Alternative Protein Agriculture: Supporting Farmers and Bolstering the Workforce for a Sustainable Transition

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Executive Summary: Alternative proteins are an emerging food technology sector that addresses global environmental, animal welfare, nutritional, and food security issues by offering foods that are not made from conventional animal agriculture. Alternative proteins can be categorized by their manufacturing method, which can be plant-based, microbe-derived, cultivated, or a mix of two or more of such methods. While some types of alternative protein products have recently been commercially available, limitations in technology and ingredients contribute to the higher price points compared to their animal-based counterparts, limiting consumer adoption. Production challenges can be alleviated by synergizing the efforts and resources between alternative protein food companies, research centers, and the agricultural sector. Essential crops for alternative proteins, such as soy and spent grain, are highly sought after, providing potential economic opportunities for the agricultural sector. Research centers, particularly those that specialize in agricultural sciences, can be utilized to provide guidance for farmers and manufacturers. However, farmers who are interested in accessing this market can face several challenges and risks, such as initial yield uncertainties and dependency on new machinery. To address these barriers, we propose policy options to the United States Department of Agriculture (USDA) to establish alternative protein-oriented programs to support farmers and rural communities. These recommendations include investment in workforce training and knowledge-sharing programs, financial incentives for infrastructure support, and establishment of pathways for sidestream development.

I. Introduction

The term "alternative proteins" describes protein sources that are not derived from conventional animal agriculture. These include foods that are either plant-based, microbe-derived, and/or cultivated (Malila et al. 2024). While the term is typically associated with modern innovations like plant-based meat analogues (such as Beyond Meat and Impossible Foods), cultivated meat (sometimes referred to as "lab-grown meat"), and precision-fermented dairy and fats, it also encompasses long-established protein-rich foods such as tofu, tempeh, and seitan, which have been staples in various cultures for centuries. Alternative proteins offer a potential solution for the growing global food system crisis, as agricultural supply chains are disrupted by pandemics and climate change, and animal-sourced foods are undergoing

extensive evaluation (Hefferon et al. 2023). Food accounts for 26% of global greenhouse gas (GHG) emissions, and over half of these emissions are from animal agriculture, indicating a viable target for reducing global GHG emissions (Ritchie 2019). The competing demands on land, water, and energy resources for both humans and animals have contributed to environmental and public health concerns, including animal waste runoff into community water sources (Malila et al. 2024, Hill et al. 2005, Burkholder et al. 2006). Additionally, the increasing global population has driven a greater need for nutritious and sustainable foods, and vegetarianism is on the rise in countries such as the U.S. and Great Britain (World Economic Forum 2022).

In response to these challenges and demands, alternative proteins gained interest globally across multiple stakeholders. In the U.S., the alternative protein market is expected to grow at more than 17.5% compound annual growth rate (CAGR) between 2021 and 2027, while the animal meat market is projected for a 3.21% CAGR during 2021-2028 (Talwar et al. 2024, Fortune Business Insights 2025). The plant-based sector represents most of the current commercially available alternative products and is estimated to grow from $4.9 billion in 2021, which is less than 1% of the overall meat market, to roughly double in 2025 (EY Parthenon 2025). There has been an increase of government and academic investment, such as the inclusion of alternative proteins in a 2022 biotechnology and biomanufacturing innovation Executive Order, the introduction of the Producing Real Opportunities for Technology and Entrepreneurs Investing in Nutrition Act (H.R.5097) in 2023, the formation of biomanufacturing and precision fermentation research and training Tech Hubs as part of the CHIPS and Science Act of 2022, and the creation of multiple centers of excellence dedicated to alternative proteins (Vegconomist 2022, U.S. Congress 2023, U.S. Economic Development Administration n.d., Tufts University Center for Cellular Agriculture 2025, North Carolina State University College of Engineering 2025).

