

Forward Osmosis Technology:
Beer Concentration

Olgica Bakajin

Membrane Technology Forum 2023



About Porifera

"Porifera's innovation may be the most important our industry has seen in the past 75 years." — Fortune 500 Customer



2009

Founded in San Francisco Bay Area



2013

Commercial Market Entry



36,000 sq. ft

Manufacturing Facility in San Leandro, CA
8000 sqft
Processing Facility in Toronto, ON



Grant Funded Tech
NSF SBIR, DARPA (US DoD), US DOE, NASA, California Energy Commission



65 Issued Patents, >14 Countries
Many more going through the application process



100+ Customers
20+ Countries

Full Solution Provider
Equipment, service, and membrane replacements



Wastewater Treatment & Reuse



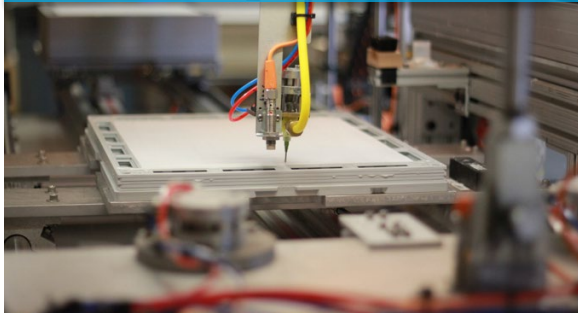
Food & Beverage Processing

Our Capabilities

System and process design, manufacture, pilot demonstration in California

Beer and alco-bev processing in Canada

Membrane Module Manufacturing Facility
11,000 sqft in San Leandro, CA USA



In-house built semi-automated membrane element assembly lines.
Established QA/QC program.

Outsourced membrane film manufacturing according to proprietary formulation.

System Manufacturing and Demonstration Facility
25,000 sqft in San Leandro, CA USA



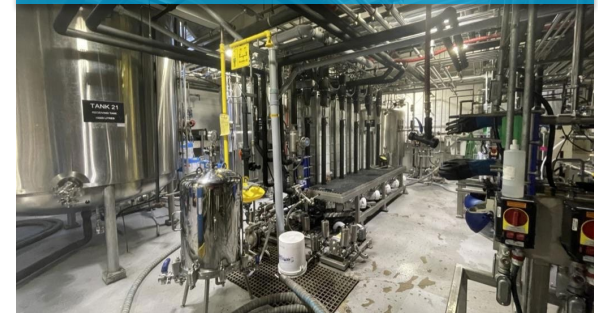
In-house:

- Process, mechanical and electrical design
- Mechanical and electrical assembly
- Small machine shop
- Facilities for factory acceptance testing
- Controls
- Lab and facilities for product processing demonstrations

Outsourced:

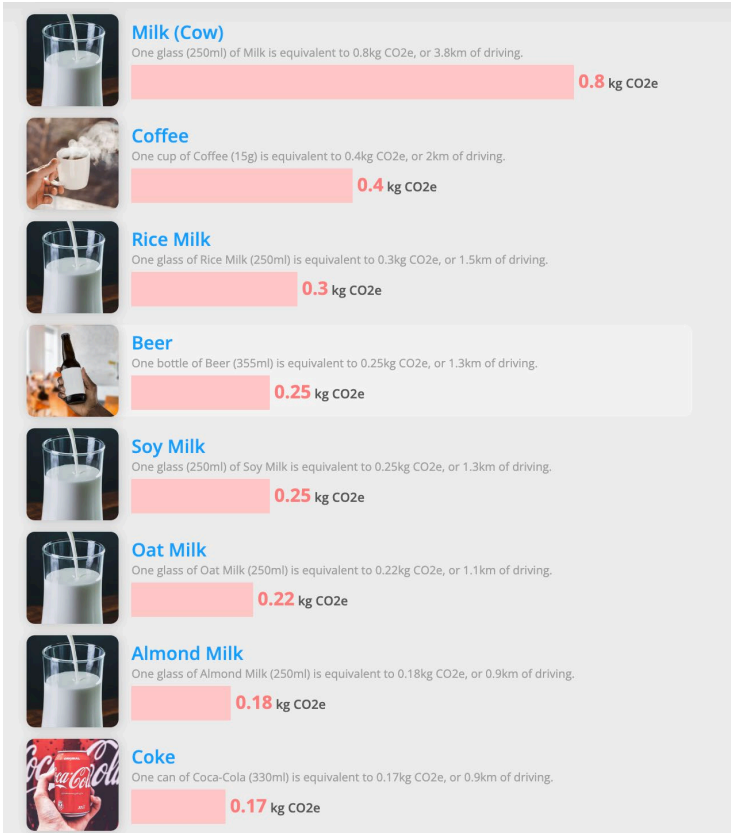
- components such as instrumentation, pumps and valves, frames & welding

Beer Concentration Facility
8000 sqft in Toronto, ON, Canada



- 40,000 HL/year Commercial demonstration scale processing facility, including beer concentration and BIB packaging line
- Customer experience demonstration area with dispense equipment
- Analytical lab facilities for QA/QC
- R&D beverage blending facility

What's The Carbon Footprint of Your Drink?



