

A decorative vertical bar on the left side of the slide, consisting of a blue rectangle on top and a red rectangle below it.

Production of Low Alcohol Beverages using RO and NF Membranes - Energy Efficient De-alcoholization

Alan Franks

Tomas Laska

15 June 2023

The Nitto logo, featuring the word 'Nitto' in a bold, blue, italicized sans-serif font. The letter 'i' has a red dot.

Innovation for Customers

Presentation Overview



1. Why de-alcoholization?
2. Contributions to sustainable development goals
3. What is de-alcoholization?
4. Comparison of methods
5. Benefits of membrane driven de-alcoholization
6. Membrane de-alcoholization steps
7. Hydranautics' solution
8. Pilot testing
9. Reference
10. Summary

Why de-alcoholization



Lifestyle

Low alcohol/ No alcohol has also gained popularity among young consumers trying to make positive lifestyle choices and manage their alcohol intake.

Other reasons: Health, Sport, Safety (driving, machine operation), Religion



Sustainability

Some processes to make Low alcohol/ No alcohol beverages are energy-intensive. Moving away from heat intensive processes is a Must Have requirement for breweries.



Quality

Maintaining flavor and aroma of the final product to ensure wider audience acceptability is a hurdle that most no and low alcohol drinks manufacturers are facing today. Conventional technologies produce poor taste (not fully fermented) or are expensive. Fermentation process produces valuable substances including vitamins, so de-alcoholized drinks are healthier options to soft drinks.



Contributions to Sustainable Development

Nitto / Hydranautics' membrane separation technologies provide solutions to global issues associated with environment, energy, and water to contribute to **sustainable development**



- Enable access to clean and safe drinking water
- Reduce environmental footprint through reclamation of wastewater



- Apply membrane separation technologies to stabilize energy supply
- Reduce CO2 emission through improvement of manufacturing processes



What is De-Alcoholization?

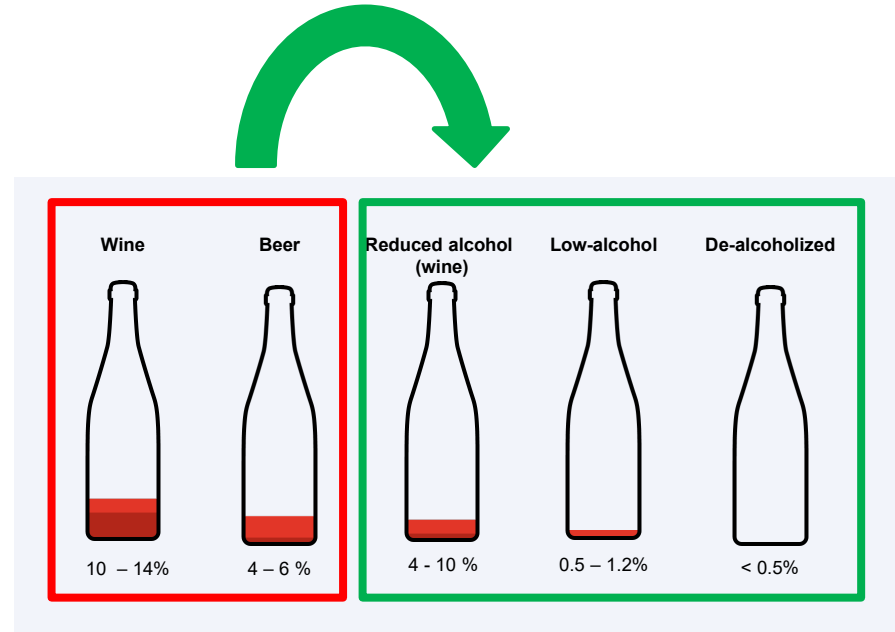
The removal of alcohol from an alcoholic beverage: Beer, Wine, Cider, etc.

Objective of Membrane Driven De-Alcoholization: Reduce or *Remove Alcohol, but preserve Flavor, Taste, and Aroma* using RO or NF Membranes.

