makers of Explosives via USGS (usgs.gov/centers/national-minerals-information-center/explosives-statistics-and-information)

Explosives Trade Associations

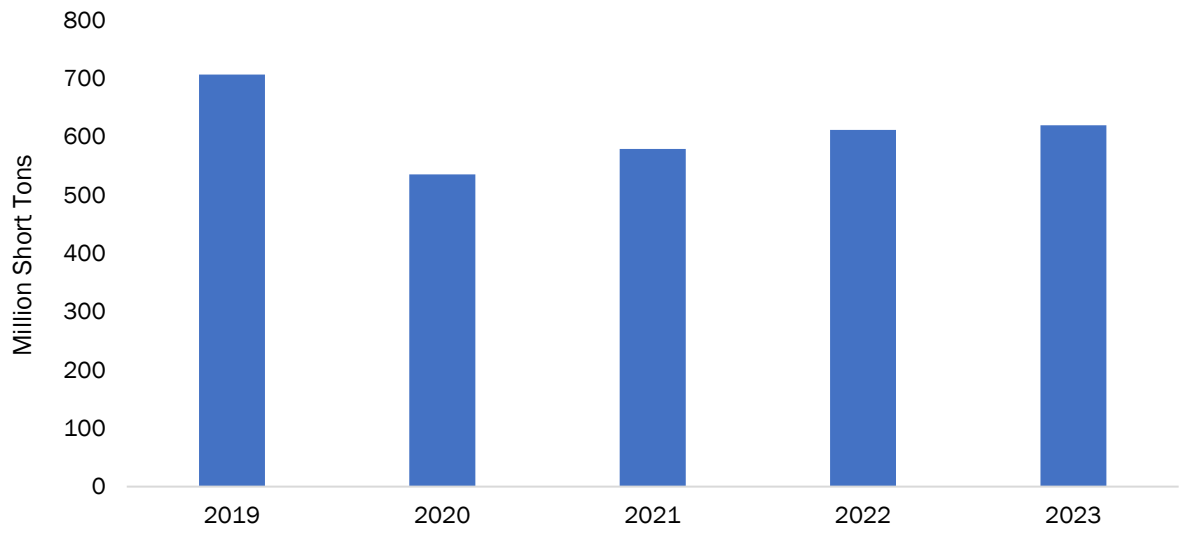
When commercializing the ANSOY technology, the following trade associations may represent key partners.

Members of ***Institute of Makers of Explosives*** make more than 95% of the explosives consumed in the U.S. The organization states its mission as follows: "To promote safety and security for the commercial explosives industry." Find more information at ime.org.

The ***International Society of Explosives Engineers*** has several stated objectives. Those include sharing information about explosives techniques and principles; educating policymakers; providing professional development opportunities; and standardizing explosives engineering terms, methods and regulations. Find more information at isee.org.

Published in January 2022, the U.S. Energy Information Administration's short-term energy outlook reported a substantial drop in coal production from 2019 to 2020 — a 24% decline. Exhibit 4.2.3 provides coal production outlook through 2023. Between 2020 and 2023, the projections do suggest that coal production will experience year-over-year improvements. However, the projected production in each of these four years doesn't yet return to the production total reported for 2019. Assuming coal production grows, explosives manufacturers may see an uptick in demand (eia.gov/outlooks/steo/report/coal.php).

Exhibit 4.2.3. Short-term outlook for U.S. coal production, 2019 to 2023



Source: U.S. Energy Information Administration (eia.gov/outlooks/steo/report/coal.php)

Construction firms use explosives to form tunnels and destroy old infrastructure (blog.technavio.org/blog/whats-trending-mining-explosives-market). Exhibit 4.2.4 presents construction industry growth projects by category. Published by the Construction Analytics blog, these data and projections are based on construction spending numbers reported by the U.S. Census Bureau. Overall, the projections suggest overall U.S. construction spending will grow by 3% in 2022. The residential category leads with the strongest projected growth followed by nonresidential buildings. Note the particular strength in projected commercial and retail space construction — 17% growth in the 2022 forecast. These projections suggest nonbuilding infrastructure spending will decline by 3.6% in 2022 (edzarenski.com/2022/01/04/construction-economic-forecast-jan-2022/).

Exhibit 4.2.4. Construction spending outlook

	Actual 2020		Forecast 2021		Forecast 2022	
	Billion dollars	YOY % change	Billion dollars	YOY % change	Billion dollars	YOY % change
Residential	638	15%	781	23%	826	6%
Nonresidential buildings	480	-2%	456	-5%	472	4%
Educational	107	-1%	98	-9%	99	1%
Health care	48	4%	49	2%	52	7%
Amusement/recreation	28	-9%	25	-9%	27	7%
Commercial/retail	87	3%	90	4%	106	17%
Lodging	29	-13%	20	-32%	18.4	-6%
Office	87	-1%	82	-6%	76.7	-6%
Manufacturing	72	-11%	78	7%	80	4%
Other	21	36%	15	-30%	14	-10%
Nonbuilding infrastructure	351	1%	347	-1%	335	-4%
Power	115	-2%	115	-0.4%	101	-12%
Highway, bridge, street	100	0%	100	-0.1%	100	0%
Transportation, air, rail	60	4%	57	-5%	53	-6%
Sewer, water, conservation	54	5%	54	0.6%	59	8%
Communication	23	2%	22	-3%	22	-0.5%
Construction overall	**1,469**	**6%**	**1,585**	**8%**	**1,633**	**3%**

* 2021 forecast uses U.S. Census Bureau data reported through November 2021; forecast informed by outlook from Dodge Outlook 2022
Source: Construction Analytics (edzarenski.com/2022/01/04/construction-economic-forecast-jan-2022)

Despite the weak projections for 2022, nonbuilding infrastructure spending will likely expand in future years as projects funded by the Infrastructure Investment and Jobs Act of 2021 get underway. The bill included $1.2 trillion in funding. Nearly half of that total stemmed from funding that's more than the baseline funding level. Of the "above-baseline spending" authorized by the bill, slightly more than half would support transportation-related projects, including roads, bridges, airports, waterways and public transit (brookings.edu/blog/the-avenue/2021/11/09/america-has-an-infrastructure-bill-what-happens-next). Construction Analytics explains that delays in nonbuilding project starts and spending are common. The spending will take place over multiple years (edzarenski.com/2022/01/04/construction-economic-forecast-jan-2022).

Relative to other states, Missouri ranked 17th in 2019 for blasting agents and oxidizers consumption. Demand totaled 30,500 metric tons. The top 10 states — ranked according to 2019 blasting agents and oxidizers consumption — used two-thirds of total U.S. consumption. In 2019, the four top users — all consumed more than 110,000 metric tons of blasting agents and oxidizers — were Wyoming, Nevada, West Virginia and Indiana (usgs.gov/centers/national-minerals-information-center/explosives-statistics-and-information).

In mining explosives, biodiesel (B100 or B20) or soybean oil could displace petroleum diesel, but a soy-based product's use depends on whether it will save on costs. The value provided by a soy-based product hinges on diesel and soybean oil prices. Exhibit 4.2.5 shows the annual cost savings for using soybean oil in place of petroleum diesel (30.5 million gallons) given varying price scenarios. The soybean oil could reduce the mining industry's costs if diesel prices are high and soybean oil prices are low. However, the likelihood that the soy-based product becomes less expensive than the petroleum-based product is low. If mining and construction companies have a requirement to use petroleum alternatives or a procurement preference states to use petroleum alternatives, then they would have a greater incentive to use those alternatives.

Exhibit 4.2.5. Cost savings sensitivity analysis if replacing petroleum diesel in ANFO mining explosives with soy oil

Soybean oil per lb.	Petroleum diesel cost per gallon				
	$1.50	$2.00	$2.50	$3.00	$3.50
$0.30	($23,790,000)	($8,540,000)	$6,710,000	$21,960,000	$37,210,000
$0.40	($46,970,000)	($31,720,000)	($16,470,000)	($1,220,000)	$14,030,000
$0.50	($70,150,000)	($54,900,000)	($39,650,000)	($24,400,000)	($9,150,000)
$0.60	($93,330,000)	($78,080,000)	($62,830,000)	($47,580,000)	($32,330,000)
$0.70	($116,510,000)	($101,260,000)	($86,010,000)	($70,760,000)	($55,510,000)

Several trends have shaped the explosives industry. The following list summarizes some of these points — highlighted by Technavio — that affect explosives manufacturers and consumers (blog.technavio.org/blog/whats-trending-mining-explosives-market).

- The mining industry has turned to bulk emulsion explosives, which can be stored and transported safely, resist water and yield lower emissions, instead of packaged explosives. These products combine small ammonium nitrate particles with oil and emulsifying compounds.
- When purchasing explosives, firms look for sellers that prioritize safe transportation and storage and environmental protection.
- To manage the supply chain, some global firms have coordinated with local firms that procure needed supplies. Other firms have opted for in-house production.