It turns out that lattes are the worst!

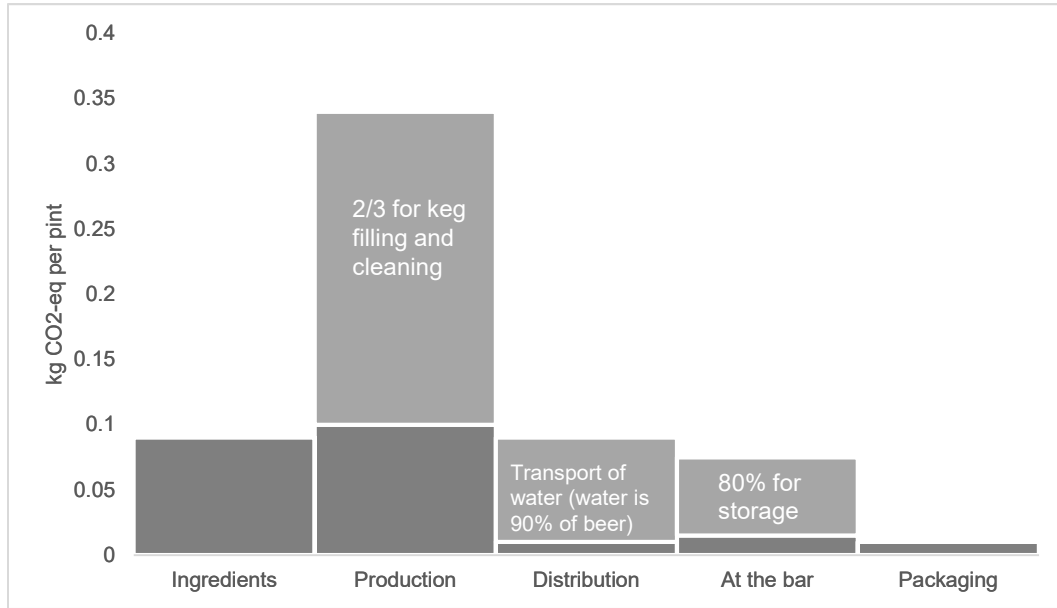
But beer is not a whole lot better.

Beer consumed per year: 1.87 Trillion liters
Emitting: 1.3 Billion Tons CO₂-eq per year

That's almost as much as cars in the US!

Cars emit 1.4 Billion Tons CO₂-eq per year

Where Do the Emissions in Beer Come From?



Since beer is mostly water, can we concentrate it, ship and store a much smaller volume?

Can we also get rid of the standard kegs along the way?

