Overcoming sustainability challenges to innovate plant protein products

George Hale

- A research center at the University of Minnesota was founded with the intention of addressing prominent technical problems surrounding plant-based foods.
- Three years later, the center is considering how to make plant proteins that require fewer resources to grow and provide the functionality processors need.
- The team is also seeking processing techniques that optimize protein purity along with taste and texture while using less water and energy.
- Still, after all these efforts, consumers will need to be educated to understand what distinguishes plant-based foods from those that are hyperprocessed.

The road from farm to table has many bumps and twists. Once a niche market, plant-based diets have been gaining ground in recent years. However, land and water use, and the heavy application of chemical fertilizers and herbicides show that plant-based foods—often touted as better for the environment than animal agriculture—have sustainability challenges of their own. After being harvested, crops must be processed, using more water and electricity, to make high-protein snacks, as well as meat and dairy alternatives. In addition, consumer desires, perceptions, and concerns must be considered for even the most sustainable plant-based food to survive on the market.

Consumer demand has driven plant-based protein development thus far, and concerns about GMOs and allergens are pushing producers beyond soybeans. But many consumers now have reservations about processed and so-called ultra-processed foods.

Pam Ismail is a food science and nutrition professor at the University of Minnesota, St. Paul. In 2021, she founded the Plant Protein Innovation Center (PPIC) which she now directs. Along with multiple industry partners, the center is focused on advancing research and innovation in the protein market space.

People choose plant-based protein products for multiple reasons and understanding those motivations will be important for anyone seeking to maintain or grow the market for these products. Developing new and more sustainable crops, creating processing methods that use less water and energy, and moving innovations from the lab bench to the supermarket will be crucial to keep plant-based protein products mainstream.

A PPIC researcher conducting aroma analysis on plant proteins. Source: PPIC

CONSUMER DESIRES AND SCIENTIFIC POSSIBILITIES

Consumer demand is driving plant-based food production. People want plant-based protein products that meet their needs for health, sustainability, and taste. This last one is critical as many people will seek out foods they are familiar with and compare them to what they have eaten before. Plant-based alternatives for favorites like burgers and pizza cheese have been gaining ground in recent years. And having flavors and textures like their animal-based counterparts is meaningful to the consumer.

"Whenever consumers are looking for alternatives to meat and dairy, they are looking for similar flavor experiences," said Ismail.

In addition to wanting certain flavor experiences, many consumers also have concerns about allergens and the use of genetic engineering. These concerns can be an obstacle for plant-based protein producers because many of the products in grocery stores today are made with soybeans.

Soy is one of the nine most common food allergens, joining milk, eggs, fish, shellfish, tree nuts, peanuts, wheat, and the most recently added sesame. Additionally, some 90 percent of soybeans grown in the United States are genetically engineered for herbicide-tolerance and insect-resistance (https://tinyurl.com/29f88tc9). These factors are affecting consumer demands and driving the search for new plant protein sources. To address this need, the PPIC is working with crop scientists to develop new high-protein crops.

Soy is a complete protein, meaning it contains all nine of the amino acids people need from the food they eat. It is also a highly functional protein. Functionality refers to the way a protein interacts with water, fats, and other substances to make different products ranging from plant-based milks to meat and cheese alternatives.

According to Ismail, pea protein is a promising candidate. Like soy, pea protein is complete, although not quite as functional. Pea protein also carries a lower risk of allergy than soy, though Ismail noted that greater exposure could change that.

A MORE SUSTAINABLE CROP?

Peas also hold the potential as a more sustainable crop than soybeans. Both plants are legumes and can capture nitrogen from the air through nodules on their roots formed through a symbiotic relationship with soil bacteria. However, soybeans need more nitrogen than this process can provide for optimal growth, causing the need for chemical fertilizers. In contrast, pea can gather the nitrogen it needs from the soil.

However, growing enough peas to meet plant-based protein demands will be a challenge. Much of the land that could be used to grow peas is already being used to grow other cash crops, and peas have a similar growing season to many other food plants. "Historically, most dry peas grown for human consumption are planted in the spring," said Steve Mulkey, research scientist in the Department of Agronomy and Plant Genetics at the University of Minnesota.