The typical targets:

- **Adjustment of alcohol level in Wine or Beer**
Alcohol reduction by just few %
- **Alcohol reduction to obtain low alcoholic drink**
- **Full De-Alcoholization to achieve ABV* $\leq 0.5\%$**

*Alcohol By Volume



What is De-Alcoholization?

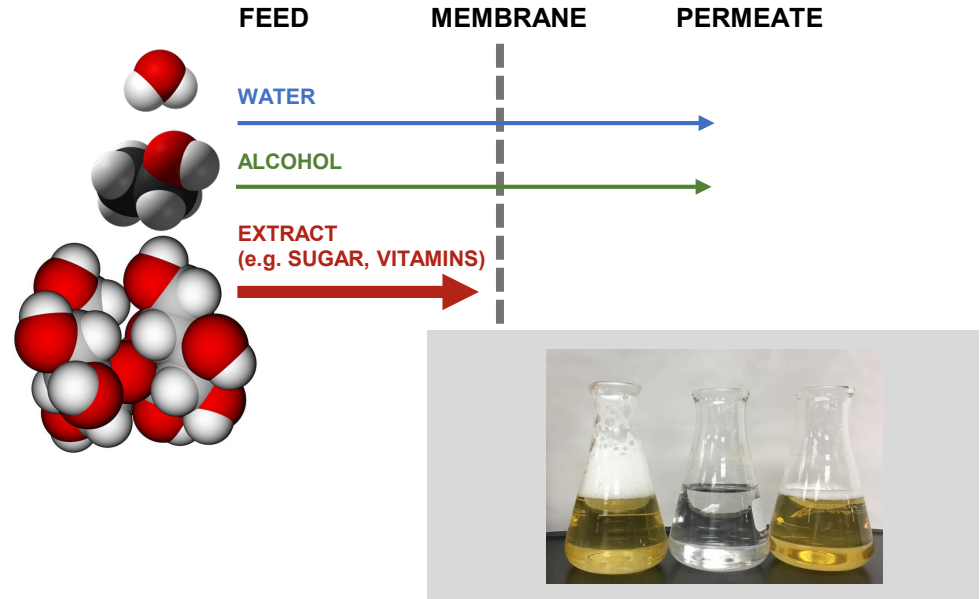
The removal of alcohol from an alcoholic beverage; Beer, Cider, Wine

Objective of Membrane Driven De-Alcoholization: *Remove Alcohol but preserve Flavor, Taste and Aroma using RO or NF Membranes.*