Beer Processing & Dispensing

START TO FINISH

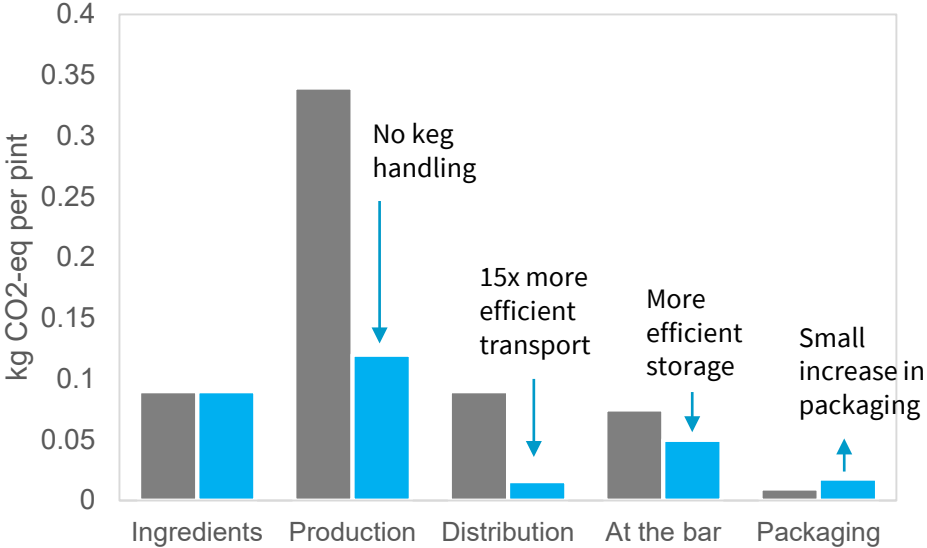
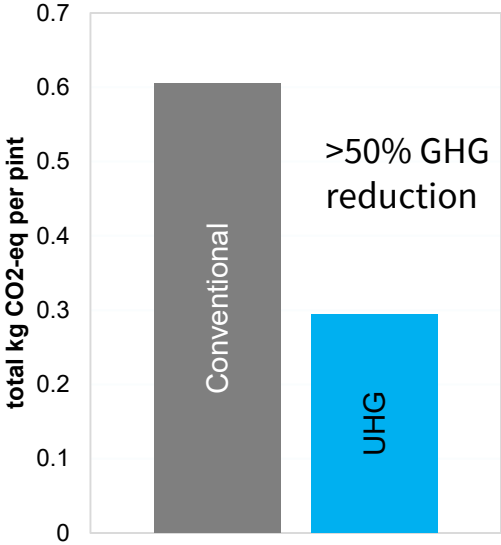
1. Beer is brewed the way it always has been
2. Before packaging in Microkegs, a portion of water is gently pulled out "Squeezed" through a membrane to produce Ultra High Gravity beer
3. Easy to handle Microkegs are delivered with a lower carbon footprint (1 Microkeg = 6 x 20 L Kegs)
4. Kegs are returnable, Microkegs are recyclable

DRAFTFOX DISPENSE

1. Ultra High Gravity beer enters the chiller
2. 3-stage carbon-filtered water is chilled and carbonated prior to blending
3. Cold, carbonated water is blended with Ultra High Gravity beer in chiller
4. Beer is dispensed through existing lines



Significantly Improved Environmental Impact from UHG at 6x



Challenges to Overcome

Technical
Challenge

1. Concentration process that does not change the beer

Technical
Challenge

2. Dispense equipment that controls mixing ratio to maintain required ABV

Commercial
Challenge

3. Achieve critical mass to sufficiently reduce costs to replace the current system

Marketing
Challenge

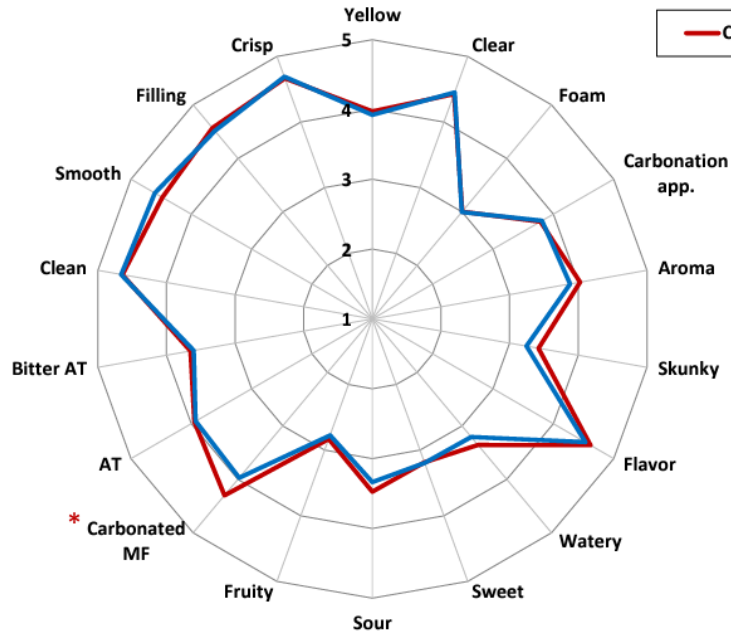
4. Psychological “yuck” factor

Question for the audience:

Which of these challenges is the hardest to overcome?

The key is to keep the beer the same when reconstituted from the concentrate.

Professional Taste Panel Evaluation: Brands Fully Reproduced From 6x “Squeeze” Concentrate



A multivariate analysis (Hotelling T²) confirmed that the two products are not significantly different overall (p=0.49)

* The only significant difference observed is for Carbonated Mouthfeel attribute, which is addressable in dispensing

