# The Development of Forward Osmosis Technology for Liquid Food Concentration




If you've ever taken a sip of a drink from concentrate and wondered why it tasted "off", you're not alone. It's a common problem the food industry has faced for years, and Leonard Seed hopes to help solve it using a new technology called Forward Osmosis (FO).

FO is an emerging, membrane-based water/wastewater treatment technology that uses an osmotic gradient to separate water from dissolved solutes. There's growing interest from the food and beverage industry in the use of FO technology for the concentration of fruit juices and other liquid food products. FO has significant advantages compared to traditional product recovery technologies, including low hydraulic pressure, low treatment temperature, low fouling tendency and the ability to handle high solids. Studies have demonstrated improved product quality using FO compared with traditional methods due to the more "gentle" nature of the technology.

Through his project The Development of Forward Osmosis Technology for Liquid Food Concentration, Leonard is building a flexible, bench-scale FO

system. He and students in Mohawk's Environmental Technician program conducted experimental studies to choose and test different draw solutions (inorganic and salt solutions such as magnesium chloride) and optimize operating conditions. Their goal: to determine the optimum draw solution for a specific liquid food concentration application, as well as the best operating conditions for the FO system.

FO is "a way to de-water, concentrate or take water out of liquid items or even semi-liquid items fairly easily without using any heat or pressure," said Leonard, adding that his long-term goal is to reduce energy consumption for forming product concentrates while improving concentrate quality.

First, Leonard and his students gathered different types of membranes to test, along with a generic membrane holder and an Aquaporin Inside® Hollow Fiber FO module

developed by **Aquaporin** (who donated it for use in this project), a Denmark-based company specializing in membrane technology, to find out which worked better. They then conducted experiments, concentrating coffee, tea and coconut water using different draw solutions and salt-type solutions, including standard magnesium chloride.

"The Aquaporin module worked quite well," said Leonard, adding the specially developed membrane worked significantly better than its generic counterpart. "It's been interesting working with that company. They're developing some new modules that will hopefully be better suited to other types of food."

The researchers were able to concentrate two litres of coffee down to less than 200 millilitres. "We basically ran out of space. We couldn't take it down any further, so we (got) a small volume of highly concentrated coffee. It was almost getting to the point of syrup."

Currently, concentrates are produced using a thermal method to get rid of water. Another method is Reverse Osmosis, which involves using a lot of pressure. Both of these options can change the flavour of the compound that's being concentrated - an undesirable result. Another win for FO: it has the potential to create new additives or food flavours.

"It has potential (in areas like) the dairy industry, and in fruit juices," said Leonard. "The downside is that people want to buy (food and beverages) that are not from a concentrate, but I think in the past that's been due to the fact that you could actually taste a quality difference between food that's been concentrated and reconstituted, versus something that hasn't. If you could make a concentrate that (is) the same quality as the (original), you can save money in terms of shipping."

In the future, food and beverage manufacturers may use FO technology as they strive to cut shipping costs, energy use, and fuel consumption while boosting product quality. The technology can also play a role in reducing greenhouse gas emissions during shipping, he said.

"In terms of actually preserving food quality, it's looking like Forward Osmosis has the potential to preserve as much of the original quality of the item as possible," he said, adding he was surprised at the positive results when coffee and coconut water were tested. He estimated that most items could be reduced to between 10% and 25% of their original volume.

Forward Osmosis uses less energy than both a thermal method and Reverse Osmosis, "so it does have the potential to save energy for food producers."

Without funding from IDEAWORKS, Leonard wouldn't have had the opportunity to learn all those lessons and delve deep into the meaning behind the discoveries.

"The fact that they have this funding available is great," he said, adding that the easy, straightforward application process and encouragement from staff meant that it was worthwhile to apply, even as a part-time faculty member.

Bonus: the students involved in the research learn about a new, emerging technology they wouldn't have seen anywhere else.

Long-term, Leonard predicts FO will continue to grow and hopes to see Aquaporin release new modules better suited to producing concentrates from other types of food.

"Right now, we're stuck with coffee, tea, coconut water - things that don't have a lot of solids in them. So nothing with pulp," he said. But if the company releases a new membrane module that can handle higher amounts of solids, his experiments could expand to orange juice with pulp, dairy items or coconut milk.

For him, the next step is to build a larger FO system and scale it to handle between 40 and 100 litres, instead of just two litres. He'd then approach potential partners in the food industry to partner with Mohawk, have students involved in applications testing, and run more realistic trials to discover if they'd want to adopt FO as part of their process.

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