The firms listed in Exhibit 4.2.6 manufacture explosives or components of those products at Missouri locations. They may have interest in incorporating a new technology.

Exhibit 4.2.6. Missouri explosives manufacturers

Firm	Location	Website
Austin Powder	Fredericktown, Montrose, Reed Springs	austinpowder.com
Buckley Powder Company	Aurora, Greenwood, Hermann, Scott City	buckleypowder.com
Dyno Nobel	Carthage, Louisiana	dynonobel.com
Orica	Liberty	orica.com

4.3 Flame-retardant polyurethanes

Polyurethanes first debuted in the 1930s. During World War II, the plastic polymers displaced rubber, and innovation during the era led to using polyurethane in new applications — namely, coatings. Since then, manufacturers have created various types of polyurethanes using different production methods (polyurethanes.org/en/what-is-it). Exhibit 4.3.1 describes the polyurethanes that manufacturers produce today. Each format offers certain characteristics that make polyurethanes well-suited for various applications.

MSMC Research Connection

To make polyurethane, manufacturers mix a polyol and isocyanate. Assume one-third of the polyurethane will be polyol. Researchers at Pittsburg State University have studied how to replace polyols made from petrochemicals with polyols derived from soybean oil. The process calls for a one-to-one replacement. Replacing a petrochemical polyol with a soybean oil polyol requires no other process changes. The research has also focused on identifying a flame-retardant material that works well in polyurethane made using soybean oil polyols.

Raw materials involved in polyurethane production include diisocyanates, polyether polyols, polyester polyols and additives (americanchemistry.com/content/download/6054/file/The-Economic-Benefits-of-the-US-Polyurethanes-Industry-2019.pdf).

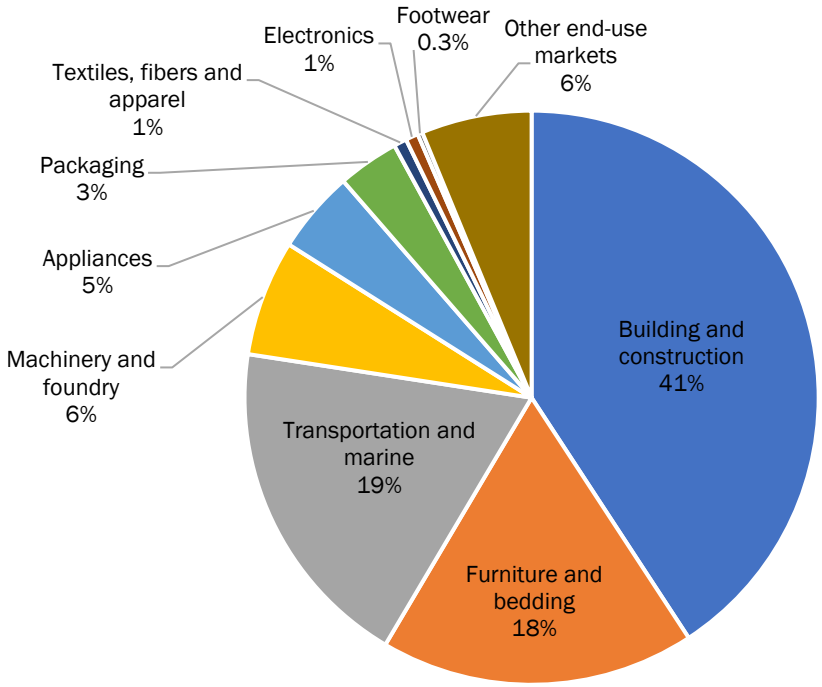
Exhibit 4.3.1. Polyurethane formats

Format	Characteristics	Applications
Flexible foam	Light, durable, supportive, conforms to desired shape and firmness	Bedding, furniture, vehicle interiors, carpet padding, packaging
Rigid foam	Insulate to manage temperatures and noise	Roof and wall insulation, insulated windows, doors, air barrier sealants
Coatings	Improve product appearance	Flooring
Adhesives	Bonding	
Sealants	Tight seals	
Elastomers	Light, mold well, resist environmental conditions, stress recovery	
Thermoplastic polyurethane	Elastic; flexible; resists abrasion, impact and weather	Maritime applications, wire and cable coatings, engine tubing, drive belts, hydraulic hoses and seals, ship molding
Reaction injection molding	Lightweight, strong, heat resistant	Car bumpers, electrical house panels, computer equipment enclosures, telecommunication equipment enclosures
Binders	Bond various particles and fibers	Wood panels, rubber, flooring, sand casting
Waterborne polyurethane dispersions	Water-based formula reduces volatile organic compounds and hazardous air pollutants	Coatings, adhesives

Source: American Chemistry Council (americanchemistry.com/industry-groups/center-for-the-polyurethanes-industry-cpi/applications-benefits/polyurethane-applications)

Multiple markets demand polyurethanes. Part of the American Chemistry Council, the Center for the Polyurethanes Industry commissioned a study in 2018 to evaluate U.S. end markets for polyurethane products. According to the report, polyurethanes production totaled roughly 7.31 billion pounds in 2018. Exhibit 4.3.2 summarizes production by U.S. end-use market. As noted, the building and construction market demanded nearly 41% of the polyurethane produced in 2018. The two markets that ranked second and third, respectively, for polyurethane use were transportation and marine, 18.9%, and furniture and bedding, 17.7% (americanchemistry.com/content/download/6054/file/The-Economic-Benefits-of-the-US-Polyurethanes-Industry-2019.pdf).

Exhibit 4.3.2. Polyurethane production by U.S. end market, 2018



Source: Center for the Polyurethanes Industry (americanchemistry.com/content/download/6054/file/The-Economic-Benefits-of-the-US-Polyurethanes-Industry-2019.pdf)

Assume that the polyol — the polyurethane component where soybean oil can fit as an input — represents 33% of the polyurethane volume that's produced. With that assumption in place, Exhibit 4.3.3 summarizes the amount of U.S. soybean oil that would be required for U.S. polyurethane production if soybean oil were used as a polyol 33% of the time. These estimates also assume that U.S. polyurethane production in the future is equivalent to 2018 production volumes published by the American Chemistry Council. Based on these assumptions, U.S.-produced polyurethane applications would require soybean oil from more than 1.3 million soybean acres.

Exhibit 4.3.3. Estimated soybean inputs required for polyurethane production

Market	Polyurethane produced (million pounds)	Polyol needs (million pounds)	Soy oil needs (million pounds)	Soybean bushels (millions)	Soybean acres
Building and construction	2,983	984.4	324.8	29.5	591,344
Furniture and bedding	1,297	428.0	141.2	12.8	257,115
Transportation and marine	1,384	456.7	150.7	13.7	274,361
Machinery and foundry	478	157.7	52.1	4.7	94,758
Appliances	340	112.2	37.0	3.4	67,401
Packaging	253	83.5	27.6	2.5	50,154
Textiles, fibers, apparel	53	17.5	5.8	0.5	10,507
Electronics	52	17.2	5.7	0.5	10,308
Footwear	20	6.6	2.2	0.2	3,965
Other end use markets	455	150.2	49.5	4.5	90,198
Total	7,315	2,414.0	796.6	72.4	1,359,912

* Assumes U.S. polyurethane production is equivalent to 2018 production values, 33% of polyurethane is polyol, 33% of polyol is made from soybean oil, 11 pounds of oil per bushel and U.S. soybean yields average 49.94 bushels per acre (2017-21 average)

As noted, three end markets in the U.S. demand roughly 80% of the polyurethane produced. Exhibit 4.3.4 details more about how these three markets use various polyurethanes.

Exhibit 4.3.4. Polyurethane applications by end market

End markets	Polyurethane applications
Building and construction	• Rigid polyurethane foam for wall and roof insulation, insulated panels and gap-fillers around doors and windows • Protective coatings for wood floors, basements, buildings and bridges • Adhesives for roofing, flooring, wallboard and window or door installations • Sealants for expansion joints, basements, driveways, windows
Furniture and bedding	• Flexible foam for upholstered household, commercial and industrial furniture; theater and stadium seating; mattresses; carpet underlay • Coatings for wood furniture
Transportation and marine	• Flexible polyurethane foam for seating; headrests; arm rests; HVAC and other interior systems for automobiles, airliners, trains, buses • Rigid polyurethane foam for automotive panels • Coatings for vehicle exteriors, window glazing • Adhesives for exterior and interior components • Elastomers for molded components and tires • Reaction injection molding for vehicle fenders, bumpers, spoilers

Source: Center for the Polyurethanes Industry (americanchemistry.com/content/download/6054/file/The-Economic-Benefits-of-the-US-Polyurethanes-Industry-2019.pdf)

Notably, these three markets drive consumption of key polyurethane products:

- The building and construction market demands rigid polyurethane foam for varied applications. Most of this rigid foam takes shape as polyiso laminate boardstock, which builders use in roofing and wall insulation.
- Within the transportation and marine market, automobiles use varied polyurethanes. In an average light vehicle, polyurethane products weigh roughly 67 pounds.
- The furniture and bedding market consumes most — 79% — of the flexible polyurethane slabstock foam produced in the country.