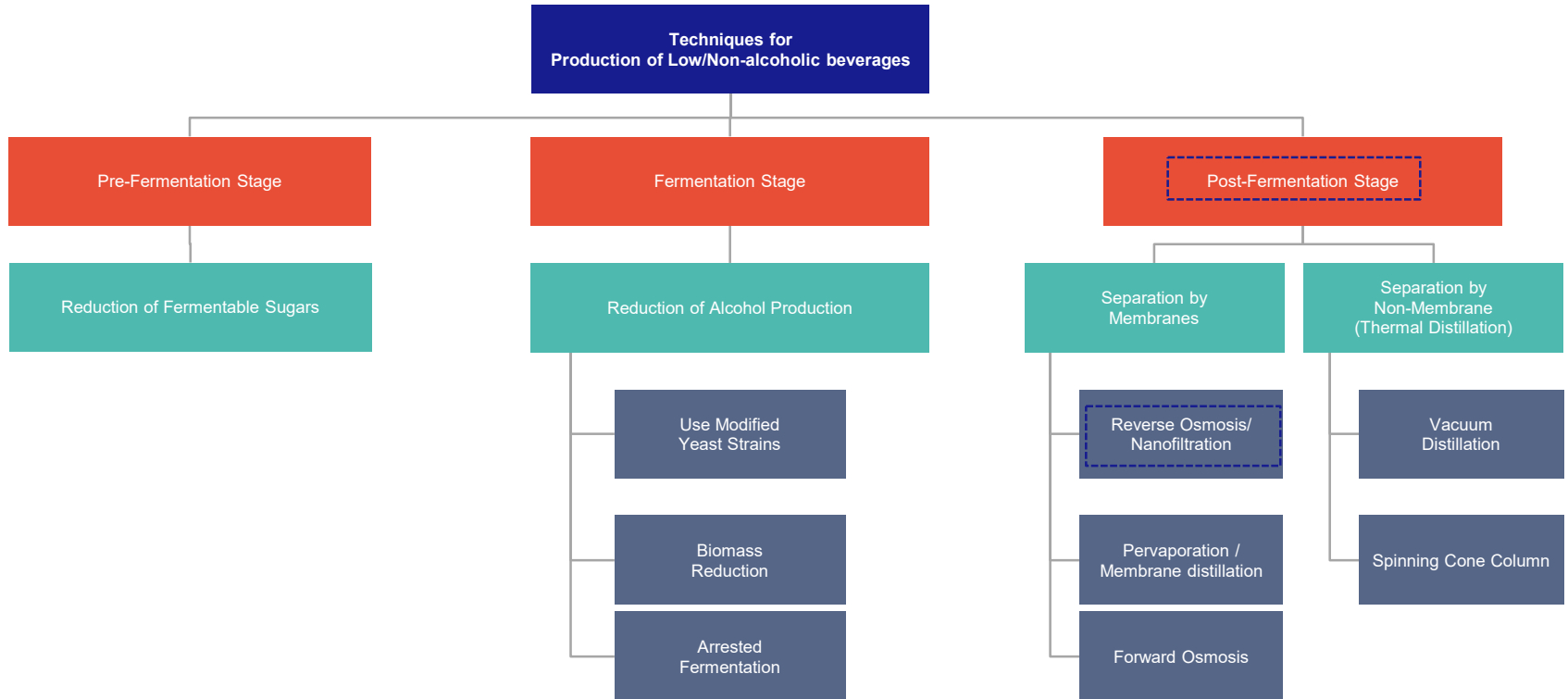
The Target ABV* $\leq 0.5\%$ ABV

Selected beer compounds:

Water	MW = 18 g/mol
Alcohol	MW = 46 g/mol
Niacin	MW = 123 g/mol
Vitamin B6	MW = 169 g/mol
Maltose	MW = 342 g/mol
Vitamin B2	MW = 376 g/mol



Overview of Methods





Thermal Distillation

- Core technology is thermal distillation which is a temperature driven separation process based on volatility of the compounds
- Process runs warm – High thermal impact
- High CAPEX and OPEX
- High aroma losses – Need for recovery (Membranes?)
- Suitable also for final alcohol content of 0.01% vol.



Membrane Driven Process

- Core technology is pressure driven separation process which is based on passage of compounds through the semipermeable membrane
- Process runs cold – No thermal impact
- Low CAPEX and OPEX
- Very low aroma losses
- Suitable for final alcohol content greater or equal to 0.5% vol.



