

Alternative proteins for farmers and agriculture

Alternative proteins support farmers, expand opportunities for agricultural livelihoods, and help create a healthy, resilient agriculture sector. By supporting alternative proteins through research and development and efficient paths to market, policymakers can make our food system more secure and create new value for farmers and the communities who depend on them.

Alternative proteins support agricultural livelihoods.

Plant-based foods are an \$8 billion retail market in the United States, and six in 10 U.S. households purchased plant-based alternatives in 2022.¹ From wheat to soybeans to so many other crops, American staples serve as essential ingredients for countless alternative protein products, feeding families all over the world. Farmers who incorporate plant proteins and feedstocks into their existing operations enjoy new sources of income while ensuring a more sustainable and resilient future.

Alternative proteins also help farmers and consumers cushion the impact of market fluctuations, such as shocks from inflation, pandemics, and wars, enhancing long-term economic resilience.² Plant-based eggs, for example, rely on a different supply chain than chicken eggs. Unexpected impacts on one may not affect the other—allowing consumers to shift between different products depending on the circumstances.

Creating a supportive environment for alternative proteins can build resilience and eliminate inefficiency in the food system broadly. These technologies support an entirely new sector in which agricultural sidestreams—waste and byproducts from crops and other food products—can be made useful and profitable. For example, products like corn zein and soy straw show potential for use in plant-based protein, cultivated meat, and fermentation.

What are alternative proteins?

Alternative proteins are foods that have the same taste, texture, and experience of animal products that consumers love—just made in different ways:



Plant-based products are made from protein-rich plants, including American staples like soy, oats, wheat, peas, and beans.



Cultivated meat is produced directly from animal cells grown under ideal conditions and is identical to traditional meat at the cellular level.



Fermentation technologies use microorganisms to either make large amounts of protein-rich food or to produce specific ingredients such as whey protein or casein.

Farmers grow the essential crops for alternative proteins.

Most alternative protein research has focused on crops grown in high volumes, which is why today's alternative proteins are largely made from soy, wheat, peas, and beans. Additional research and product development can expand the list of ingredients even further, creating more market opportunities for farmers. Table 1 lists crops that are currently prominent in the market for plant-based protein, as well as those that hold the highest potential for use in alternative proteins as they become widely available and scientific study continues.

Table 1: Plant-based protein sources

Top crops used today for plant-based protein³

soy	rice	peanut
pea	fava bean	sunflower
oat	lentil	quinoa
wheat	mung bean	potato
canola	chickpea	sorghum
almond	navy bean	mycoprotein
corn		

High-potential future protein sources⁴

bambara bean	hemp	pennycress	sugarcane
beach pea	jackfruit	pigeon pea	bagasse
camelina	lima bean	pongamia	tomato pomace
cashew nut	mesquite	potato bean	watermelon seed
chia	bean	pumpkin seed	wheat grass
duckweed	millet	sesame	yam bean
dulse	mushrooms	spirulina	yeast
flax	mucuna bean		

Cultivated meat and fermentation create new markets for commodity crops

In addition to participating in new markets created by plant-based meat and dairy products, farmers will also likely benefit from the emerging cultivated meat and fermentation markets. These products rely on crop-based inputs for ingredients and feedstock. Markets for corn ebb and flow, and alternative proteins represent an economic opportunity for American corn farmers—adding new buyers, diversifying markets, and mitigating the risk of changing demand in the coming years.

Corn can be an important ingredient for cultivated meat and precision fermentation. To make these foods, producers use glucose as a source of energy in the production process—and that glucose often comes from corn.⁷ In the 21st century, production of corn-based glucose has increased by nearly 80 percent.⁸ Using corn-based glucose in alternative protein production could help ensure corn farmers can continue to fuel the economy.

Soybeans can also be a source of protein in cultivated meat production. This new market in biotechnology could offer higher prices and an opportunity to diversify the market. In fact, experts at Purdue University predict soybean farmers will benefit from the growth of cultivated meat.⁹

Whether through plant-based, fermented, or cultivated products, farmers stand to benefit from alternative proteins succeeding in the marketplace.