A field of yellow peas. Source: PPIC

Another variety of pea, known as winter peas, are planted in the fall. But most winter peas do not have the protein content or quality needed to make food products. When farmers plant winter peas they grow until conditions become too cold, at which point they go dormant. Even while dormant, winter peas prevent soil erosion. In the spring, winter peas are used as forage for animals or are worked into the soil to improve nitrogen content. At the same time, despite their name, many winter pea varieties cannot be planted in colder parts of North America. "Not much will survive a Minnesota winter," said Mulkey.

Because of this, Mulkey and his colleagues are developing a new variety of winter pea that can survive harsh winter conditions and provide high-quality protein for use in food products. Researchers have been crossing different cold-hardy winter pea varieties and growing them in climate-controlled growth chambers that simulate extremely cold winters. Using these chambers enables consistent growth conditions and allows the research team to grow and test multiple generations of plants in a year. The project, now in its fourth year, is showing some promising results, though more work is needed. Mulkey says, the team is simultaneously crossing high-protein spring peas with varieties that can thrive in extreme cold in an ongoing attempt to develop a plant stacked with genes that eventually express both traits.

A PPIC researcher determining the genetics that result from crossbreeding pea plants. Source: PPIC

Such a crop could effectively double the amount of food a plot of land can produce. At the same time, these crops would improve sustainability. Winter pea plants provide a protein source that requires little input, protects against soil erosion, and prevents nutrient runoff. An ideal crop could also be used as green manure and tilled into the soil before planting springtime crops. This would reduce the amount of fertilizer needed and decrease potentially harmful runoff.

Although promising, it could take years before such a crop is ready for widespread use. Once researchers have developed a winter hardy and high-protein pea variety, the next step will be to assess the crop's market value, develop supply chains, and promote adoption of the new crop. Mulkey notes that farmers tend to be risk averse, and there would need to be a clear financial incentive for farmers to start planting this new crop.