Despite the growing market for alternative proteins, the field faces a major challenge of cost-effective, scalable production and reliable suppliers for key ingredients and equipment (EY Parthenon 2025, Malila et al. 2024). These challenges impact the price parity of alternative protein food products compared to their animal-sourced counterparts, which is a limiting factor of widespread consumer adoption (The Good Food Institute 2022). For example, the most widely accepted alternative products, plant-based foods, can be up to four times the price of conventional products, and a survey found that over 20% of consumers who had tried plant-based meat alternatives said that it was too expensive to buy again (Thompson-Richards 2025). Scaling up the multiple processes to produce alternative proteins for final food products is a costly feat. Substantial resources are needed in order to extract, isolate, or separate alternative proteins from their starting materials, and this requires diverse manufacturing methods. As an example, fermentation generally requires specialized tanks, sterile environments, purification, and drying equipment. This process can be further divided into the type of desired fermentation product, such that submerged fermentation is required for bacteria-derived proteins and solid fermentation is required for algae-derived proteins (Malila et al. 2024). It is estimated that fermentation capacity must grow by more than 200-fold for it to take 1% of the global meat market (Malila et al. 2024, EIT Food 2023). Overall, the alternative protein industry is tasked with identifying cost-effective scale-ups to production.

We have identified farmers to be key players in advancing the alternative protein industry and transforming the food system. There is a need to build a resilient supply chain for alternative protein food producers to obtain the required materials and equipment, and there is currently a shift towards local production of raw alternative protein inputs (EY Parthenon 2025). Interviews from farmers in animal industries suggest that they are open to being involved in alternative protein food production due to the economic opportunity and potential for diversification through participation in the alternative protein supply chain (ProVeg International 2022). Farmers are currently facing financial losses and other unprecedented challenges such as the avian flu outbreak, and such an opportunity may be beneficial for both the farmers and the industry (Pettypiece 2025, Ford 2025).

Farmers entering the alternative protein market must also take on considerable risk such as market uncertainty and regulatory challenges. Potential strategies for farmers to be involved, whether partially or completely transitioning to alternative protein production, include retrofitting existing farming equipment to be used for fungi agriculture or on-farm processing ingredients needed for food manufacturers, such as soy meal concentrates for plant-based foods and corn-derived sugars for fermentation feedstock (ProVeg International 2024, Eastham et al. 2023). However, without support, this involvement would not be accessible for all farmers.

We propose that the U.S. government enact policies that allow farmers to voluntarily participate in the growing alternative protein sector through resources for workforce training, infrastructure support, and sidestream opportunities development.

II. Policy options

i. Option 1: Development of workforce training and knowledge sharing programs

Alternative protein research centers across the U.S., such as Tufts University Center for Cellular Agriculture, provide spaces for research advancements in the field. However, there remains a gap between such research endeavors and the bioeconomy, particularly for both the manufacturing workforce and the farms that may use and be impacted by new technologies. To bridge this gap, there is a need for workforce training programs specific to alternative protein production and manufacturing as well as a communication framework to connect farms, manufacturing, and research.

We propose that the U.S. government utilize its network of existing federal and state-level training and educational programs to train a local workforce in skills relevant to participating in production and manufacturing of alternative proteins, such as food science, bioreactor operation, cell culturing, and protein isolation (Huang 2023). Training in the agricultural sector should also focus on the economic opportunities presented by alternative proteins and implementing methods to incorporate alternative protein farming practices and processing methods into their operations, with the potential for farmers to diversify and strengthen their revenue streams.

Currently, many federally-funded workforce training programs are undersized and underutilized largely due to a lack of knowledge regarding existing programs (Gutter et al. 2020, Hanks and Madland 2018). These existing workforce development programs can be leveraged for alternative protein-focused training programs in biomanufacturing and agriculture without the need for increased spending on new programs, rather focusing on publicizing existing programs. The effectiveness of federally-funded training programs, such as those run by the Department of Labor under the Workforce Innovation and Opportunity Act (WIOA) is severely minimized by insufficient funding and inadequate focus on sectoral specific training (Hanks and Madland 2018). In addition to bolstering federal workforce development programs with sector-specific training, state level programs can also be leveraged to complement the local economy with relevant sector-specific training to maximize impact. Many state-level, sector-specific training programs exist for biotechnology, biomanufacturing, and farming, such as the Maryland Department of Labor Biotechnology training program or the University of Maryland Aspiring Farmer resources. These types of state-level training, in conjunction with expanded federal-level programs, provide a structure to build sector-specific workforce development programs for the alternative protein economy.