CASE STUDY Heart-healthy plant-based steak in the Heartland: Building new markets for fava in North Dakota

North Dakota is well-situated to enjoy the growth of plant-based foods. Beyond Meat's plant-based steak uses protein from fava beans, a nutritious, nitrogen-fixing crop that requires no fertilizer—resulting in a final product that is recognized as heart-healthy for consumers.¹⁰ When growers like fifth-generation farmer Steven in Munich, North Dakota transition to crops like fava beans, they can increase their profits and take pride in producing healthy, sustainable food.¹¹

“The return on investment has been, I would say, significantly higher – maybe 20, 25 percent higher than any of the other crops we would replace it with.”

– Steven, North Dakota farmer growing fava beans for Beyond Meat's Steak Product¹¹

Alternative proteins strengthen the agricultural sector through circular economies.

Alternative proteins open new possibilities for ingredient sidestreams to make farmers more money from their existing crops. New technologies in protein production can create new uses for crop byproducts, especially for post-harvest or post-processing crop residues to be developed into feedstock for growing cells.¹² These sidestreams not only reduce waste, they benefit both farmers looking to maximize their earning potential and food manufacturers in need of lower-cost ingredients.

A Good Food Institute analysis of 20 agricultural sidestreams from the eight highest-volume crops in North America has found that 11 are suitable for plant-based food applications, nine were suitable as protein sources for cultivated or fermented cells, and 13 can be used as sources of sugar for those cells.¹³ Although some of these sidestreams are commonly used for animal feed or other low-value applications, many do not have mature value chains and would greatly benefit from new end uses. Building a circular economy through developing alternative proteins would reduce food loss and waste, create value for farmers, and benefit the emerging biotechnology sector by reducing the cost of key ingredients.

Top sidestreams for alternative protein applications from GFI’s “Cultivating alternative proteins from commodity crop sidestreams”

Protein concentrates	Protein hydrolysates	Lignocellulosic sugar
Economic	Economic	Economic
1. Soy meal	1. Soy meal	1. Corn stover
2. Canola meal	2. Soy meal PC	2. Soy straw
3. Wheat bran	3. Corn DDGS	3. Rice hulls
4. Tomato pomace	4. Canola meal	4. Sugarcane trash
5. Wheat gluten	5. Barley BSG	5. Barley straw
6. Rice bran	6. Corn gluten meal	6. Sugarcane bagasse
7. Barley BSG	7. Rice bran	7. Rice straw
Integrated	Integrated	Integrated
1. Soy meal	1. Soy meal	1. Corn stover
2. Tomato pomace	2. Soy meal PC	2. Soy straw
3. Canola meal	3. Corn gluten meal	3. Sugarcane bagasse
4. Corn DDGS	4. Corn DDGS	4. Sugarcane trash
5. Corn gluten meal	5. Tomato pomace	5. Barley husks
6. Wheat bran	6. Tomato pomace PC	6. Soy hulls
7. Barley BSG	7. Barley BSG	7. Canola straw



CASE STUDY Taking a bite out of food waste with corn zein: Researching new uses for agricultural sidestreams in Indiana

Researchers at Purdue University are chewing on a tough problem—what to do with corn zein, a protein-rich byproduct of ethanol production? With support from the Foundation for Food and Agriculture (FFAR), the Plant Protein Enhancement Project is evaluating how zein, which has a tough, chewy quality, could be used to perfect the texture of plant-based meat products. An underutilized and abundant edible resource, corn zein could be just one of many byproducts that finds a new use in plant-based, fermented, or cultivated alternative proteins.¹⁴

“Using a cheap, abundant ingredient to make [plant-based protein] products more attractive to consumers will increase incentives to grow high-protein plants as well as invest in further research to improve their nutritional value.”

– Dr. Jeffrey Rosichan, director of FFAR’s Crops of the Future Collaborative

Alternative proteins help address challenges facing farmers.

