Maple Syrup Digest

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Reducing Maple Sap Spoilage
Variation in Sap Sugar Content Across States
Bottle Maple Sap

The Newsletter of the North American Maple Syrup Council

Exploring the Beginnings of Reverse Osmosis in the Maple Syrup Industry

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The greatest, most impactful innovation in the production of maple syrup over the last 50 years is unquestionably the introduction of reverse osmosis (RO) technology in the concentration of maple sap. Curious minds may wonder why RO was invented in the first place and how it came to the maple syrup industry.

In the 1950s, the United States government encouraged scientists to develop innovative new methods for large-scale desalination of salt water. In response, university researchers experimented with a variety of designs and materials, arriving at workable design that pushed pressurized salt water through a semi-permeable membrane, working as a kind of filter to prevent the salt in solution from passing through the membrane, producing clean water as a result. The first commercial membranes were developed and patented by UCLA researchers Sidney Loeb and Srinivasa Sourirajan in 1959.

Not long after, Sourirajan expanded on his research with a new position with the National Research Council (NRC) in Ottawa, Ontario. As a leading expert in the young, but promising technology of reverse osmosis, Sourirajan often visited with other labs and scientists who were beginning their own investigations into the potential of RO. At one such visit to a laboratory at Dartmouth College in 1965, Sourirajan met with a group that included graduate student Dean Spatz. In an October 2022 interview with the author, Spatz shared that he had been experimenting with ideas for using RO to clean wastewater from mining activities but became curious about reversing the application and considering its potential as a tool for concentrating solids in solutions. With such thinking in mind, at this meeting Spatz asked Sourirajan if he thought RO could be used to concentrate maple sap as part of the maple syrup making process, to which Dr. Sourirajan responded, that he did not see why not. This exchange led both Spatz in the Dartmouth lab and Sourirajan in the NRC lab, to conduct independent experiments with concentrating sugar solutions using table top RO units.

In 1966, Spatz obtained a few gallons of fresh maple sap and ran it through a small RO in the Dartmouth lab, discovering the membranes worked great and exactly as expected in concentrating the sap. Unbeknownst to Spatz, that same year in Ottawa, Sourirajan ran his own RO experiments, also successfully concentrating a sugar solution, which was published in the spring of 1967. Curiously, this single experiment and publication was as far as Sourirajan went with applications of RO to sap concentration. However, he did go on to be a world leader in the advancement of RO

technology.

At the same time Spatz and Sourirajan were conducting their own independent parallel experiments, scientists at the US Department of Agriculture's maple research program at the Eastern Utilization Research and Development Division (Eastern Regional Lab) in Wyndmoor, Pennsylvania had also arrived at the idea of using RO for concentrating maple sap. In the spring of 1966, under the direction of Dr. C.O. Willits, director of the maple program at the Eastern Regional Lab, maple sap was concentrated from 2.5% to 10% sugar using a small, table-top RO set up in their laboratory.

Concluding that the technology was viable for sap concentration, the Eastern Regional Lab determined that their RO unit needed to be scaled up and field tested in a real-life sugarbush setting. As early as 1966, even before conducting their first field tests, the scientists at the Eastern Regional Lab were claiming that the adoption of RO technology "should lead to full automation of the maple syrup industry".

A large, portable, eight membrane RO machine was built and tested in the 1968 season at the sugarhouse of Lloyd Sipple in Bainbridge, New York. Wanting to try the system with a greater volume of sap, over the following two years the Eastern Regional Lab team moved to a larger sugarbush at Mountain Meadow Farms in Sommerset County, Pennsylvania. At the end of the 1970 season the Eastern Regional Lab prototype RO was sold to Mountain Meadow Farms where it was used for a few more years before the farm exited the maple syrup business.

Despite the new technology being experimental and having a significant learning curve for working with maple sap, the field tests were unquestionably successful. Using relatively low pressure on the membranes, their tests were able to achieve a 50% removal of water from sap. Less anticipated or understood were the problems of bacterial buildup and growth, heat effects from operation of the machine, and changes to sap chemistry over the course of the season which resulted in loss of operational efficiency. There was still much to learn about effective membrane flushing and the best cleaning agents.

The Eastern Regional Lab made great research strides with RO leading to aggressive efforts to promote RO technology as the future of maple industry. Unfortunately, with the retirement of Dr. Willits in 1969, the Eastern Regional Lab began to phase out maple research and their RO research ceased at the end of the 1970 season. Apart from a few small test cases, government and university research into RO for the maple industry in the United States and Canada, stopped for the remainder of the 1970s.