Polyurethanes Trade Associations

When commercializing the polyurethane technology, the following trade associations may represent key partners to reach polyurethane manufacturers.

The ***Polyurethane Manufacturers Association*** specializes in providing information about cast polyurethane technology, practices and knowledge. It also advocates for polyurethane processors in policy discussions. It also hosts an annual meeting and publishes a newsletter for its members. Find more information at pmahome.org.

Open to U.S. and international polyurethane foam manufacturers and suppliers, the ***Polyurethane Foam Association*** provides training, a technical library, meeting access and other resources to members. Find more information at pfa.org.

Members of the ***Spray Polyurethane Foam Alliance*** include spray foam contractors, manufacturers and distributors. The alliance offers a certification program for installers, contractors and suppliers. It also provides technical resources, legislative advocacy, an annual convention and expo and educational publications. Find more information at sprayfoam.org.

Building and construction

Using data from Construction Analytics, Exhibit 4.3.5 articulates previous growth and growth potential in construction spending by category. As noted, the 2022 forecast suggests that the nonresidential commercial and retail spaces category has the greatest opportunity to grow its construction spending (edzarenski.com/2022/01/04/construction-economic-forecast-jan-2022).

Other building infrastructure categories with forecasted spending growth in 2022 that at least exceeds 5% are health care nonresidential buildings, 6.7%; amusement and recreation nonresidential buildings, 6.5%; and residential buildings, 5.7%. For all of these categories but residential buildings, the forecast suggests improved growth potential in 2022 compared with the growth recorded in 2020 and 2021 (edzarenski.com/2022/01/04/construction-economic-forecast-jan-2022).

Exhibit 4.3.5. Construction spending outlook

	Actual 2020		Forecast 2021		Forecast 2022	
	Billion dollars	YOY % change	Billion dollars	YOY % change	Billion dollars	YOY % change
Residential	638	15%	781	23%	826	6%
Nonresidential buildings	480	-2%	456	-5%	472	4%
Educational	107	-1%	98	-9%	99	1%
Health care	48	4%	49	2%	52	7%
Amusement/recreation	28	-9%	25	-9%	27	7%
Commercial/retail	87	3%	90	4%	106	17%
Lodging	29	-13%	20	-32%	18.4	-6%
Office	87	-1%	82	-6%	76.7	-6%
Manufacturing	72	-11%	78	7%	80	4%
Other	21	36%	15	-30%	14	-10%
Nonbuilding infrastructure	351	1%	347	-1%	335	-4%
Power	115	-2%	115	-0.4%	101	-12%
Highway, bridge, street	100	0%	100	-0.1%	100	0%
Transportation, air, rail	60	4%	57	-5%	53	-6%
Sewer, water, conservation	54	5%	54	0.6%	59	8%
Communication	23	2%	22	-3%	22	-0.5%
Construction overall	**1,469**	**6%**	**1,585**	**8%**	**1,633**	**3%**

* 2021 forecast uses U.S. Census Bureau data reported through November 2021; forecast informed by outlook from Dodge Outlook 2022
Source: Construction Analytics (edzarenski.com/2022/01/04/construction-economic-forecast-jan-2022)

Transportation and marine

Light vehicles, trucks, aircraft, trains and boats all represent potential transportation-related applications for polyurethane products. In the polyurethanes economic impact report for 2018, the American Chemistry Council estimated that a light vehicle contains 67 pounds of polyurethane materials on average. Of all the plastic used in a light vehicle nearly 20% is polyurethane-based. Compared with other types of materials, polyurethanes weigh less. Therefore, polyurethane components support better fuel efficiency for those lightweight vehicles (americanchemistry.com/content/download/6054/file/The-Economic-Benefits-of-the-US-Polyurethanes-Industry-2019.pdf).

According to estimates published in September 2021, IHS Markit estimates that global light vehicle production has room to grow in the next few years. According to the firm's projections, global light vehicle production will increase from 75.8 million units in 2022 to 98.9 million units in 2025 (ihsmarkit.com/research-analysis/major-revision-for-global-light-vehicle-production-forecast.html). Exhibit 4.3.6 estimates the implications of light vehicle production output growth on polyurethane demand. The estimates assume that an average light vehicle uses 67 pounds of polyurethanes, which are 33% polyol — 33% of which is derived from soybean oil. Given these assumptions, light vehicle manufacturing would require the equivalent of at least 100,000 acres of soybeans annual to satisfy the polyurethane demand for these vehicles.

Exhibit 4.3.6. Estimated soybean inputs required for polyurethane used in global light vehicle production

Year	Vehicle units (millions)	Polyurethane needs (million pounds)	Polyol needs (million pounds)	Soybean oil needs (million pounds)	Soybean bushels (millions)	Soybean acres
2022	75.8	507.9	167.6	55.3	5.0	100,677
2023	92.0	616.4	203.4	67.1	6.1	122,194
2024	97.3	651.9	215.1	71.0	6.5	129,233
2025	98.9	662.6	218.7	72.2	6.6	131,358

* Assumes IHS Markit projections for global light vehicle sales, American Chemistry Council estimate that 67 pounds of polyurethane in an average light vehicle, 33% of polyurethane is polyol, 33% of polyol is made from soybean oil, 11 pounds of oil per bushel and U.S. soybean yields average 49.94 bushels per acre (2017-21 average)

Furniture and bedding

Furniture Today and Easy Analytic Software Inc. identified three categories that led furniture sales in 2021. Exhibit 4.3.7 lists those categories, estimated 2021 sales and sales growth in 2021. Bedding led. Stationary sofas followed closely. Consumers made investments in these categories as the COVID-19 pandemic led them to spend time at home (furnituretoday.com/research-and-analysis/retailing-rebound-fuels-120-4-billion-in-furniture-bedding-sales). All three of these categories have the potential to use polyurethane foam.

CertiPUR-US Certified Foam

Administered by the Alliance for Flexible Polyurethane Foam Inc., the CertiPUR-US certification program outlines several criteria for participating flexible polyurethane foam makers.

Namely, foam production processes must exclude these inputs: ozone depleters; certain flame retardants correlated with health problems; mercury, lead and heavy metals; formaldehyde; and prohibited phthalates. Plus, the process must have low volatile organic compound emissions.

Applications for certified foam that receives the certification include bedding and upholstered furniture. Find more information about the certification program at certipur.us.

In total, furniture and bedding sales summed to about an estimated $120.4 billion in 2021. Sales growth for the total industry averaged 4.5%. Not since 2012 had furniture and bedding sales increased to such an extent (furnituretoday.com/research-and-analysis/retailing-rebound-fuels-120-4-billion-in-furniture-bedding-sales).

Exhibit 4.3.7. Furniture categories ranking in the top three for sales growth, 2021 estimate

Category	2021 sales estimate	Sales growth, 2020-21
Bedding	$18.5 billion	8.8%
Stationary sofas	$18.4 billion	5.0%
Outdoor furniture	$5.23 billion	4.8%

Source: Furniture Today and Easy Analytic Software Inc. (furnituretoday.com/research-and-analysis/retailing-rebound-fuels-120-4-billion-in-furniture-bedding-sales)

Looking forward, Furniture Today projects strong sales potential for stationary sofas, curios, swivel and glider rockers, home office furniture, entertainment furniture and casual dining sets. Factors affecting future sales include retail sales constraints, supply chain challenges, inflation, purchasing power and unemployment trends (furnituretoday.com/research-and-analysis/retailing-rebound-fuels-120-4-billion-in-furniture-bedding-sales). The housing market will also shape consumer spending on household furnishings. A forecast published by Furniture Today suggests that furniture and bedding spending will increase by 4.1% in 2022 to exceed $125 billion (furnituretoday.com/research-and-analysis/amid-uncertainty-furniture-industry-remains-in-growth-mode).

As suggested by the Furniture Today and Easy Analytic Software Inc. sales data for 2021, bedding represents a large segment of the furniture market. Within that category, mattresses represent a use for polyurethane foam. A 2019 survey conducted by CertiPUR-US, a foam certification program, collected input from consumers who purchased or planned to purchase a new mattress within 12 months of survey participation (certipur.us/wp-content/uploads/2020/03/0585_CertiPUR-US_ConsumerSurvey_Interactive.pdf).