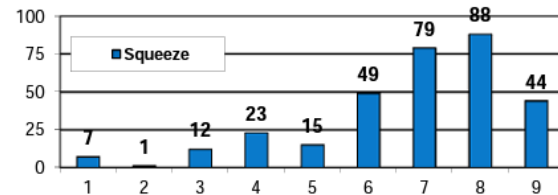
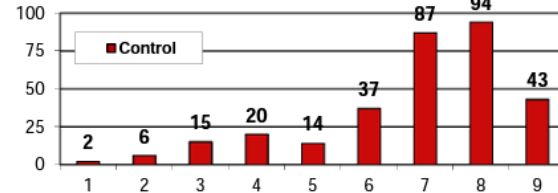
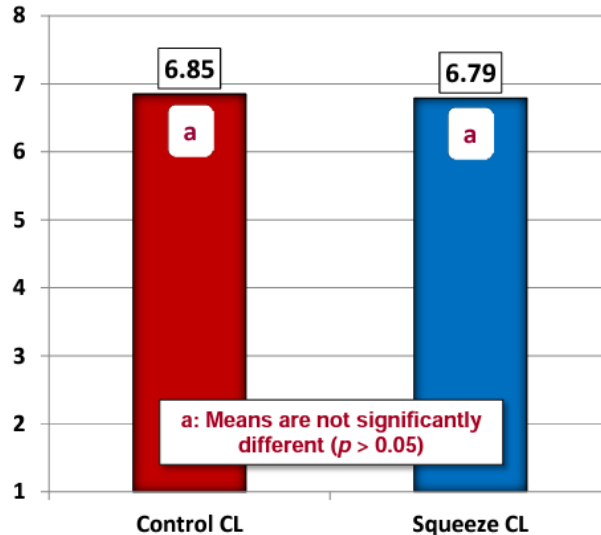
Consumer Experience:

No Difference Between Control and "Squeeze" dispensed through "DraftFox"

"Please select the button next to the phrase below which best describes your overall opinion about the beer you just tasted"

- 9 Like extremely
- 8 Like very much
- 7 Like moderately
- 6 Like slightly
- 5 Neither like nor dislike
- 4 Dislike slightly
- 3 Dislike moderately
- 2 Dislike very much
- 1 Dislike extremely

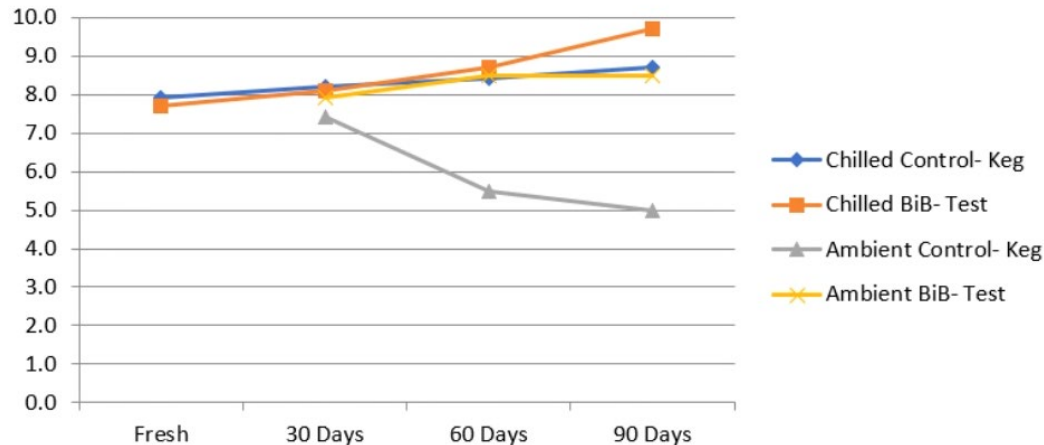
Overall Liking Means and Score Distributions



UHGB (6x) in Microkeg Has Better Shelf Stability Than Standard 1x Beer in a Standard Keg

Reduced refrigeration requirement saves money, reduces GHG emissions and opens new markets.

- Ultra high gravity beer (UHGB) stored at ambient in a Microkeg or Bag in a Box (BiB) at 90 days performs as well as a standard keg refrigerated.
- Refrigerated UHGB in BiB performs better than the control chilled keg.