Land access is a major barrier for new farmers, with average prices for agricultural cropland more than doubling since 2009.¹⁵ Finding available and affordable land is by far the top challenge facing young farmers in every region of the country according to a 2022 survey: “Over half of all respondents (54 percent), and 75 percent of Black farmers, said that they currently need more access to land, whether to buy or lease.”¹⁶

Alternative proteins use anywhere from 45 to 97 percent less land than conventional meat.¹⁷ Growing crops for alternative proteins can be done on fewer acres than conventional food products, making it easier for young farmers, new farmers, and farmers from underrepresented racial and Indigenous groups to find suitable land for their operations.

Farm consolidation and rising costs are significantly limiting the access and availability of agricultural land to small farmers across the United State. Data from USDA shows that the majority of agricultural revenue is generated by large operations, with most small farms barely breaking even.¹⁸ Alternative proteins use less land and create new, high-value markets for specialty crops often better suited to small family operations. This could allow today’s farmers to increase their revenue and tomorrow’s farmers to enter the sector with a lower up-front investment.

Stewardship is part of the job for today’s farmers, who take their responsibility toward their neighbors and the ecosystem seriously. In 2022, 83 percent of young farmers named one of their farm’s primary purposes as “engaging in conservation or regeneration,” while 97 percent consider their farms “sustainable.”¹⁹

Pollution threatens crop yields, food safety, and the health of farmers and their neighbors. Producing crops used in alternative proteins can help mitigate pollution risks while improving water, soil, and air quality.²⁰ In fact, some important crops such as peas and lentils are nitrogen-fixing, alleviating the need for costly fertilizer.²¹ Alternative proteins offer a solution for farmers to grow the foods we love while regenerating soil and strengthening water quality.



Sustainability benefits:



66-99%
less water use



75-99%
less fertilizer runoff



and up to
99%
fewer GHG emissions

See more at:

gfi.org/resource/environmental-impact

Water scarcity endangers the American food supply. Alternative proteins can reduce water use and alleviate the strains on rivers and aquifers as seen by the ongoing water scarcity crisis in the American West.²² New and diverse crops like mung beans or duckweed can not only feed Americans around the country, they can reduce the overall demand for water in these regions—as they are water-efficient and resilient.

Soil health is also a major concern; over one-third of the Corn Belt’s farmland has already experienced topsoil degradation, causing nearly \$3 billion in annual losses.²³ The eroded soil can reach water bodies, causing sedimentation that degrades water quality. Decreased soil fertility from erosion could create a food production shortfall of 25 percent by 2050.²⁴ Farmers can efficiently grow crops for alternative proteins that require fewer inputs, lessening the effects of runoff and soil erosion.



CASE STUDY Innovation in central Texas: Creating new markets with duckweed

Plantible, a Texas-based startup, is using duckweed to create protein with a tiny footprint.²⁵ Growing the duckweed is easy—all that is needed is shallow concrete pools, recycled water, and off-the-shelf greenhouses—so Plantible decided to scale up production on site in central Texas. Their high-quality RuBisCO protein matches animal protein functionality at a competitive price and a fraction of the footprint—so in water-parched Western states like Texas, it may be duckweed to the rescue.²⁶

“Low-tech is highly scalable and very affordable.”

— Tony Martens Fekini, chief executive of Plantible

CASE STUDY Embracing alternative proteins to save the family farm in North Carolina

Contract hog producers face a slew of challenges; not only are they tasked with maintaining millions of gallons of liquid manure in lagoons, they’re also often expected to take out sizable loans to afford the upfront expenses. The Butler family, longtime hog growers in North Carolina, are taking a new approach, retrofitting the facilities they built for hogs to grow oyster mushrooms instead—no lagoons necessary.²⁷

“[Because] we care about our neighbors, my brother and I took an oath to do whatever we could to lessen our impact.”

—Tom Butler, co-owner of Butler Farms



CASE STUDY Sugar, power, and people in Indiana

When Liberation Labs announced a new fermentation facility in Richmond, Indiana (IN-06), the company cited three reasons to choose the Midwest: high-quality energy, labor, and sugar—specifically, corn sugar.²⁸ The facility, which received a \$25 million loan guarantee from USDA, will use corn dextrose as a feedstock, supporting the state’s corn farmers and processors.

“This type of company and industry is a perfect fit for the Hoosier state given Indiana’s strong agriculture and manufacturing sectors...We love to see innovative new technologies creating quality jobs and career pathways for both today’s and tomorrow’s workforce.”