When asked to identify the factors they felt were most important to shaping their purchase decision, consumers most mentioned comfort and price. However, materials used in mattress production ranked third. That said, a segment of those consumers felt they knew little about mattress materials. Of the consumers who answered the question, 55% said they were very knowledgeable or knowledgeable about mattress materials. However, 37% said they were not too knowledgeable, and 8% said they were not at all knowledgeable. The top resources that consumers references to learn about mattress materials were as follows: manufacturer or retailer websites, other websites, information on mattress or labels in the store and past experience (certipur.us/wp-content/uploads/2020/03/0585_CertiPUR-US_ConsumerSurvey_Interactive.pdf).

Considering the furniture and bedding market more generally, consumers have cited interest in sustainable products. In 2021, the Sustainable Furnishings Council surveyed homeowners to understand their thoughts about sustainability and environmental issues. Exhibit 4.3.8 reports the percentage of 523 homeowners who selected various factors as those that would be important to them when they next purchase furniture. Of the eight factors included in the question, sustainability ranked fourth behind style, quality and price. Women were slightly more likely than men to say they find "made with materials and processes that do not harm the environment" to be important (sustainablefurnishings.org/sites/default/files/documents/SFC_2021_Green%20Survey_Topline%20Summary%20Report_Final_051921.pdf).

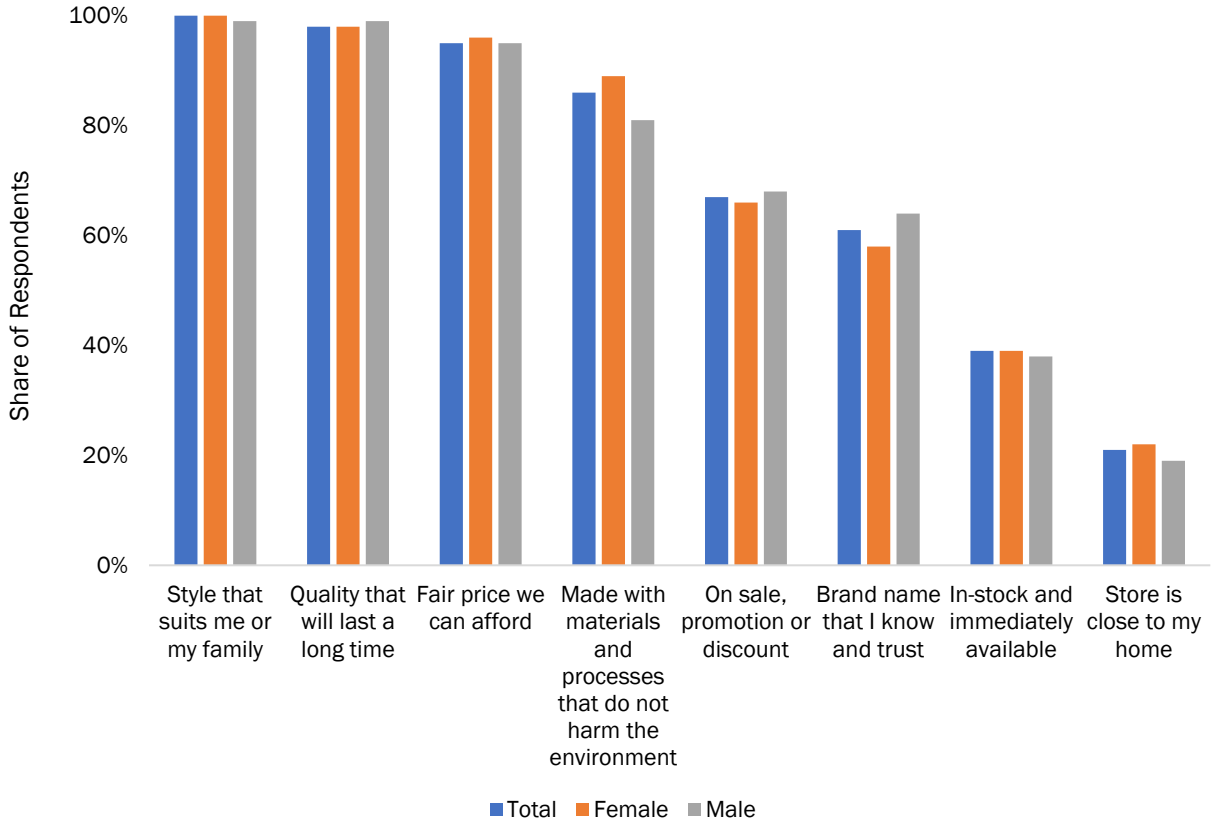
Sustainable Furnishings Council

Manufacturers, retailers and designers participate in the Sustainable Furnishings Council to encourage consumers to understand and consider environmentally sustainable home furnishings. Its mission states that it desires to "help companies reduce environmental footprint … and help consumers find healthier products and design services." Find more information at sustainablefurnishings.org.

Homeowners responding to the survey did indicate they have experience with purchasing environmentally safe products. They were most likely to have purchased environmentally

safe options of these three products: cleaning supplies, 82%; paper products, 74%; and lighting including lambs and bulbs, 63%. Other notable datapoints include that 42% of homeowners said they had purchased environmentally safe plastic products at some point, and 35% said they had purchased environmentally safe home furnishings (sustainablefurnishings.org/sites/default/files/documents/SFC_2021_Green%20Survey_Topline%20Summary%20Report_Final_051921.pdf).

Exhibit 4.3.8. Importance of factors in affecting homeowners' furniture purchases



Source: Sustainable Furnishings Council (sustainablefurnishings.org/sites/default/files/documents/SFC_2021_Green%20Survey_Topline%20Summary%20Report_Final_051921.pdf)

Polyurethane manufacturing

The firms in Exhibit 4.3.9 manufacture polyurethane products at Missouri locations. They may have interest in using soybean oil-based polyol in their polyurethane formulations.

Exhibit 4.3.9. Missouri polyurethane manufacturers

Firm	Products	Location	Website
AM Foam Products Inc.	Polyurethane foam	Kansas City	amfoam.com
Applied Urethane Technology	Moldable castable polyurethane	Ozark	urethaneservices.com
ArmorThane USA	Varied polyurethanes	Springfield	armorthane.com
Arnette Polymers	Polyurethane intermediates	Richmond	arnettepolymers.com
Atro Engineered Systems	Polyurethane parts for heavy-duty trucks	St. Clair	atrobushing.com
Carlisle Construction Materials	Foams, surface and specialty coatings, binders, casting resins, adhesives, sealants and elastomers	Maryland Heights	carlisleps.com
Chemline	Polyurethane coatings	St. Louis	chemline.net
Conklin Company	Polyurethane roof coatings and foams	Kansas City	conklin.com
Creative Polymers	Polyurethane systems	Hazelwood	creativepolymersinc.com
DAP	Spray foam	Fenton	dap.com
Devan Sealants	Polyurethane adhesives and sealants	St. Louis	devansealants.com
Delden Manufacturing Company	Commercial polyurethane insulated garage doors	Kansas City	deldenmfg.com
Diversified Foam Products	Flexible polyurethane	St. Louis	diversifiedfoam.net
Dynasauer Corp.	Custom polyurethane products	St. Louis	dynasauer.com
Foam Products Manufacturing	Flexible and rigid urethane foams	St. Louis	fpcfoam.com
Foam Supplies Inc.	Polyurethane systems	Earth City	foamsupplies.com
Henkel	Polyurethane structural adhesives	Richmond	henkel-adhesives.com
Leggett and Platt	Specialty foam for bedding and furniture	Carthage	leggett.com
MD Custom Polyurethane	Polyurethane parts	Union	rubbermolding.org/md-custom-polyurethane
Meramec Group	Polyurethane for footwear	Sullivan	meramec.com
Surco	Polyether polyurethane, polyester polyurethane, foams	St. Louis	surco.bz
Tnemec Company Inc.	Polyurethane coatings	North Kansas City	tnemec.com
Urethane Roller Specialist Inc.	Urethane rollers	Eureka	urethaneroller.com
US Coatings	Polyurethane finishes	St. Louis	uscoatings.com

5. Alternative soybean industrial product opportunities

Soybean components have market potential in various other industrial product markets. This chapter introduces those potential uses and forces shaping these markets.

5.1 Fuel

Soybean oil represents one feedstock used in fuel applications that range from biodiesel to renewable diesel to additives. This section highlights trends relevant to each of these types of applications.

