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Envision a future where dairy waste has more value

Research and innovation can help turn the low-value by-products of dairy processing into something more.

by John Lucey

WHAT do we get when we make cheese? Curds and whey.

Until recently, whey was viewed as a low-value by-product and was disposed of by either feeding it to animals or spreading it on fields. When our industry consisted of many small cheese factories dotted across the countryside, the amount of whey they each produced was manageable.

From the 1950s onward, with innovations in the mechanization of cheesemaking equipment, cheese plants became much larger. The dairy processing industry took a giant step forward in the 1970s when equipment and facilities were developed to concentrate and separate valuable components like protein from whey, resulting in the production of new ingredients like whey protein concentrates and later, isolate.

These whey powders have been a big success story for the cheese industry, becoming a multibillion-dollar global market. Ingredients like whey protein powders and isolates are highly valued by the food and beverage industry for the high-quality nutrition and functionality they can add.

Today, the dairy processing industry continues to evolve. Individual plants are much larger, and the industry is processing more cheese, Greek yogurt, and other dairy products than ever before. While this is good news for the industry, the flip side is that we are also producing more by-products like acid whey and low-value ingredients like permeate, which is whey after removing the protein.

The U.S. annually produces about 120 billion pounds of liquid whey, 600,000 tons of dry permeate, and about 2 million metric tons of acid whey. Acid whey is challenging to utilize as it contains little protein, so it's considered low-value and is hard to dry. Our industry also struggles to find valuable uses for permeate, which is primarily used in animal feed at the current time.

Waste costs money

In the dairy processing industry, we spend a lot of money and resources on disposing of product washes and other waste streams. It costs about $6 to $7 million to build a waste treatment system for a medium-sized dairy processing plant with a waste volume up to 300,000 gallons per day. Operating costs are also very expensive, at about 1.9 cents per gallon of treatment.

Some dairy processing plants have been able to develop partnerships with their local municipalities to use their waste treatment facilities to dispose of by-products like acid whey. Some have also collaborated with other nearby plants. For example, Schreiber Foods and Foremost Farms USA jointly built a wastewater management system for their plants in Richland Center, Wis. The two dairy companies collaborated to build Richland Center Renewable Energy, a water-treatment facility that generates renewable energy from the dairy plants' wastewater. This also reduces hauling costs for shipping waste. While this is a great story, it is not necessarily practical for most dairy processing plants.

Capturing more value

One suggestion is to rethink how we view dairy co-products, with less emphasis on considering them "waste" and more on how to extract value and fully utilize these streams. For example, in some European countries — ones that do not have the option of land spreading — there is more focus on trying to make useful products out of their dairy by-products. This strategy isn't necessarily about making a profit, but rather it is a necessity of reducing waste.

For the U.S. industry, is there a better use for these dairy co-products that we currently think of as waste products? Perhaps we should instead think of it as feedstock that could be fermented into valuable chemicals or products.

We already have anaerobic digesters in some locations that produce renewable energy. But there are other options that could create more value-added products, such as a sort of biorefinery. If you think about oil refineries, massive amounts of crude oil come into the refinery where it is fractionated and converted into useful profitable products like gasoline, diesel, and petrochemicals. How feasible is it in the future that we would have some sort of biorefinery to take all kinds of agricultural or dairy industry by-products like permeate, acid whey, and manure and turn them into valuable products?

Some work on that approach has already started. Here at the Center for Dairy Research at the University of Wisconsin-Madison, we are supporting projects that are researching methods to take low-value by-products like acid whey and, using engineered microorganisms, ferment the acid whey into green chemicals that can be utilized to produce valuable products like bioplastics. These projects are in the early stages, but with support from the Dairy Business Innovation Alliance, we are currently looking into acquiring large-scale bioreactors to move this work forward and scale-up any promising biofermentations.

THIS BIOFERMENTER WAS RECENTLY installed at Babcock Hall on the University of Wisconsin-Madison campus.

This type of biofermentation work and research is also happening with agricultural waste. Here in the Midwest, we are starting to see neighboring states building agricultural bioprocessing pilot facilities.

In 2018, the University of Illinois opened its Integrated Bioprocessing Research Laboratory. This facility is developing methods to process agriculture wastes into biofuels. The waste is processed using mills, presses, blenders, mixers, and so forth. The processed biomass is then added to specialized fermentation tanks or bioreactors where bacteria ferment or break down the biomass into the desired chemicals to ultimately produce sustainable biofuels or other products.

This is exciting technology, but it is not a simple process and will take some research and development to fine tune, scale up, and determine if it is economically viable. One of the challenges in these specialized fermentations is that the feedstock (the material going into the tanks) should be consistent; otherwise, the bacteria may not produce the desired chemicals. In other words, you can't just add a bunch of different biomass into the tanks and hope for the best.

The conditions in the bioreactors need to follow very specific temperatures, pH levels, and so forth. Still, this is a technology that has a lot of potential to better utilize dairy and agricultural waste and convert it to biochemicals and other products.

Looking back, it was research and innovation that facilitated the dairy industry in developing methods to fractionate whey and turn it into value-added products like whey protein powders. Similarly, I hope that a new generation of research and innovation can help the dairy and agricultural industries find new ways to utilize by-products or waste streams and turn them into valuable chemicals. This could help change the public perception of our industry to a sector that not only produces highly nutritious foods but one that is also actively addressing sustainability by producing renewable alternatives to fossil fuel-derived chemicals.

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