— Indiana Governor Eric Holcomb²⁹

Alternative protein R&D supports the entire U.S. agriculture economy.

Agricultural research and development plays a crucial role in supporting the entire U.S. agriculture economy. Research-driven growth in the alternative protein sector is poised to benefit farmers, food manufacturers, and consumers alike, resulting in higher-yield crops, increased protein functionality, new food categories, and new uses for agricultural products and sidestreams.

Further, research on alternative proteins has broad cross-benefits in other high-impact research areas. For example, the Tufts University Center for Cellular Agriculture, which focuses on cultivated meat, unites faculty and students from nutrition, medicine, chemistry, engineering, and more.³⁰ These partnerships can create interdisciplinary breakthroughs and new career opportunities for the emerging workforce. Public investments in alternative protein research and development are needed to advance these important opportunities for U.S. agriculture and biotechnology.

“Studies have shown that every dollar invested in agricultural research creates \$20 in economic activity.”

– U.S. Secretary of Agriculture Tom Vilsack³¹



Photo courtesy of
Swedish Temptations

Alternative proteins benefit consumers and society.

Nutrition

In multiple studies, replacing animal meat with plant-based or mycelium-based meat led to statistically significant reductions in overall weight and LDL cholesterol.^{34, 35} Likewise, cultivated and fermented products, while biologically identical to animal products, could be designed to be lower in fat and cholesterol than many foods on our shelves today.

Food security

Alternative proteins contribute to global food security by diversifying protein sources and using vastly fewer resources to produce than other protein sources.³⁶ Most, if not all, ingredients for alternative proteins can be sourced domestically, and there are significantly fewer links in the supply chain. The simplification and localization of production increase overall food system resilience and benefit national security.


Switching to plant- or fungi-based meat can result in:

-9%
LDL cholesterol³⁴

+22%
fiber intake³⁴

-2 lbs
average weight³⁴

+100%
muscle growth rate
among athletes³⁵



Support public investment and a level playing field for alternative proteins.

Alternative proteins promise to create new opportunities for farmers and value for the agricultural sector. In order to deliver on that promise, public investment is necessary to help develop the best technologies, deploy them at commercial scale, and ensure that farmers, processors, and consumers all benefit.³⁷

About GFI

The Good Food Institute is a 501(c)(3) nonprofit working internationally to make alternative proteins like plant-based and cultivated meat delicious, affordable, and accessible. GFI advances open-access research, mobilizes resources and talent, and empowers partners across the food system to create a sustainable, secure, and just protein supply. GFI is funded entirely by private philanthropic support.