Biodiesel: made from soybean oil
Soybean oil represents an important feedstock for the U.S. biodiesel industry. Approximately 79% of soybean oil directed to industrial uses in 2020 was for biofuels (marketviewdb.centrec.com). Other feedstocks used in U.S. biodiesel production include canola oil, distillers corn oil, choice white grease, poultry fat, inedible and tech tallow and used cooking oil. Biodiesel is made through a chemical process called transesterification (biodiesel.org/what-is-biodiesel/biodiesel-basics). Although biodiesel can be used in neat (100%) form, it is typically used in blends with petroleum diesel fuel. The most common blends in commercial use range from 5% by volume (B5) to 20% by volume (B20).

In November 2021, the U.S. biodiesel industry's annual production capacity totaled roughly 2.389 billion gallons from 85 plants (eia.gov/biofuels/biodiesel/production). Missouri's capacity ranked third in the U.S. with 243 million gallons per year, according to U.S. Energy Information Administration. Exhibit 5.1.1 lists Missouri's biodiesel plants by facility name, location, feedstock and capacity.

Exhibit 5.1.1. Missouri biodiesel plants, locations, feedstock and capacity

Facility	Location	Feedstock	Capacity (MGY)
AGP	St. Joseph	Soy oil	42
ADM	Deerfield	Soy oil	50
Ethos Alternative Energy of Missouri LLC*	Lilbourn	N/A	5
Lakeview Biodiesel LLC**	Moberly	Soy oil, corn oil, white fats, used cooking oil	10
Mid-America Biofuels	Mexico	Soy oil	60
Natural Biodiesel Plant LLC**	Hayti	Multi-feedstock	5
Paseo Cargill Energy LLC	Kansas City	Soy oil	56
Seaboard Energy Missouri LLC	St. Joseph	Animal fats/corn oil	35

* Not operational
** Operational but not running (March 2022)
Source: Missouri Soybean Association and Biodiesel Magazine (biodieselmagazine.com/plants/listplants/USA)

Looking forward, U.S. biodiesel plants will represent one type of soy-derived fuel. Renewable diesel or other biofuels may also use soybean oil as feedstock material. To ensure they have

adequate feedstock, Missouri biodiesel facilities may consider how to strengthen feedstock relationships or contracts.

Renewable diesel: made from soybean oil

Derived from biomass, renewable diesel refers to transportation fuel that can be used in diesel engines (afdc.energy.gov/fuels/emerging_hydrocarbon.html). It is produced in a high-temperature, high-pressure process (i.e., hydrotreating) similar to the environment found in a traditional refinery. Renewable diesel is a complete substitute for petroleum diesel, meaning it can represent as much as 100% of a usable fuel, and it meets the ASTM D975 specification for petroleum-based diesel fuel. Feedstocks used in renewable diesel production include soybean oil, waste oils, other plant-based oils, fats and greases. Approximately 8 pounds of feedstock is needed to produce 1 gallon of renewable diesel for most processes (agriculture.com/news/business/renewable-diesel-boom-is-wild-card-for-us-soybeans).

Biodiesel and Renewable Diesel Uses

- **Biodiesel:** Used in blends with petroleum diesel — no more than 20% biodiesel
- **Renewable diesel:** Can completely replace petroleum diesel or be used in blends

To see the estimated inputs and outputs involved in biodiesel and renewable diesel production, see Exhibit 5.1.2. Little data have been published concerning the renewable diesel energy balance equation, but Exhibit 5.1.2 represents the data that have been available. In both cases, inputs total 100 MJ. As noted, biodiesel production requires more natural gas as an input compared with renewable diesel production. Electricity needs are greater in renewable diesel production than they are in biodiesel production (Danish Energy Agency and Energinet 2017).

Exhibit 5.1.2. Inputs and outputs involved in biodiesel and renewable diesel production

	Biodiesel (fatty acid methyl esters)	Renewable diesel (hydrogenated vegetable oil)
Inputs	• Vegetable oil: 95.2 MJ • Methanol: 4.64 MJ • Natural gas: 2.55 MJ • Electricity: 0.35 MJ	• Fats and oils: 88.07 MJ • Hydrogen: 10.49 MJ • Natural gas: 0.68 MJ • Electricity: 0.76 MJ
Outputs	• Fatty acid methyl esters: 90.3 MJ • Glycerine: 3.91 MJ • Energy loss: 5.83 MJ	• Hydrogenated vegetable oil: 84.99 MJ • Naptha: 6.6 MJ • Fuel gas: 3.3 MJ • LPG: 2.75 MJ • Heat loss: 2.37 MJ

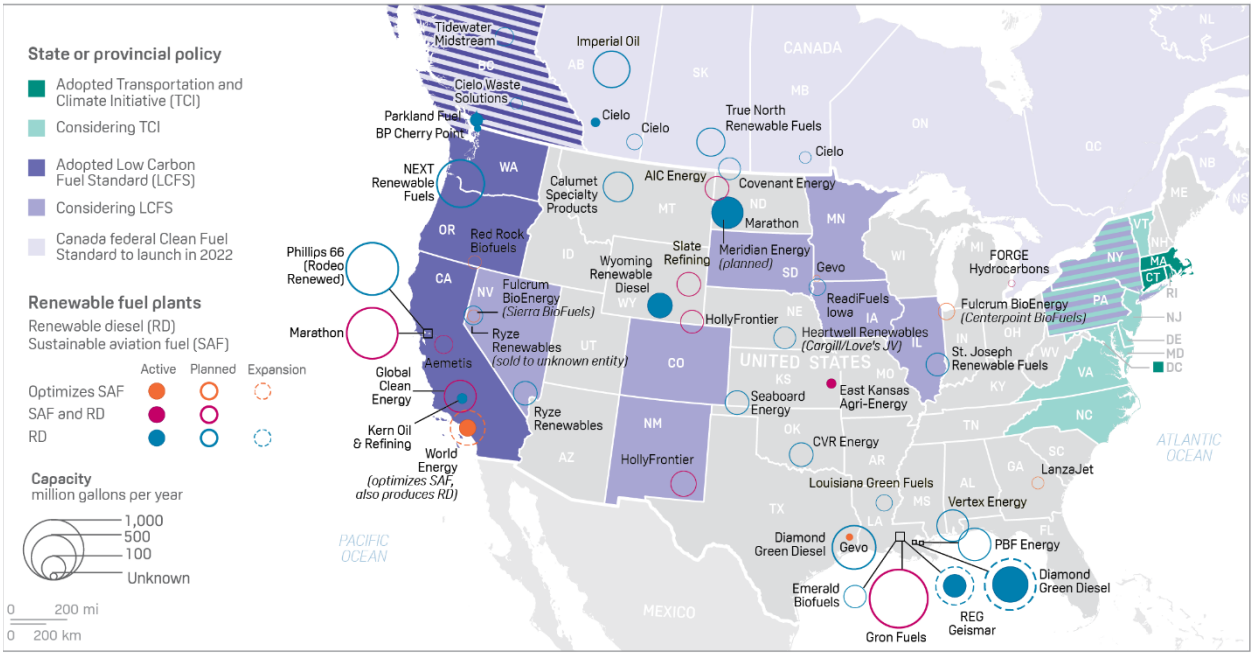
Source: Danish Energy Agency and Energinet (2017)

Multiple policies are driving renewable diesel growth. These include California's Low Carbon Fuel Standard (LCFS), Renewable Fuel Standard (RFS) and blender's tax credits that have generated financial incentives to expand renewable diesel production capacity (ers.usda.gov/webdocs/outlooks/102821/ocs-21l.pdf?v=5891.6). The country's biodiesel tax credit expires at the end of 2022 if Congress takes no action. The credit provides $1 per

gallon for eligible blends of biodiesel and renewable diesel. Past legislation has provided retroactive coverage, but production has shown strength in years when the credit was known to be in effect (eia.gov/todayinenergy/detail.php?id=42616). A renewable diesel plant involves more capital expenditures than a biodiesel plant. Most company announcements have suggested traditional refineries have been retrofitted for producing renewable diesel.

In the U.S., renewable diesel annual production capacity at six plants was slightly more than 1 billion gallons by the end of 2021 (eia.gov/biofuels/renewable/capacity). Proposed or announced renewable diesel projects would add 5 billion gallons or more capacity by 2024, assuming all facilities are built and begin processing. Exhibit 5.1.3 shows locations of active and planned renewable diesel plants along with other renewable fuel plants.

Exhibit 5.1.3. Renewable fuel plants, October 2021



Source: S&P Global Platts; EIA.(https://www.spglobal.com/platts/en/market-insights/latest-news/agriculture/091621-feature-us-refiners-delve-deeper-into-saf-production-on-policy-support-hopes)

Most analysts don't predict all announced renewable diesel capacity to be built. Industry tends to estimate that annual renewable diesel production capacity will likely range from 2 billion gallons to 3 billion gallons by 2025. This renewable diesel production would add to existing biodiesel capacity. Many oil companies are partnering with agricultural companies to secure feedstock. For example, Chevron and Bunge have formed a joint venture that will double soybean crushing capacity from Cairo, Illinois, and Destrehan, Louisiana, plants by 2024 (bunge.com/news/chevron-bunge-announce-proposed-joint-venture-create-renewable-fuel-feedstocks).