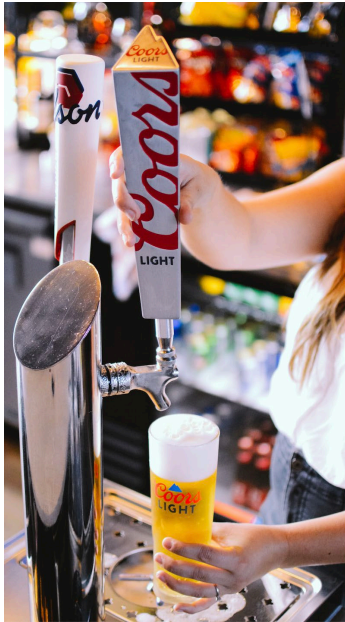
Chilled BiB- Test				
	Fresh	30 Days	60 Days	90 Days
Estery	2.5	2.4	2.8	3.0
Hoppy	2.2	1.9	2.0	1.9
Stale	0.0	0.2	0.1	0.0
Non-Yeast Sulphurs	0.0	0.0	0.0	0.0
Yeast Sulphurs	0.1	0.0	0.0	0.0
Isoamyl Acetate (Estery)	1.5	1.2	1.2	1.9
Ethyl Acetate (Estery)	0.7	0.9	0.8	0.8
Ethyl Hexanoate (Estery)	0.3	0.3	0.7	0.3
Kettle Hop (Hoppy)	1.2	1.1	1.3	1.2
Hop Oil (Hoppy)	0.9	0.8	0.7	0.7
Malty	2.1	2.1	2.0	2.2
Sour	1.1	1.0	1.0	1.1
Sweet	2.2	2.1	2.1	2.0
Astringent	1.2	1.2	1.3	1.2
Bitter	2.1	2.2	2.0	2.2
Body	2.1	2.1	2.1	2.1

Working With Leading Dispense Companies on a Variety of Dispense Solutions

- At the bar:
 - with refrigeration to replace the kegroom
 - Or attach to existing lines in the kegroom
- At a stadium or at a hotel
 - Vending machine
- Draft beer at home



In Market Since 2019: Successful Commercial Demonstration in Ontario and Quebec



30 bars /
restaurants

1 brewer

3 brands

2k HL beer



Consumer & Customer Testimonial

Through Thousands of Pints Poured, Consumer Complaints Were Unchanged vs Standard Keg Beer and Customers Loved the Efficiency.



“Massively help to control the wastage and it would make the task of doing inventory so much easier. It would me incredibly time saving for the manager.”

“Oh wow, that was easy.”

“That’s the Perfect Pour!”

“Make our day to day operations run more efficiently and help us give better service to our customers.”



Benefits For Everyone

~\$150M Annual savings unlocked @50% of Canadian draft beer market

FOR THE BREWER

- Brew as you always do
- Reduced shipping & warehousing cost – 15x more efficient
- Open new markets

*"As soon as our expert tasters and brewers tasted it, we knew this was a solution for us."
– Brewer Customer*

FOR THE BAR / RESTAURANT

- No heavy keg changes – improved worker health and safety
- No product loss changing microkegs
- More choices on tap in a smaller footprint
- Longer shelf life of product

*"Bar staff love it! ...Our bartenders feel comfortable lifting the new kegs!"
– Firkin on Bloor, ON*

FOR THE CONSUMER

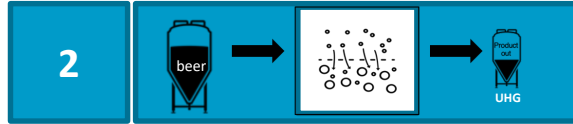
- Same drink experience, reduced ecological impact
- Reduced wait time without need for keg changes
- Increased consistency of beverage, less foaming

*"It just seems to taste much fresher, more 'alive' than regular draft."
– Toronto Consumer, 35-45*