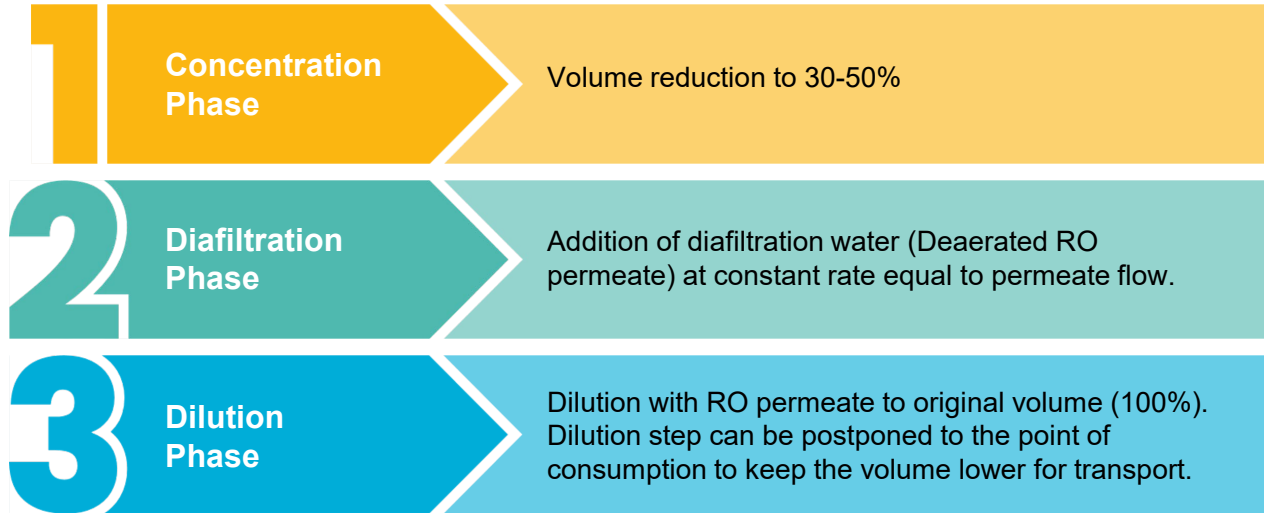
The benefits of Low Alcoholic Beverage production using Membrane Filtration

- No denaturation due to the heat exposition
- Low energy consumption
- Flexible production planning and final alcohol content adjustment
- Low alcoholic beverages are being produced from an actual alcoholic drink (Taste and composition remains as close as possible to the original source)
- Vitamins, minerals, and other valuables remain in the final product
- Less calories than a regular alcoholic beverage wine or beer

De-Alcoholization Steps

Membrane De-Alcoholization Process

Both Continuous and Batch processes are possible



Step 1: Concentration Phase

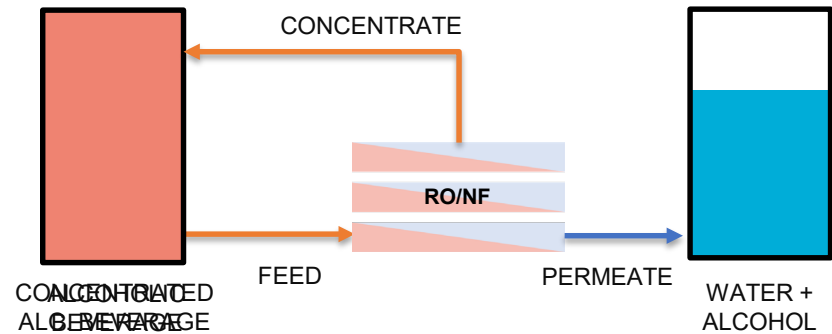
Volume of the feed beverage is reduced **30 - 50%**

Permeate produced during this step contains alcohol and small amount of some low molecular substances from the beverage. This water and alcohol mixture could be used for production of Hard Seltzer

Higher concentration factor during the initial concentration step reduces significantly the consumption of diafiltration water.

OBJECTIVE:

Concentrate the feed beverage



Step 2: Diafiltration Phase

2

Addition of RO permeate (CO₂ saturated for Beer or deaerated for wine) at constant rate equal to permeate flow.

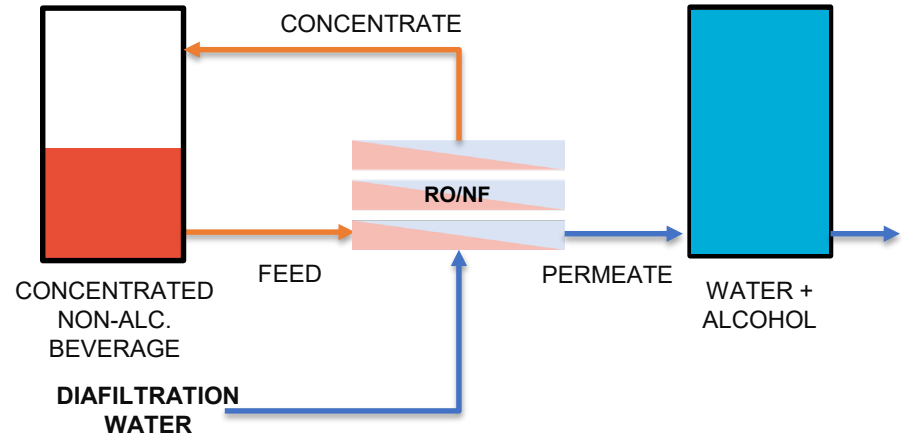
Once the volume of beverage reached **30-50%** of the original volume, **diafiltration water is introduced**.