Exhibit 5.1.4 shows how increased renewable diesel production may influence the soybean industry. This scenario assumes all production capacity sources soybean oil as a feedstock. If all announced production capacity were built, then it could utilize approximately 85 million acres of soybeans to produce renewable diesel.

Exhibit 5.1.4. Potential soybean demand from increased U.S. renewable diesel production

Billion gallons	Soybean bushels	Acres
1	683,760,684	13,407,072
2	1,367,521,368	26,814,144
3	2,051,282,051	40,221,217
4	2,735,042,735	53,628,289
5	3,418,803,419	67,035,361
6	4,102,564,103	80,442,433

Note: Assumes 51-bushel soybean yield per acre, 11.7 pounds of soybean oil per bushel and 8pounds of soybean oil feedstock per gallon of renewable diesel.

Sustainable aviation fuel: made from soybean oil

Sustainable aviation fuel (SAF) shares similarities with conventional jet fuel, but it's created from sustainable feedstocks (energy.gov/eere/bioenergy/sustainable-aviation-fuels). Possible feedstocks include soybean oil, other fats and oils, ag residues, manure, wood wastes and energy crops. When combined with conventional jet fuels, SAF can represent up to 50% of the blend.

SAF can lower the aviation sector's carbon intensity or footprint. Therefore, many airlines and airports are looking for alternative fuels to meet sustainability and environmental goals or mandates (nrel.gov/docs/fy21osti/78368.pdf). The jet fuel market is large and growing. In 2019, U.S. jet fuel consumption averaged approximately 1,743,000 barrels per day, which represented about 25% of global consumption (eia.gov/opendata/qb.php?category=2135044).

Renewable diesel plants can be modified to produce SAF. Capital needs and energy requirements are greater in a SAF plant compared with renewable diesel or biodiesel plants. Exhibit 5.1.3 shows locations of existing or planned SAF plants. East Kansas Agri-Energy located in Garnett, Kansas, is the facility located most closely to Missouri. The plant began as a 35-million-gallon ethanol plant. It has since expanded into serving renewable diesel and SAF markets. It had 3 million gallons of annual production capacity as of Jan. 1, 2021 (eia.gov/biofuels/renewable/capacity). In Hugoton, Kansas, Seaboard Energy has invested in a renewable diesel plant. Using animal fat and vegetable oil, the renewable diesel plant has the capacity to produce 85 million gallons of renewable biodiesel. The Hugoton site also includes a greenfield fat and oil pretreatment plant, hydrogen plant and biodiesel blending and shipping infrastructure. Biodiesel produced at the company's Guymon, Oklahoma, and St. Joseph, Missouri, facilities could be blended and shipped from the Hugoton facility. Previously, the Hugoton site operated as an Abengoa ethanol facility (biomassmagazine.com/articles/18000/seaboard-energy-builds-renewable-diesel-plant-in-hugoton-kansas).

Research has studied what feedstocks can be used and how to optimize SAF production. For example, the USDA Agricultural Research Service has evaluated approaches to use high-oleic soy oil in jet fuel. A challenge with existing soy jet fuel is its lack of aromatic compounds, which lower SAF's percentage in blended fuel (biodieselmagazine.com/articles/2517862/usda-makes-air-travel-more-sustainable-with-

soy-fuel-innovations). Made from alkyl compounds, tetralins and naphthalenes, aromatics have low specific energy, help fuels have the appropriate density and contribute seal-swelling capacity. They also, however, can lead to fuels not burning cleanly (energy.gov/eere/bioenergy/downloads/sustainable-aviation-fuel-review-technical-pathways-report). The ASTM has approved multiple pathways to produce SAF. Using lipids represents just one of those pathways. Because of the higher investment costs tied to SAF production, most industry analysts believe further policy changes will be necessary to increase SAF use.

SoyShield and SoyUltra: fuel additives made from soybean oil
Schaeffer Manufacturing has operated in St. Louis since 1839. It manufactures products such as engine oils, fuel additives, greases, gear lubricants, hydraulic fluids, metalworking fluids, food-grade lubricants and motorcycle lubricants. It uses soybean oil to make two fuel additives: SoyShield and SoyUltra (schaefferoil.com).

The all-season, multifunctional SoyShield may be added to all diesel fuels. It's particularly well-suited for low-sulfur and ultra-low-sulfur diesels (schaefferoil.com/soyshield.html). The product combines methyl soyate biodiesel with an additive package. Benefits attributed to SoyShield include making a four-point improvement in cetane number, enabling easier starting during cold weather, improving fuel economy by as much as 5% and promoting storage life (schaefferoil.com/documents/50-139A-td.pdf).

The soybean oil-based SoyUltra fuel additive is formulated for use in gasoline and ethanol blends that fuel two- and four-stroke gasoline vehicles (schaefferoil.com/soyutlra.html). SoyUltra's components include methyl soyate fuel made from soybean oil and an additive package that's ashless. Quantifiable performance benefits tied to SoyUltra include as much as a 2% increase in fuel economy for new vehicles and 5% for old vehicles and 40% increase in fuel lubricity (schaefferoil.com/documents/34-131C-td.pdf).

5.2 Transportation

Several innovations made from soybean components have application as road treatment products or other transportation goods. The following summaries highlight key points about these technologies and how they're used. Plus, the summaries identify potential industry associations that may provide access to individuals who make decisions about using these types of products.

EPIC EL Dust Suppressant: made from soybean oil and glycerin
The soybean-based EPIC EL spray suppresses dust when applied to locations where vehicles or industrial, agricultural or material handling equipment create dust (bioblend.com/wp-content/uploads/EPIC-EL-Dust-Suppressant-04172021-Final-1.pdf). Its benefits include preserving the integrity of roadway surfaces and reducing dust-related air pollution that can affect respiratory health and other health-related risks ("What biobased Products Can Do For Your County, Community or Company, United Soybean Board). The dust may also inhibit visibility on and near roadways and affect traveler safety (soybiobased.org/videos).

Compared with products made using magnesium and calcium chloride, EPIC EL lasts longer. It also can use traditional application equipment and doesn't corrode equipment. The product has received certification from the USDA BioPreferred Program. Illinois-based BioBlend markets EPIC El (bioblend.com/wp-content/uploads/EPIC-EL-Dust-Suppressant-04172021-Final-1.pdf). North Dakota State University, the North Dakota Soybean Council and the United Soybean Board supported the product's development ("What biobased Products Can Do For Your County, Community or Company, United Soybean Board).

EPIC EL applications include roads, construction sites and wind farms (soybiobased.org/new-soy-biobased-dust-suppressant-available-to-help-clear-air-for-rural-and-urban-alike). An Upper Great Plains Transportation Institute representative has described two situations where EPIC EL product have value (soybiobased.org/videos):

- Intersections where gravel roads meet
- High-traffic gravel roadways

Construction Management Association of America

Construction sites represent one potential EPIC EL user. The product can suppress dust at construction sites. The Construction Management Association of America convenes construction managers who work for federal, state or local governments; private-sector businesses; construction consultancies; and other organizations that support construction project management. The association, which has a stated goal to improve U.S. infrastructure, has more than 16,000 members.

Member benefits include access to training materials, a certification program and conferences. Several local chapters have organized, though Missouri doesn't have one. Find more information at cmaanet.org.

If they apply EPIC EL to gravel roadways, then users may need to add new gravel less often. As vehicles travel roads, they create dust as they stir the fine material found in the roadway material. Wind then carries away those fine particles. This effectively reduces the material available to cover roadways. Each vehicle traveling gravel roads causes about 1 ton per year of roadway material to leave the site as dust (soybiobased.org/videos).

Missouri Association of County Transportation Officials

The nonprofit Missouri Association of County Transportation Officials provides opportunities for its members to cooperate and learn, so they can better serve the public through constructing and maintaining bridges and highways. Members include county engineers, public works directors, road and bridge administrators, road supervisors and superintendents.

The organization hosts an annual conference that allows attendees to learn, network and peruse the exhibit hall. It has scheduled its 2022 conference to take place from Oct. 18-19 in Columbia, Missouri. The conference may present an opportunity to share about soy-based road treatment products, such as the EPIC EL dust suppressant.

Find more information about the association at gomacto.com.