A joint framework that combines the strengths of both USDA's Cooperative Extension System (CES) program and Regional Technology and Innovation Hubs program can be leveraged to lay the groundwork for comprehensive, sector-specific training programs to be disseminated to farming and biomanufacturing communities throughout the nation. CES connects farmers and communities through non-credit educational opportunities, and it works with local organizations, particularly in rural and underserved communities, to share agricultural research and knowledge (Gutter et al. 2020). The CES plays a crucial role in connecting farmers to educational resources and can provide another avenue to sharing pertinent information with farmers on developments in the alternative protein research and development sector to help them

prepare for future demands. In addition to federal funding, the CES receives about 20-50% of its funding from various state-level government agencies depending on the state, enabling federal and local agencies to share the initial investment cost while also developing programs relevant to each states' agricultural and economic strengths (The Association for Public and Land-grant Universities). The Regional Technology and Innovation Hubs program, formed through the CHIPS and Science Act of 2022, introduced funding for several Tech Hubs, including in Indiana and in Illinois which together received over $50 million in funding for biomanufacturing and precision fermentation technologies. (U.S. Department of Commerce 2024). Precision fermentation is a method to produce proteins using microbial hosts. These Hubs aim to bring together academic, industrial, government and labor union stakeholders to address needs from research and development to sector-specific training (U.S. Department of Commerce 2024). The combination of the CES community-oriented approach and Hubs' resources can bridge the gap between research, production, and manufacturing methods.

Together, USDA, WIOA, state labor departments, and federally funded research and training centers can provide workforce development programs and connect communities to the information and resources needed to participate in the alternative protein economy. These systems provide a setting for all stakeholders—from farmers to academic researchers—to communicate with each other, building an inclusive and resilient economy (Buys and Rennekamp 2020, Gutter et al. 2020).

Advantages

Workforce training programs directed at specific sectors improve individual worker wages and employment, leading to increased business outcomes (Hanks and Madland 2018). In fact, a study found that workers who underwent sector-specific training in healthcare and IT increased their wages by 19% in the 12 months following training as compared to workers who received no training (Maguire 2010). The alternative protein field could benefit from sector-specific training programs for farmworkers and biotechnology and biomanufacturing workforce development to improve the economic opportunities of individuals and businesses. Educational programs will also provide a needed framework for increased communications between stakeholders in the alternative protein network, including farmers, manufacturers, technology companies, and researchers. Building out training and knowledge sharing initiatives targeting alternative proteins from existing federally funded programs will allow for financial and logistical efficiency, while elevating the voices of all stakeholders.

Challenges

Due to the decentralization of existing training programs, there is potential for a lack of standardization in the training provided, as well as overlap with existing workforce training programs. For example, the National Farmworkers Jobs Program (NFJP), which is run through the U.S. Department of Labor, operates in 49 states and Puerto Rico by providing grants to local government agencies and non-profit organizations that administer a range of workforce support programs tailored to their local needs (Employment and Training Administration 2024). However, these programs are often small and have limited reach, so more programs would most likely increase public awareness and access, thereby improving worker and program outcomes (Hanks et al. 2018). Other challenges exist due to the alternative protein research landscape constantly evolving and facing funding and investment discontinuities, leading to potential uncertainty in training program outcomes. Similarly, on the agricultural side, workers who participate in workforce training may not see a return on their investment if alternative protein practices are not adopted by farms on the predicted timeline (MacMillan et al. 2024).

ii. Option 2: Infrastructure support

Farmers invest significant resources into optimizing their land for specific commodities, and farmers are often hesitant to take on the financial risk required to transition to a different type of product. For example, the infrastructure required for fermentation (namely, fermentation tanks and their installation) is extensive and expensive, and infrastructure has been cited as the limiting factor in the so-called "fermentation bottleneck" (Southey 2024). While farmers may often have the space or

existing buildings to house fermentation facilities, equipment for these facilities can incur startup costs in the millions of dollars, and as with many production industries, these facilities are the most profitable when scaled to produce fermentation products in large batches (ProVeg International 2022, Lever VC 2023). Manufacturing and improving this equipment requires extensive technological effort, yet the USDA has dedicated less than one-hundredth of one percent of its annual budget to alternative protein research and development (Ataman 2024). Ultimately, it is in the best interest of the USDA to provide financial support for transitioning farming infrastructure such as fermentation facilities as the alternative protein market grows and the demands for specific products change.