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References

- 1) The Good Food Institute. n.d. "U.S. retail market insights for the plant-based industry." Accessed February 11, 2024. <https://gfi.org/marketresearch/#overall>.
- 2) Climate Advisers and The Good Food Institute. 2022. "Why the United States Should Champion Alternative Proteins As A Food and National Security Solution." <https://gfi.org/resource/alternative-proteins-are-a-global-food-security-solution/>.
- 3) The Good Food Institute. n.d. "Deep dive: Plant-based meat crop development." Accessed February 11, 2024. <https://gfi.org/science/the-science-of-plant-based-meat/deep-dive-plant-based-meat-crop-development/>.
- 4) The Good Food Institute. 2021. "Plant Protein Primer." https://gfi.org/wp-content/uploads/2021/02/2021-02-23_Plant_Protein_Primer_GFI.pdf.
- 5) USDA Economic Research Service. 2024. "U.S. corn sweetener supply and use." <https://www.ers.usda.gov/data-products/sugar-and-sweeteners-yearbook-tables/sugar-and-sweeteners-yearbook-tables/#Corn%20Sweetener%20Supply,%20Use,%20and%20Trade>.
- 6) Hossain, Shahadat and Joe Janzen. 2022. "The Impact of Long-Run Declines in Gasoline Use on the US Corn Market." *farmdoc daily* 12: 195. Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign <https://farmdocdaily.illinois.edu/2022/12/the-impact-of-long-run-declines-in-gasoline-use-on-the-us-corn-market.html>.
- 7) The Good Food Institute. n.d. "Deep dive: Cultivated meat cell culture media." Accessed February 11, 2024. <https://gfi.org/science/the-science-of-cultivated-meat/deep-dive-cultivated-meat-cell-culture-media/>.
- 8) *ibid.* USDA Economic Research Service. 2024. "U.S. corn sweetener supply and use."
- 9) Ma, Yanyu, H. Holly Wang, Yizhou Hua, and Shihuan Kuang. 2023. "The Rise of Meat Substitute Consumption and its Impact on the U.S. Soybean Industry." *Purdue Agricultural Economics Report* PAER-2023-25. <https://ag.purdue.edu/commercialag/home/paer-article/the-rise-of-meat-substitute-consumption-and-its-impact-on-the-u-s-soybean-industry/>.
- 10) Beyond Meat. 2023. "Press Release: Beyond Meat® invites consumers on a journey to see the goodness in each step of creating the company's delicious, nutritious, and sustainable plant-based proteins." <https://www.beyondmeat.com/en-US/press/beyond-meat-invites-consumers-on-a-journey-to-see-the-goodness-in-each-step-of-creating-the-company-s-delicious-nutritious-and-sustainable-plant-based-proteins>. American Heart Association. n.d. "Heart Check Digital Grocery List." [https://www.heart.org/en/grocery-list#f:@glcategory=\[Meat%20Substitutes\]](https://www.heart.org/en/grocery-list#f:@glcategory=[Meat%20Substitutes])
- 11) Beyond Meat. 2023. "Meet Steven, Faba Bean Farmer." <https://www.youtube.com/watch?v=dA7PObs8Ofc>.
- 12) The Good Food Institute. 2023. "Cultivating alternative proteins from commodity crop sidestreams." <https://gfi.org/resource/cultivating-alternative-proteins-from-commodity-crop-sidestreams/>.
- 13) *ibid.*
- 14) The Foundation for Food and Agriculture. 2021. "FFAR Grant Uses Corn Protein to Improve Meat Alternatives." <https://foundationfar.org/news/ffar-grant-uses-corn-protein-to-improve-meat-alternatives/>.
- 15) USDA National Agricultural Statistics Survey. August 2023. "Land Values, 2023 Summary." <https://downloads.usda.library.cornell.edu/usda-esmis/files/pn89d6567/9w033j15z/mp48tw728/land0823.pdf>.
- 16) Ackoff, Sophie, Evan Flom, Vanessa García Polanco, David Howard, Jessica Manly, Carolina Mueller, Holly Rippon-Butler, and Lytisha Wyatt. 2022. "Building a Future with Farmers 2022: Results and Recommendations from the National Young Farmer Survey." <https://www.youngfarmers.org/22survey/>.
- 17) The Good Food Institute. 2023. "Environmental benefits of alternative proteins." <https://gfi.org/environmental-impact-pdf>.
- 18) USDA Economic Research Service. 2022. "America's Farms and Ranches at a Glance: 2022 Edition." <https://www.ers.usda.gov/publications/pub-details/?pubid=105387>.
- 19) The Good Food Institute. 2023. "Environmental benefits of alternative proteins." <https://gfi.org/environmental-impact-pdf>.
- 20) *ibid.*
- 21) Spence, Audrey. 2023. "Plant protein for a regenerative food system." The Good Food Institute. <https://gfi.org/blog/plant-protein-for-a-regenerative-food-system/>.