When applied to a surface, EPIC EL dries similarly to calcium chloride. On a warm sunny day, it will dry in 30 minutes to 45 minutes, but drying time would extend to longer periods during

cool, cloudy weather. If temperatures fall below the freezing point, then EPIC EL must not be applied. Users in at least nine states have used the product. Those include neighboring Iowa, Illinois and Kansas. The product has the potential to be used nationwide. Buyers may purchase EPIC EL as a concentrate or emulsion ("What biobased Products Can Do For Your County, Community or Company, United Soybean Board). A fact sheet from BioBlend describes that the concentrate must mix with water, and an agitator can mix the blend. In some cases, the blend may be heated (bioblend.com/wp-content/uploads/EPIC-EL-Dust-Suppressant-04172021-Final-1.pdf).

PoreShield: concrete enhancer made from soy methyl ester-polystyrene
Concrete treated with PoreShield has more durability to resist breakdown attributed to salt, deicing products and freezing-and-thawing weather conditions. The product works because it fills empty pores throughout poured concrete (indianasoybean.com/checkoff-investment/new-uses-innovation). The product also has a "self-sealing" habit, meaning it maintains its fluid nature and can fill new cracks that form over time (poreshield.com/wp-content/uploads/2021/06/PoreShield_Product_Sheet_SME_5_21_R03.pdf). A single PoreShield application can impart these benefits for a 10-year period (indianasoybean.com/checkoff-investment/new-uses-innovation).

Penetrating through the concrete pores presents an advantage relative to how other concrete sealants function. The alternatives only form a surface-level protective film that may degrade after two years or three years. Concrete treated with PoreShield may last five times to nine times longer, according to some research (poreshield.com). To develop and test the product, three entities collaborated: the Indiana Department of Transportation, Purdue University's Civil Engineering Department and the Indiana Soybean Alliance (indianasoybean.com/checkoff-investment/new-uses-innovation).

Possible PoreShield applications include bridge decks, highways, parking garages, sidewalks, retaining walls, barns, stadiums and spillways (poreshield.com). The product can cover horizontal and vertical surfaces (poreshield.com/wp-content/uploads/2021/06/PoreShield_Product_Sheet_SME_5_21_R03.pdf). Made from 93% biocontent, PoreShield has the USDA BioPreferred certification (poreshield.com).

Missouri Municipal League

The nonprofit Missouri Municipal League represents cities, towns and villages across the state. More than 600 municipalities, 100 affiliates and 31 associate members participate in the association, which provides member benefits including access to newsletters, legislative bulletins and *Missouri Municipal Review* magazine. The magazine accepts advertising, and public works is part of its coverage. The magazine may represent a channel to promote soy-based road treatments such as PoreShield to municipal public works departments and decision makers. Find more information about the Missouri Municipal League at mocities.com.

The application is clean. The product doesn't require applicators to use personal protective equipment, and it doesn't present contamination problems if it enters water bodies or is applied to land. That's due to the nontoxic product releasing low levels of volatile organic compounds. Cleanup is easy, too. It only demands a soap and water treatment

(poreshield.com). Every mile of treated road consumes about 400 bushels of soybeans (indianasoybean.com/checkoff-investment/new-uses-innovation).

RePlay: asphalt sealant and preservation agent made from agricultural oil
Available from BioSpan Technologies, RePlay preserves asphalt. To protect asphalt surfaces, RePlay prevents asphalt oxidation and erosion.

After applying RePlay, asphalt surfaces are less likely to have potholes form and experience edge rutting and cracking along the center line. This protection is made possible as RePlay can penetrate as deep as 1.25 inches below the asphalt surface. When the asphalt surface absorbs RePlay, it's less likely to absorb moisture (biospantech.com/products/replay).

Transportation Engineers Association of Missouri

Founded as the Highway Engineers Association of Missouri, the Transportation Engineers Association of Missouri seeks to provide education and enhance communication among the state's transportation engineers.

The association hosts an annual conference. The 2022 event is scheduled for March in Osage Beach, Missouri. The conference features exhibitor booths and educational sessions. The conference may present an opportunity to build awareness of soy-based road treatments, such as the RePlay asphalt sealant. Find more information about the conference at teamconference.org.

Goodyear tires: tires made from soybean oil to displace petroleum
The United Soybean Board and Goodyear have expressed interest in collaborating to create new products. The tire company has already achieved a milestone by using 25% more soybean oil by 2020. Its long-term goal states to replace the petroleum-based oils used in its products by 2040. Soybean oil may displace some petroleum-based oil used in tires. Adding soybean oil can make rubber tires more flexible in cool temperatures. Plus, the soybean oil enables tires to achieve better traction on wet or snowy roads.

By weight, oil represents 8% of a typical tire. Four Goodyear tires already use soybean oil as a tread compound. In two of these products, the tread contains 100% soybean oil. The other two products list soybean oil as a tread compound. The petroleum-based oil reduction in these products ranges from 42% to 62%.

5.3 Other uses

Other industrial products manufacturers create products from soy-based inputs. Described in this section, these manufacturers — two of which operate in Missouri — represent potential buyers of Missouri-produced soybean inputs.

Express Chem: mastic removers made from soybean oil-derived methyl ester
Self-described as a "full-service waste management and industrial cleaning company," Express Chem based in Kirkwood, Missouri, markets mastic removers that include soybean components (expresschem.com/about-us). Buyers may use Mast Away Soy-Pro Mastic Remover to lift the mastic adhesive — black mastic and yellow carpet glue — that attaches vinyl asbestos tile, vinyl composite tile, ceramic tile or carpet to subfloor surfaces. It's an alternative to petroleum-based options. The company recommends the product for schools,

hospitals and occupied buildings. Competing products include Bean-e-doo, Sentinel 909 and Control Soy (masticremover.com/shop/soy-pro-mastic-remover).

For the MA-99 Soy-Pro Mastic Remover, the product's safety data sheet lists the following components: nonylphenol, ethosylated; methyl ester, soybean oil; and D-Limonene. The end product is 70% to 100% methyl ester from soybean oil (masticremover.com/wp-content/uploads/2018/03/MA-99-Soy-Pro-SDS.pdf). A 5-gallon pail would sell for $80, and to purchase a 55-gallon drum, the cost would total $713 (masticremover.com/shop/soy-pro-mastic-remover). A second product — MA-98 Soy HP — has similar applications (masticremover.com/wp-content/uploads/2019/01/MA-98-Tech-Data-Sheet.pdf). Its safety data sheet mentions the following components: nonylphenol, diethylene glycol butyl ether and methyl ester from soybean oil. The latter may represent 50% to 100% of the total concentration (masticremover.com/wp-content/uploads/2019/01/MA-98-Soy-HP-SDS.pdf).

The business began in 2009 as a Chemisphere Corporation division. Its first mission involved selling industrial products to U.S. and Canadian contractors. As the Express Chem business grew, it began providing services to manufacturing and industrial facilities. In particular, it found a niche in cleaning bulk soybean oil and vegetable oil tanks. Today, its services include vacuuming tanks, hydro-blasting pipes, cleaning tanks and removing and recycling waste materials (expresschem.com/services-2).

Soya System: hair care products made with soy protein

Soya System claims its products "are the first in the world to contain hydrolyzed soya protein." The company sells shampoos, conditioners and styling aids. All three of its shampoo products and all three of its styling aids feature the hydrolyzed soy protein. In the company's marketing materials, one of the four conditioner products specifically lists hydrolyzed soy protein as a component (soya.com).

When developing its hair care products, Soya System uses enzymes to break down soy protein into the appropriate particle size to penetrate hair. Unlike the process used to make other hair care products, Soya System's process uses no acids (soya.com). The product's pure ingredients, including hydrolyzed soy protein, leaves no film that can dull hair and add weight to it. Because of the benefits it offers, the hydrolyzed soy protein carries a premium. It has been several multiples more expensive than alternative protein sources (soyinfocenter.com/pdf/235/Rals.pdf).

The company operates from St. Louis (soya.com). It has sold its hair care products since the early 1980s. A 2020 publication from the Soy Info Center describes that the hydrolyzed soy protein technology originated from Ralston Purina, which found the technology to be cost-prohibitive to use for its own purposes (soyinfocenter.com/pdf/235/Rals.pdf).

A 2016 story from *Missouri Life* describes that Soya System originally developed its hydrolyzed soy protein-based hair care products for the Grabber School of Hair Design and the area salons it operated (issuu.com/missourilifemagazine/docs/ml0612-elifelr). In September 2021, the school on its website shared that it has continued to make Soya System products available to its customers (grabberschool.edu/soya-hair-care-products.html). Wholesale distributors have represented another key market for Soya

System products. When those firms purchase Soya System products, they then resell them to beauty salons (soyinfocenter.com/pdf/235/Rals.pdf).