We propose that policies supporting farming infrastructure and the transition to alternative protein products focus on increasing access to financing, reducing economic burdens, and mitigating loss potential. Financing can be offered by expanding existing loans provided by the federal government, and economic burdens can be reduced by promoting farmer cooperatives that share knowledge and equipment, as well as offering grants and credits to farms that transition to more environmentally-friendly commodities (NCBA CLUSA 2025, ProVeg International 2024). Loss avoidance can take the form of alternative protein subsidies and enhanced crop-revenue insurance. These policies can be incorporated as part of or parallel to programs that align with these aims, such as the USDA's Environmental Quality Incentives Program or USDA Conservation Practice Standards (USDA "Environmental Quality Incentives Program (EQIP)" 2025, USDA "Conservation Practice Standards" 2025). For example, Conservation Practice Standard Code 375 supports improved energy efficiency for agricultural operations, as the development of better alternative protein food manufacturing is expected to produce methods that require less energy than traditional animal farming. The median greenhouse gas emission footprint of plant-based substitutes was found to be 34, 43, 63, 72, 87, and 93% less than those of farmed fish, poultry meat, pig meat, farmed crustaceans, beef from dairy herds, and beef from beef herds, respectively, per 100 grams protein (Santo et al. 2020).

Advantages

Expanding federal loans, grants, and subsidies can help farmers invest in the necessary infrastructure, allowing for accessible and successful transition with reduced financial risk. This policy also aligns with USDA's mission towards rural development (USDA "Mission Areas" 2025) . Because 86% of all farms in the US are small family farms (Lim et al. 2024), they cannot be expected to make these kinds of investments on their own. Government-sponsored infrastructure development in farming communities builds resources and economic flexibility for these families. Alternative proteins then provide a competitive advantage in land, water, eutrophication, and biodiversity implications compared to traditional meat production (Hefferon et al. 2023). Supporting technology advancement will also extend benefits to other industries like pharmaceuticals that use similar equipment, promoting partnerships between sectors and driving research innovation (Bumelis 2025, Carsanba et al. 2021).

Challenges

Even with financial assistance, the upfront costs of transitioning to alternative protein production could remain a burden, as specialized equipment can require additional maintenance expenses. Another potential challenge is limited interest from farmers due to the length of time required to install and become trained on the new technology, particularly in rural areas. Implementation of this policy would increase administrative and financial burdens to USDA existing programs, such as developing criteria for grants, monitoring compliance, and evaluating progress. These burdens would be reduced with Congressional appropriations earmarked for alternative proteins as well as administrative guidance on how to effectively provide grants and monitoring. The USDA could initiate these efforts by providing a comment period for farmers and other stakeholders to register their needs and opinions, thereby allowing USDA officials to estimate overall costs and implementation strategies.

iii. Option 3: Support for sidestream development

Premium pricing limits consumer demand for alternative proteins due to production costs (Talwar et al. 2023). Sidestream development offers a viable strategy to address the issue by valorizing waste crops and repurposing by-products from commercial

agricultural output. This approach can potentially reduce production costs, diversify farmers' revenue streams, and enhance economic viability and sustainability in alternative protein industries (Eastham et al. 2023).

One of the two primary pathways for sidestream development involves utilizing leftover or overproduced commodity crops as feedstock for the alternative protein process. In North America, it's estimated that only about 25% of total crop biomass is used for human consumption or industrial purposes, with the remaining roots, stalks, leaves, husks, etc. being considered as "low value", which are burned, landfilled, or used as animal feed (Eastham et al. 2023). However, many of these "low-value" crop products are high in protein and starch, which can be extracted for plant-based food and cell-cultured meat industries (Azman et al. 2023, Zhu and Pan 2022, Voutilainen et al. 2021, Fatima et al. 2024). The second pathway focuses on co-product valorization, where products generated during the alternative protein process are repurposed for added monetary value (Watanabe et al. 2021, Bello et al. 2023). Growth factors and other nutrient-rich materials can be recycled at research institutions for reagents that stimulate the growth and division of cells (Nath et al. 2017, Quek et al. 2024). Both approaches for sidestream development can help farmers build a diversified business model that turns waste into resources or marketable products, cutting down the overall cost of the production process and reaching price parity between alternative and traditional meats.