Patented Process, Every Step Is Important



Brewing – unchanged, skip final centrifugation



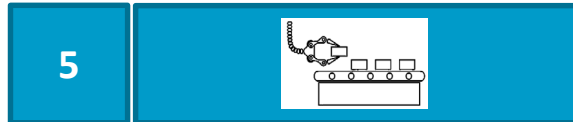
Concentration to 6x with PFO



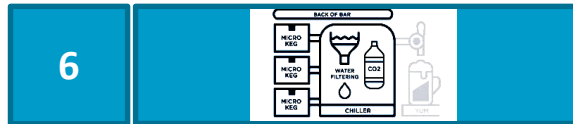
Draw recovery: RO + distillation



Cold filtration of UHG

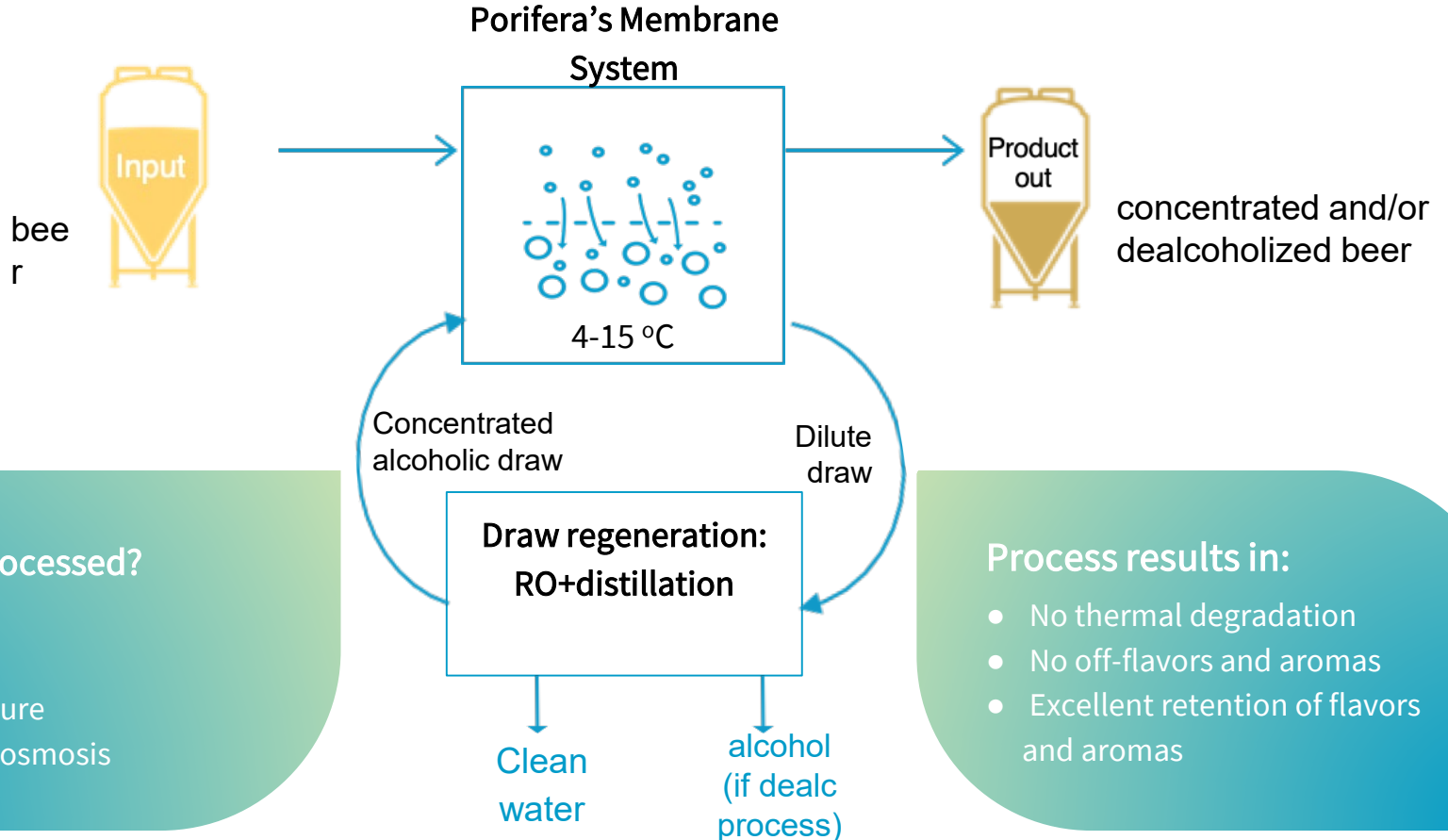


Packaging in Microkegs: using a special Bag in a Box for low oxygen environment

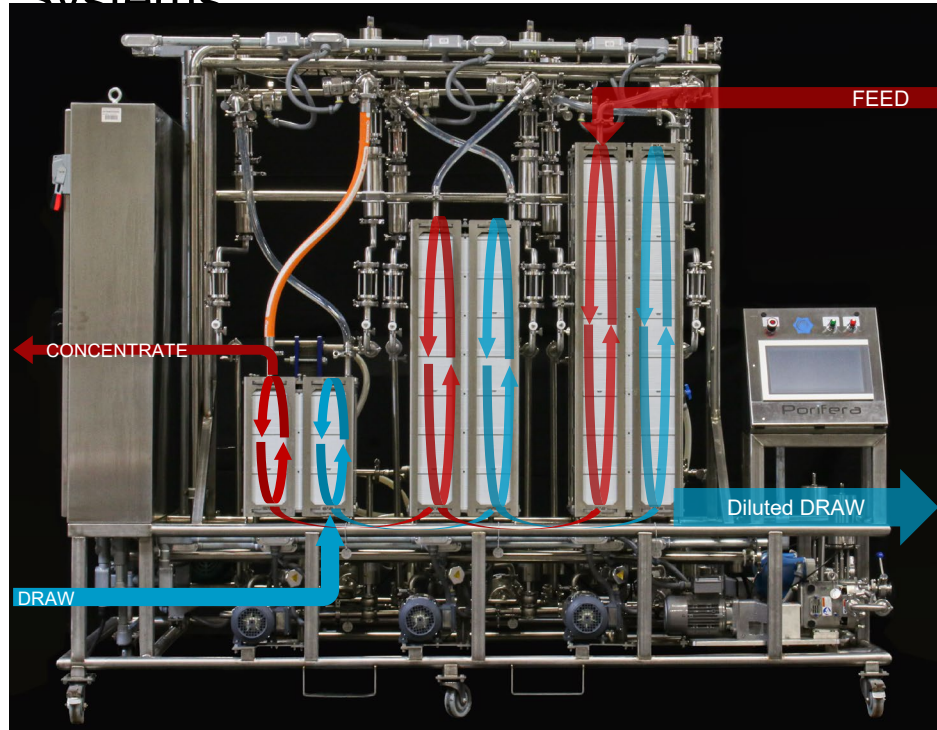


Dispense at the bar: need precise mixing, carbon filtered water + CO2

Gentle Patent-Protected Process That Preserves Great Taste



Scalable & Customizable PFO Systems



System is operated in stages, each of which is recirculated independently. Flow control can achieve desired concentration factors (CFs) for a wide range of CFs and the same system can process at different flux and CFs.

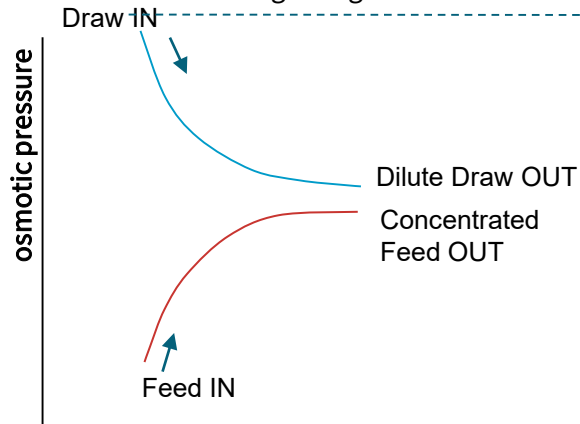
	Continuous (PFO Recirc) Porifera
Customizable	Yes
Automated Operation in counterflow	Yes
Cross flow past membrane	High, adjustable
Aroma/Flavor loss	Minimal
Process under low oxygen	Yes
Draw solute migration to feed	Minimal
Ability to achieve different concentration factor (CF) ranges with same equipment?	Broad
Effects of change of flux (due to fouling, temperature changes etc.)	CF & product consistency is maintained, throughput processing
Prone to fouling	Minimally

What is Counter Flow and Why It Is Critical For Beer Concentration?