Roof Maxx: roof shingle rejuvenator made from soy oil

Based in Westerville, Ohio, Roof Maxx specializes in treating roof shingles to extend their useful lives. After they're installed on roofs, asphalt shingles over time become dry and brittle, which makes them less capable of sheltering homes as weather and temperatures change. The Roof Maxx oil soaks into aging shingles to make them more flexible, durable and waterproof. A roof can last five years longer after its shingles have had one Roof Maxx treatment. The company offers a five-year warranty. If treated every five years, then roofs may last 15 years longer, according to tests done at The Ohio State University. The Ohio Soybean Council supported Roof Maxx's development (roofmaxx.com).

The Roof Maxx treatment can save money because it may cost only about one-fifth of what's typical for a roof replacement. Plus, by extending shingle life and delaying reroofing, the product can reduce the shingle waste that's diverted to landfills. According to the company, a Roof Maxx treatment keeps 3.8 tons of trash from entering landfills. Treating a roof instead of replacing shingles also saves on carbon dioxide emissions. The USDA BioPreferred program has certified that Roof Maxx has 86% bio-based materials (roofmaxx.com).

Midwest Roofing Contractors Association

The Midwest Roofing Contractors Association formed in 1950 and attracted members from Nebraska, Kansas, Oklahoma and Missouri. Roofing contractors who join receive benefits such as discounted annual conference registration, access to training, subscription to an association magazine and ads in member directories.

The association has a technical and research committee that pursues research into understanding the value and performance of roofing systems.

Find more information at mrca.org.

Roofing and Siding Contractors Alliance Inc.

Based in St. Louis, the Roofing and Siding Contractors Alliance has created a network of area commercial and residential roofing and siding contractors.

The alliance provides member services such as education, labor union relations and a consumer advocacy protection program. The organization also has stated a code of ethics for members to pledge to uphold.

Find more information at rsca-inc.org.

Home Builders Associations

Home builders associations throughout Missouri list roofing contractors and suppliers as members. The specific member benefits vary by organization, but they include education and information access. The following home builders associations in Missouri may help to reach roofers:

- Home Builders Association of Central Missouri (hbacentralmo.com)
- Home Builders Association of Columbia (columbiahba.com)
- Home Builders Association of Greater Kansas City (kchba.org)
- Home Builders Association Southwest Missouri (hbabuilders.com)
- Home Builders Association St. Louis (stlhba.com)

SYNLawn: synthetic grass backing made from soy polyol

A type of artificial grass, SYNLawn features a backing that's made from a soy-based polyol. Compared with petroleum-based alternatives, the backing — branded as EnviroLoc — uses soybean oil to reduce petroleum polyurethane use by 60% (synlawn.com/news/soy-backed-synlawn-solving-problems-coast-to-coast). SYNLawn has several products listed with the USDA Certified Biobased Product label (synlawn.com/press-releases/u-s-soy-turf-to-cover-more-ground-than-ever-in-2021). Additionally, the company has released new iterations of the product to improve its performance. For example, in February 2022, SYNLawn introduced artificial grass made with EnvironLoc+, which is a soy-based backing that has a coating that gives the product antifungal and antialgae properties. The coating makes the product particularly well-suited for individuals who suffer from respiratory allergies (globenewswire.com/news-release/2022/02/08/2381030/0/en/SYNLawn-Debuts-Exclusive-EnviroLoc-Backing-System.html).

Uses of the SYNLawn synthetic grass include sports fields, rooftops and road medians. In addition to being made from renewable resources, the product can help users to conserve water after it's installed on surfaces (synlawn.com/press-releases/u-s-soy-turf-to-cover-more-ground-than-ever-in-2021). Between 2008 and February 2022, 250,000 installations worldwide had used the SYNLawn artificial turf. Those installations covered 162 million square feet (hoosieragtoday.com/soy-based-turf-one-of-over-1000-soy-based-products-available-today).

Missouri Field Designers and Turf Installers

Missouri is home to multiple firms that design field surfaces and install artificial turf. The following list names several of these businesses, which may promote the soy-based SYNLawn products among their clients.

- Byrne and Jones Construction, Bridgeton, Missouri (byrneandjones.com)
- Hall Turf, Kansas City, Missouri (hallturf.com)
- Jeffrey L. Bruce & Co., Lee's Summit, Missouri (jlbruce.com)
- Mid-America Sports Construction, Lee's Summit, Missouri (mid-americasportsconstruction.com)
- Paric Corporation, St. Louis, Missouri (paric.com)

Sports Field Management Association

Based in Lawrence, Kansas, the Sports Field Management Association attracts professionals responsible for field upkeep at sports stadiums, universities, colleges, schools and parks and recreation sites. Members manage grass and synthetic fields. Originally called the Sports Turf Managers Association, the organization recently rebranded.

In the U.S., 34 satellite chapters exist. Missouri has three chapters:

- Gateway chapter (gatewaystma.squarespace.com)
- MoKan chapter (mokanstma.org)
- Ozarks chapter (sportsfieldmanagement.org/ozarks-chapter)

Find more information about the Sports Field Management Association at sportsfieldmanagement.org.

6. Recommendations

Based on the industrial products market research conducted for this project, Exhibit 6.1 identifies strengths, weaknesses, opportunities and threats related to expanding Missouri industrial use of Missouri-produced soybean ingredients.

Exhibit 6.1. SWOT analysis for Missouri soybean industry increasing in-state use of soybean components for industrial uses

Strengths	Weaknesses
• Based on jobs data, Missouri has a high concentration of industries that may use soy (e.g., manufacturers of storage batteries; power, distribution and specialty transformers; explosives; and unlaminated plastics film and sheet, except packaging). • Several Missouri firms have innovated products made from soy inputs (e.g., Express Chem, Soya System). • The MSMC industrial products investments can offer sustainability or renewable benefits. • Manufacturers may seek a local supply of soy components to stabilize access to inputs. • Emerging in-state investment infrastructure (e.g., venture capitalists, angel investors) offers financial support to startups.	• In some cases, soybean oil competes with other feedstocks that have a price and first-mover advantage. • Relatively small shares of soybean oil have been used for industrial purposes — the exception being biofuels. Therefore, these markets have been relatively niche but require efforts to open and sustain. • Missouri has trailed other states in installing small and large-scale batteries — those that store energy and may use soy components. • Industrial products manufacturers may not have the margins to pay premiums for inputs, despite their claims (e.g., non-GMO) attached to those inputs.
Opportunities	**Threats**
• Renewable diesel and sustainable aviation fuel innovations may increase soy oil use. • As building infrastructure investment grows, construction firms have the potential to demand more blasting agents and oxidizers. • To incentivize mining and construction companies to use explosives made from materials other than petroleum, an opportunity exists to create a procurement preference or get buy-in for alternatives. • Adoption of electric vehicles and deployment of large-scale storage batteries has expanded markets for batteries — potentially those made with soy carbon. • Light vehicle manufacturers may be targets to use electric batteries made from soy carbon and soy-based polyurethane materials. • Polyurethane manufacturers may use soy-based polyol in many products (e.g., building and construction materials, transportation and marine products, furniture and bedding).	• More industrial users (e.g., renewable diesel producers) sourcing soybean oil would increase the oil's price and affect the economics of other soy-based product manufacturing (e.g., biodiesel). • Much battery manufacturing occurs overseas and may limit U.S. input sales. • Coal mining has been a major use of some explosives. Switching to alternative energy may affect explosives demand. • U.S. consumers have shown more hesitation to adopt electric vehicles than drivers in international markets. • Use of renewable inputs may rely on policy decisions, which are difficult to foresee and may change. • Most analysts don't predict all announced renewable diesel capacity to be built. • Public and policy support of efforts such as the RFS and LCFS is needed to grow low-carbon solutions' adoption.

To increase Missouri soybean demand for industrial applications, Exhibit 6.2 reports multiple recommendations.

Exhibit 6.2. Recommendations to increase soybean demand in industrial products

Category	Recommendations
Goal	• **Elevate Missouri-produced soy component use in industrial products manufactured by Missouri facilities.**
Strategy	• For each MSMC-commercialized technology, prioritize one market to understand and ultimately reach.
Tactics	• Weigh the market opportunity with other factors (e.g., policy environment, competition) to choose the opportunities that fit best with available resources. • Demonstrate the soy-based product's performance improvements, and document those findings in promotional materials.
Strategy	• Establish a boots-on-the-ground effort to convert Missouri industrial products manufacturers into soy component users.
Tactics	• Identify an industry liaison who can champion using soy components in key applications where MSMC has made investments. • Reach Missouri manufacturers that may demand soy components as inputs to assess their interest in choosing a Missouri-produced soy component. • Engage with industry associations that have members who make decisions about industrial products or components to source and use.
Strategy	• Support other Missouri industrial products manufacturers using soy components.
Tactics	• Connect these manufacturers with supply chain assistance to source Missouri-produced soy components. • Encourage manufacturers to participate in the Buy Missouri program, which requires that at least 51% of a product's content originates from Missouri (buymissouri.net).