In contrast to the outcome of RO research at the Eastern Regional Lab, upon his graduation from Dartmouth University, Dean Spatz took his connection to RO to the next level. In 1969, Spatz moved to Minnesota and started the company Osmonics, Inc., building

RO machines for water purification and industrial filtration. As the Osmonics company was getting started, Rex Alwin a Minnesota maple producer, engineer, and later president of the North American Maple Syrup Council, convinced Spatz to allow him to test one of Osmonics' new small single membrane machines. Alwin later presented the results of his test at the Eighth Conference on Maple Products in October 1971. The successful tests in the Alwin sugarbush convinced Spatz to begin marketing Osmonics' RO technology to the maple syrup industry with advertisements in the Maple Syrup Digest appearing as early as 1976.

Through the 1970s, a small handful of larger syrup producers installed Osmonics RO units in their sugarbushes, such as the Great Mountain Forest sugarbush in Norfolk, Connecticut; the Pouliot sugarbush near Saint-Philemon, Québec; and the David Near sugarbush at Shelby, Michigan. Reverse osmosis units in the 1970s, with their long horizontal 4" membranes, were noisy, expensive, often over heated, and could only concentrate sap in one cycle from 2% to 6%.

Also in the 1970s, many larger syrup producers began shifting from wood to fuel oil for their evaporators. A rapid increase in fuel prices during the energy crisis of the 1970s increased the focus on alternative fuels and fuel saving technologies like RO. However, for the bulk of the 1970s, Osmonics was the only commercial manufacturer of RO for use in the maple syrup industry. The RO market for the maple industry began to grow in the 1980s with the introduction of RO units from Electrohome of Kitchener, Ontario; Memtek of Ottawa, Ontario; and Springtech of Wilmington, VT. New RO designs saw a shift to smaller quieter, machines with vertical, higher-pressure membranes that were built specifically for the maple industry.

Research into the effectiveness and cost of commercial RO, as well as its effect on syrup quality, resumed in the 1980s with studies by Morseli and Sendak in Vermont and Gaston Allard in Québec. Interestingly, multiple early studies using blind taste testing when questioning the effect of RO on syrup flavor found no difference in taste compared to non-RO made syrup.

By the end of the 1980s and into the 1990s, RO units had come down in price and the technology had proven itself for larger commercial maple syrup producers. Reverse osmosis was becoming standard industry equipment and all major equipment manufacturers at that time, brands like Leader, Dominion & Grimm, Small Brothers, and G.H. Grimm, got on board with their own RO designs or partnered with existing RO makers to offer the technology to their customers. Reverse osmosis had earned its place in the process of modern syrup making and was here to stay.

Dr. Matthew M. Thomas is a maple industry historian. You can read more maple history articles like this at his website,www.maplesyruphistory.com.

Figure 1
Dr. Willits of the USDA Eastern Regional Lab examining an experimental RO membrane (source: February 1969 Maple Syrup Digest).

Figure 2
USDA Eastern Regional Lab's prototype eight membrane RO unit, field tested from 1968 to 1970 (source: Moore and Willits 1970 ARS report 73-66).

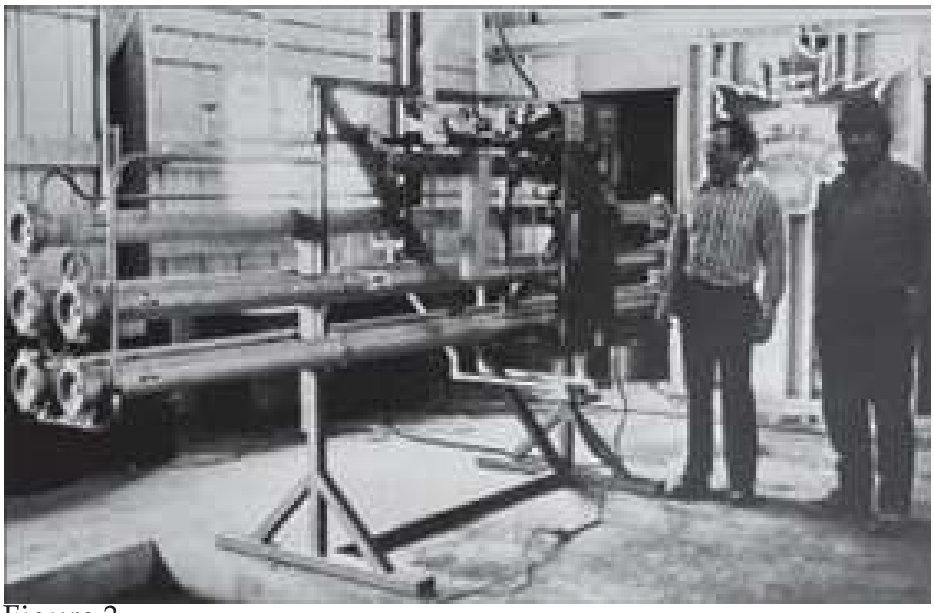

Figure 3
Example from the 1980s of a large commercial RO machine built by Osmonics, Inc. for use in the maple syrup industry (source Osmonics sales brochure -collections of the author).