Match the flow of diafiltration water with permeate flow (This ensure that the volume of the batch stays constant in the process)

Amount of diafiltration water used in this step depends on beverage type and required final alcohol content.

OBJECTIVE:

Washing out alcohol using diafiltration



Step 3: Dilution Phase

3

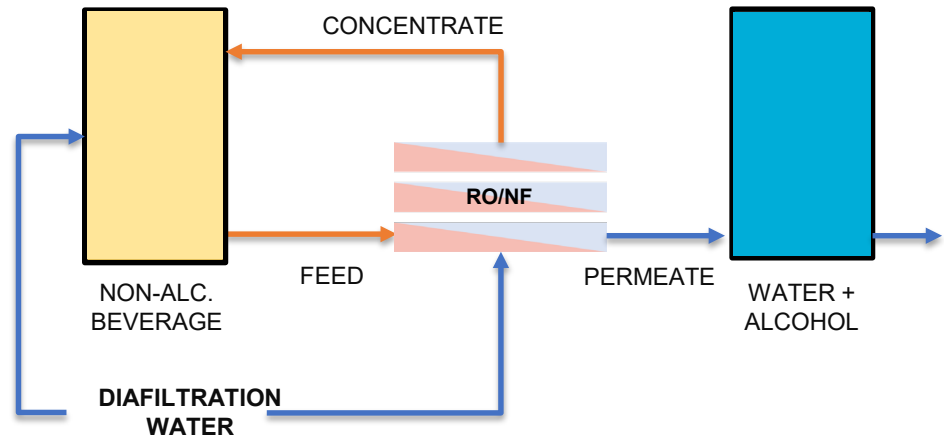
Dilution with RO permeate to original volume (100 %).

Dilution step can be postponed to the point of consumption to keep the volume lower for transport.

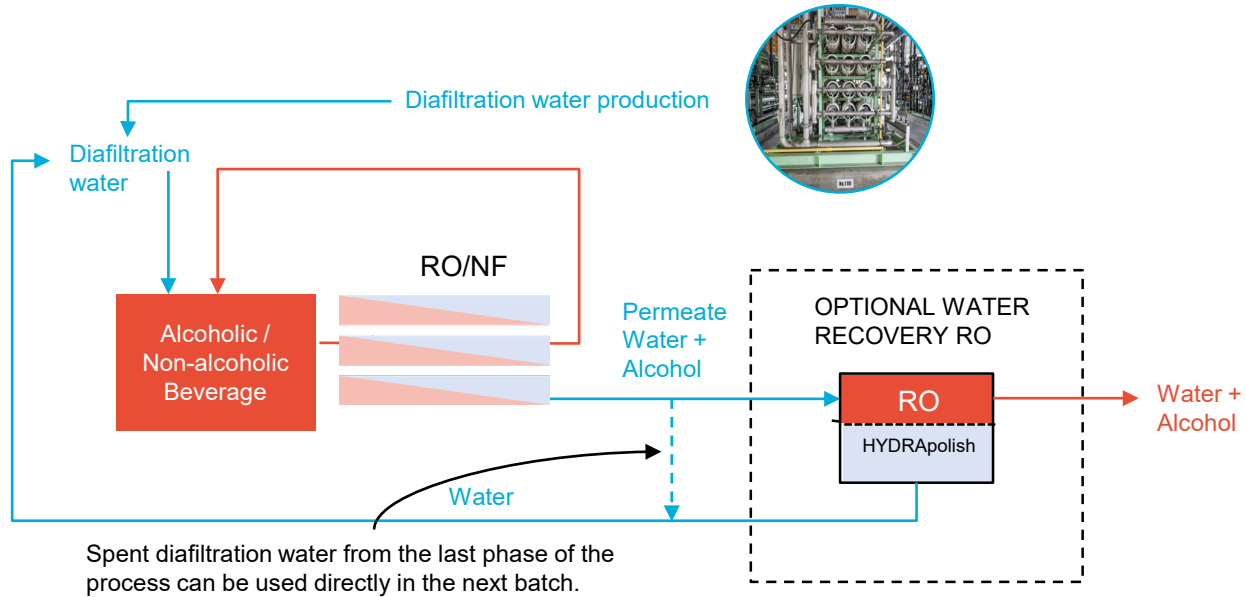
Additionally, beer can be enriched with more CO₂ and some additives could be added per customer's requirements.