Porifera is the only counter-flow multistage FO solution provider

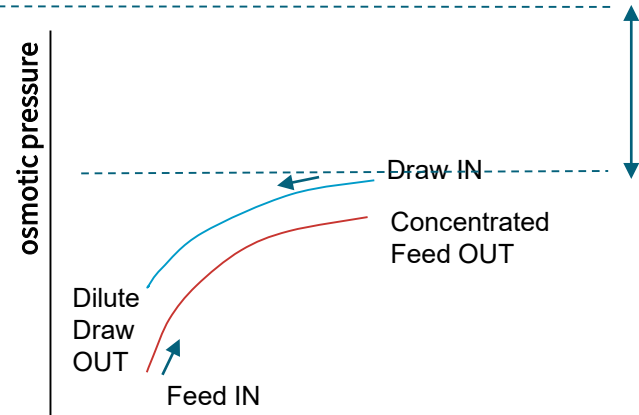
Co-current flow (“Batch”)

- Higher strength draw required to reach the same feed concentration
- Uneven driving force:
 - requires significantly more draw solute to reach target feed concentration
 - results in more fouling because of high flux at the beginning of the concentration process




Counter flow

- *Lower strength draw* required to reach the same feed concentration
- *Even driving force*
- Can maintain ethanol concentration on the feed and the draw balanced in all steps of the process



Our Competition:

PFO is the Clear Concentration Technology Choice for Brewers

	Revos RO (AlfaLaval)	Porifera 	GEA Freeze Conc
Process Full Portfolio at up to 4x	X	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> ¹
Process Pale American Lagers at up to 4x	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> ¹
Process Full Portfolio at 6x	X	<input checked="" type="checkbox"/>	X
Process Pale American Lagers at 6x	<input checked="" type="checkbox"/> ²	<input checked="" type="checkbox"/>	X
CAPEX	Lowest for low conc. factors (<4x)	Lowest for high conc. factors (4x and above)	Very high

Molson Coors evaluated other technologies and determined that

Porifera is the only technology that can concentrate the full beer portfolio to 6x and beyond.