We propose that the USDA consider implementing a multi-faceted pathway to support farmers developing sidestreams dedicated to alternative protein production. Research efforts of such an approach should encourage collaborative partnerships and prioritize identifying suitable sidestream pathways, optimizing recovery and conversion of high-value alternative protein feedstock, and enhancing value chain efficiencies. Clear regulatory measures and safety metrics for sidestream operations should also be established, including product toxicity and allergenicity identifications. Farmers who are interested in pursuing this path could receive financial incentives to assist with sidestream operations development and scale-up.

Advantages

Sidestream development offers farmers opportunities to diversify their income streams and reduce production costs while providing innovative approaches to utilize agricultural by-products and wastes. This practice can also contribute to a more resilient supply chain and reduce the cost of the final alternative protein product, thus incentivizing consumer demand.

Challenges

Challenges include lagging infrastructure and supply chain support, no comprehensive life cycle assessments, and unclear regulatory guidance. Additionally, high upfront costs and a lack of financial incentives can deter farmers from repurposing low-value crop wastes into high-value alternative protein products. A lack of the necessary training and knowledge about the sidestream approach can impede its widespread adoption.

III. Policy recommendations

Alternative protein is an emerging field with the potential to strengthen the current food system. The PLANT Act was previously proposed to support farmers and rural communities through plant-based food production (Jim McGovern Press Release 2023). While this bill prompts the USDA to connect farmers with new markets, the landscape of alternative proteins offers a greater variety of products. As a new farm bill is being renegotiated in Congress in 2025, similar measures could open resources for manufacturing all alternative protein products, in addition to the USDA using existing grant programs (Monke et al. 2024).

We recommend that the USDA implement pathways to ensure equitable opportunities for farmers interested in transitioning to this growing market. Adoption of Option 1 would strengthen communication between alternative protein research and farmers and prepare a workforce for jobs related to alternative proteins. Option 2 would provide financial support and incentives for infrastructure needed to transition. Finally, with Option 3, farmers can expand their revenue streams to include alternative proteins. Of these, Option 2 (infrastructure support) is likely to relieve the largest financial burden placed on farmers who wish to transition to manufacturing alternative protein sources, and so it should be prioritized if only a

subset of these aims can be pursued. However, these three options build upon each other and are most effective when implemented together in order to expand opportunities for farmers and manufacturers interested and willing to take advantage of the alternative protein market to improve their economic outcomes. Similarly, if the USDA fails to implement these options, states with large farming sectors could implement one or multiple of the options on their own, which could boost the diversity of that state's farming output.

Should no new federal support for alternative protein production be established, transition to such production would rely on market demands and company incentives. It may be argued that federal implementation of programs that are focused on the highly dynamic field of alternative proteins may be costly and high risk, especially if there is low participation from farmers. It is exactly these costs and risks that make federal support necessary. Lagging infrastructure and supply chain support as well as unclear regulatory guidance make it unreasonable for farmers to make their own choice on whether to transition to alternative proteins. Additionally, high upfront costs and lack of financial incentives can deter farmers from repurposing low-value crop wastes into high-value alternative protein products. A lack of the necessary training and knowledge about the sidestream approach can impede its widespread adoption.

To ensure the inclusion of farmers' voices in expanding the bioeconomy, we propose including farm and biomanufacturing representatives on advisory panels for grant-giving organizations. Grant applications for alternative protein research programs should also require a statement of considerations of farmer and/or manufacturing needs and challenges. The lack of federal intervention would limit and delay progress in both alternative proteins and agriculture sectors, potentially excluding American farmers and workers from participating in the growing alternative protein sector. We strongly urge the USDA to develop and build upon programs to expand the economic opportunities for farmers and manufacturers in the growing alternative proteins sector.

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