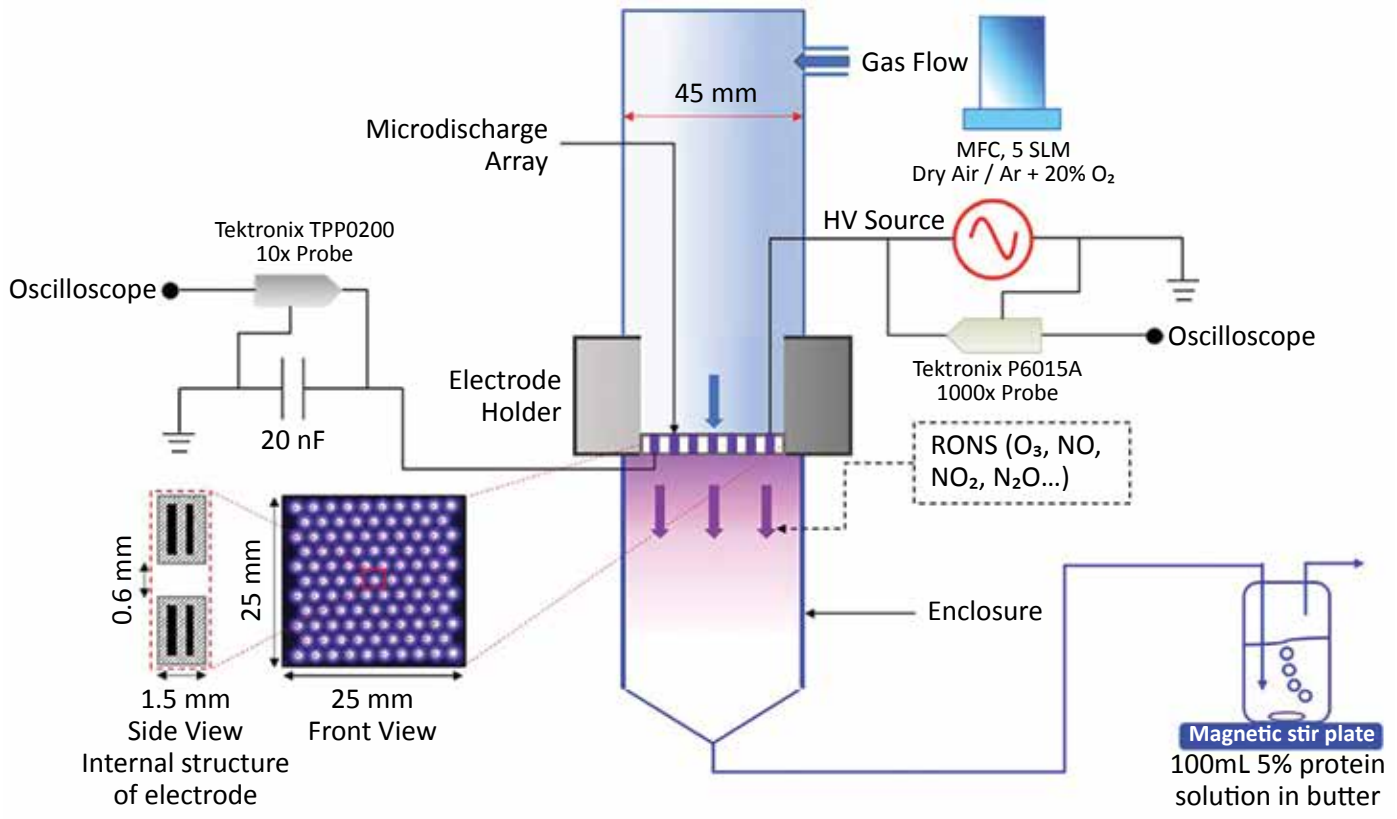
PLANT PROCESSING IMPROVEMENTS

Crop production is just one step in the journey to make commercially viable plant-based protein products. The PPIC is also working on ways to turn high-protein crops into different foods. This involves analyzing plant proteins for their nutritional value, flavor and texture properties, functionality, and other properties. Additionally, researchers are looking for new processing methods that are more sustainable and preserve the nutritional content of plant proteins.

Even the highest protein crops contain other compounds like starches and fiber, as well as compounds that affect flavor and digestibility. A plant protein that is complete and functional but that has grassy or grainy flavors would likely not be successful as a meat or dairy alternative. So, food scientists separate proteins from starches, fiber, and other compounds to yield high-purity powders.

Once purified, proteins are then further processed into different food products and functionality is critical. To make something resembling cheese, a protein would need to have good emulsification properties. For a meat substitute, proteins combine with water to form fibrous, muscle-like structures.

Although plant-based meat and dairy can be more sustainable than conventional animal-based products, there are still sustainability challenges that food scientists and producers are working to overcome. Processing methods to separate protein from starches and fiber, eliminate unwanted compounds, and improve functionality but also use large amounts of water



A schematic of a cold plasma technique for separating protein from its source. Source: PPIC

and energy. Researchers at the PPIC are working on ways to use less water and other chemicals in these processes and are developing a non-thermal technique that uses partially ionized gas, known as cold plasma, to process plant proteins. Cold plasma interacts with plant matter, causing chemical reactions that can affect protein structures in desirable ways. At the same time, producers are working to improve existing methods, such as improving energy efficiency, reducing emissions, and increasing the use of renewable energy.

KITCHEN TABLE ISSUES

None of the achievements outlined here matter if consumers will not buy products. The latest consumers concerns seem focused on processed and so-called ultra-processed foods. Ismail notes that the industry needs to be careful not to mislead consumers.

Part of the issue lies in how foods are labeled and how consumers are informed and educated. For example, she says labeling a food that has never had gluten as gluten-free causes confusion. In addition, Ismail argues that the processing used to isolate proteins and improve functionality and digestibility is not the same as the methods used to make what are known as hyperpalatable foods that are high in calories, fat, sugar, and salt, but low in nutrients.

"It is not fair to put soy milk in the same category as something like Twinkies," says Ismail.

Better consumer education and marketing will likely play a role in the adoption of plant protein products in the future. Ismail notes that food scientists and producers have not been educating consumers as well as they could and that scientists need to take a greater role in defining and labeling food products. "We need really good definitions," she says.

THE FUTURE OF PLANT PROTEINS

Further research and development and better education and marketing could lead to greater adoption of plant proteins. However, researchers and producers must also be mindful of changes in consumer desires. Ismail notes that Gen Z and Gen Alpha consumers have a greater awareness of environmental and animal welfare issues than their older counterparts. This means younger generations could be more open to a wider variety of plant-based foods and less interested in meat alternatives. "These are generations we need to watch out for and plan accordingly," said Ismail.

Plant protein adoption has grown in recent years, but may soon plateau. However, greater concerns about health and sustainability, and development of innovative products could lead to more people including plant-based proteins in their diets in the future. "When it comes to nutrition, you can have a balanced diet even from plant sources," said Ismail. "The question is how we can be creative in products that are plant-based."

George Hale is a freelance science and technology writer based in Pearland, Texas. He can be contacted at halegr@gmail.com.