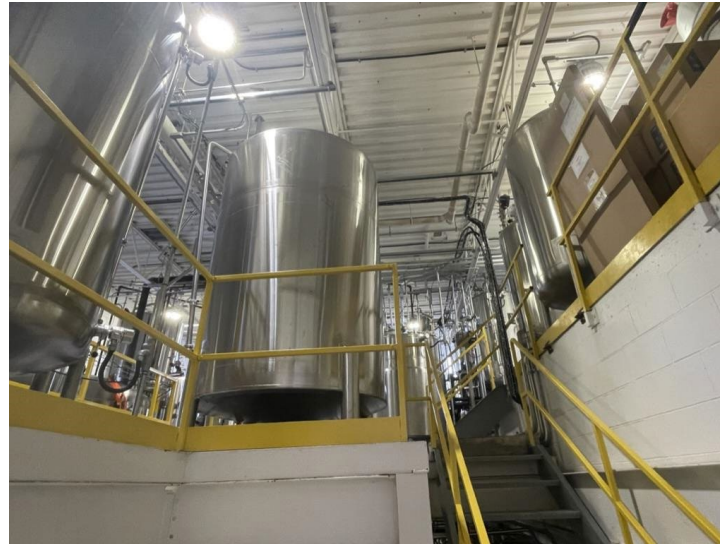
¹Limited to 4-6% abv at dispense.

²Limited to 4-5% abv at dispense.

Our Facility in Toronto is Available For Commercial-Scale Demonstrations



- 5-stage System
- Designed for beer concentration ~40,000 HL/year
- Can also dealcoholize
- Packaging line for BiBs
- 100 Dispense systems available for rehydration & carbonation



A Dispense System That Replaces The Kegroom at the Bar



Challenges & Perceptions to Overcome

Technical
Challenge



1. Concentration process that does not change the beer

Technical
Challenge



2. Dispense equipment that controls mixing ratio to maintain required ABV

Commercial
Challenge



3. Achieve critical mass to sufficiently reduce costs to replace the current system

Marketing
Challenge



4. Psychological “yuck” factor

We at Porifera and our partners have made significant commercial and technical advances against the most difficult obstacles & have proven viability.

Squeeze with DraftFox Delivers the same great draft beer

with increased shelf life

with 50% lower environmental footprint

at a lower cost

It's possible.

All we need to do is change our old ways.

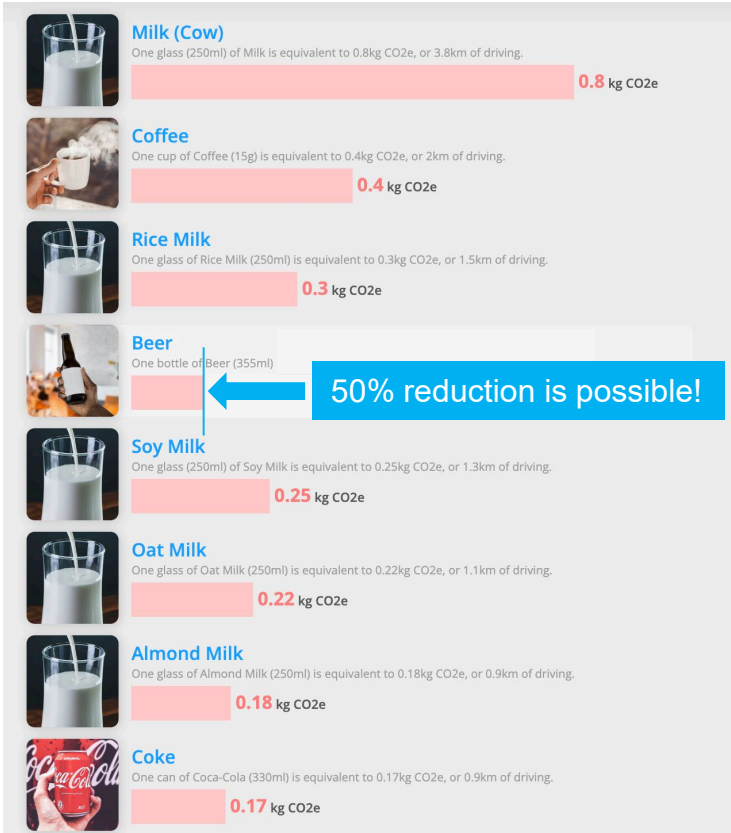
...and a few regulations in the US

but Canada is ready, and we are moving forward with more brewers and more restaurants on the platform!



Join the
Future of Beer

Conclusion



Drink more beer!

Also concentrate milk.