- 22) Flavelle, Christopher, Somini Sengupta and Mira Rojanasakul. 2023. "How America's Diet Is Feeding the Groundwater Crisis." *The New York Times*. December 24, 2023. <https://www.nytimes.com/interactive/2023/12/24/climate/groundwater-crisis-chicken-cheese.html>.
- 23) Thaler, Evan A., Isaac J. Larsen and Qian Yu. 2021. "The extent of soil loss across the US Corn Belt." *Proceedings of the National Academy of Sciences of the United States of America* 118(8), e1922375118. <https://doi.org/10.1073/pnas.1922375118>.
- 24) International Union for Conservation of Nature and Natural Resources. 2019. "Issues Brief: Conserving healthy soils." <https://www.iucn.org/resources/issues-brief/conserving-healthy-soils>.
- 25) Plantible Foods. n.d. "Our Story." Accessed February 12, 2024. <https://www.plantiblefoods.com/our-story>.
- 26) Coren, Michael J. "The plant protein that could push meat off your plate" *The Washington Post*. June 27, 2023. <https://www.washingtonpost.com/climate-environment/2023/06/27/new-plant-based-meat-developing-rubisco-duckweed/>.
- 27) Atwater, Will. "From hogs to mushrooms: a family farmer fights to chart a new path." *North Carolina Health News*. December 6, 2022. <https://www.northcarolinahealthnews.org/2022/12/06/from-hogs-to-mushrooms-a-family-farmer-fights-to-chart-a-new-path/>.
- 28) Inside Indiana Business. "Liberation Labs secures additional funding for Richmond plant." November 30, 2023. <https://www.insideindianabusiness.com/articles/liberation-labs-secures-additional-funding-for-richmond-plant>.
- 29) Indiana Economic Development Corporation. 2023. "Liberation Labs Joins Indiana's Thriving Agbiosciences Sector to Fuel Future of Food." <https://www.iedc.in.gov/events/news/details/2023/01/24/liberation-labs-joins-indiana-s-thriving-agbiosciences-sector-to-fuel-future-of-food>.
- 30) Tufts University Center for Cellular Agriculture. n.d. "Leadership and Collaboration." Accessed February 12, 2024. <https://cellularagriculture.tufts.edu/about/leadership-and-collaboration>.
- 31) United States Department of Agriculture. 2014. "USDA Secretary Announces Creation of Foundation for Food and Agricultural Research." Release No. 0156.14. <https://www.usda.gov/media/press-releases/2014/07/23/usda-secretary-announces-creation-foundation-food-and-agricultural>.
- 32) Chicago Public Library. "Union Stockyards, Part 3: Technology That Changed Chicago." January 21, 2014. <https://www.chipublib.org/blogs/post/technology-that-changed-chicago-union-stockyards-part-three/>.
- 33) Nature's Fynd. 2021. "Nature's Fynd Adds New 200,000 Sq. Ft. Facility in Chicago to Support Rapid Growth." <https://www.naturesfynd.com/press-release/new-facility>.
- 34) Crimarco, Anthony, Sparkle Springfield, Christina Petlura, Taylor Streaty, Kristin Cunanan, Justin Lee, Priya Fielding-Singh et al. 2020. "A randomized crossover trial on the effect of plant-based compared with animal-based meat on trimethylamine-N-oxide and cardiovascular disease risk factors in generally healthy adults: Study With Appetizing Plantfood-Meat Eating Alternative Trial (SWAP-MEAT)." *The American Journal of Clinical Nutrition* Volume 112, Issue 5, 1188-1199. <https://pubmed.ncbi.nlm.nih.gov/32780794/>.
- 35) Monteyne, Alistair J., Mariana O.C. Coelho, Craig Porter, Doaa R. Abdelrahman, Thomas S.O. Jameson, Sarah R Jackman, Jamie R. Blackwell et al. 2020. "Mycoprotein ingestion stimulates protein synthesis rates to a greater extent than milk protein in rested and exercised skeletal muscle of healthy young men: a randomized controlled trial." *The American Journal of Clinical Nutrition*, Volume 112, Issue 2: Pages 318–333. [https://ajcn.nutrition.org/article/S0002-9165\(22\)00802-4/fulltext](https://ajcn.nutrition.org/article/S0002-9165(22)00802-4/fulltext).
- 36) Climate Advisers and The Good Food Institute. 2022. "Why the United States Should Champion Alternative Proteins As A Food and National Security Solution." <https://gfi.org/resource/alternative-proteins-are-a-global-food-security-solution/>.
- 37) U.K. Foreign, Commonwealth, and Development Office and the ClimateWorks Foundation. 2021. "Global Innovation Needs Assessment: Protein Diversity." <https://www.climateworks.org/wp-content/uploads/2021/11/GINAs-Protein-Diversity.pdf>