OBJECTIVE:

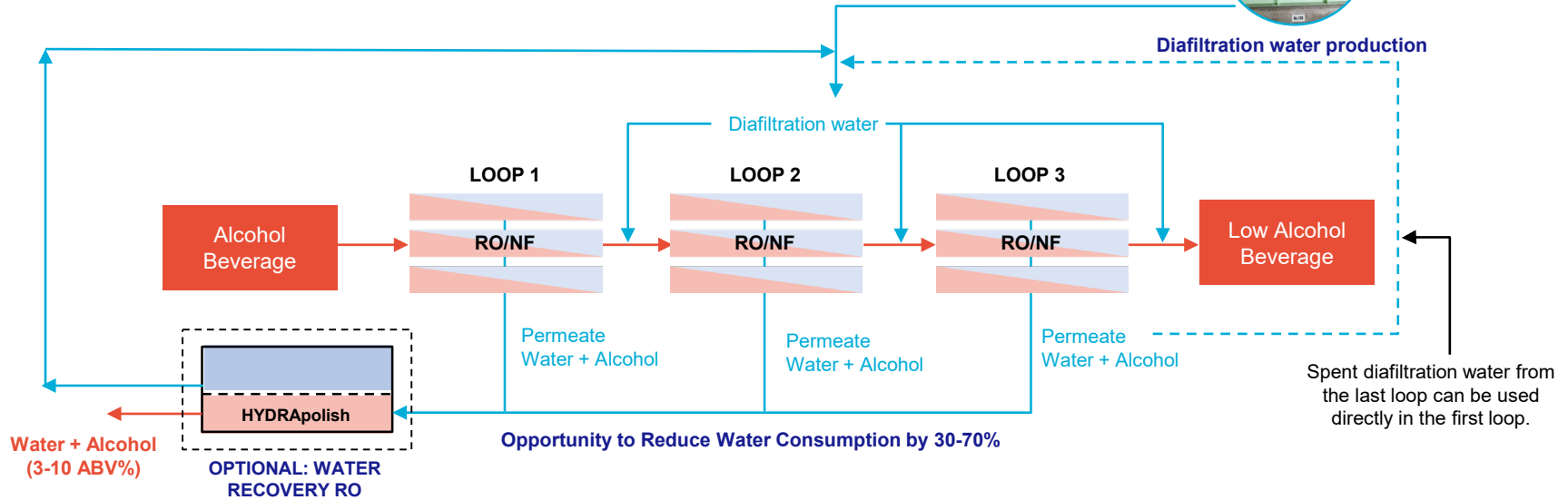
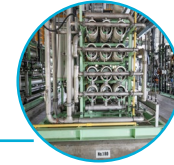
Achieve the desired final alcohol and extract content for either a low-alcohol or non-alcoholic beer and to fine-tune the flavor



Proposed Hydranautics Solution (Batch Process)

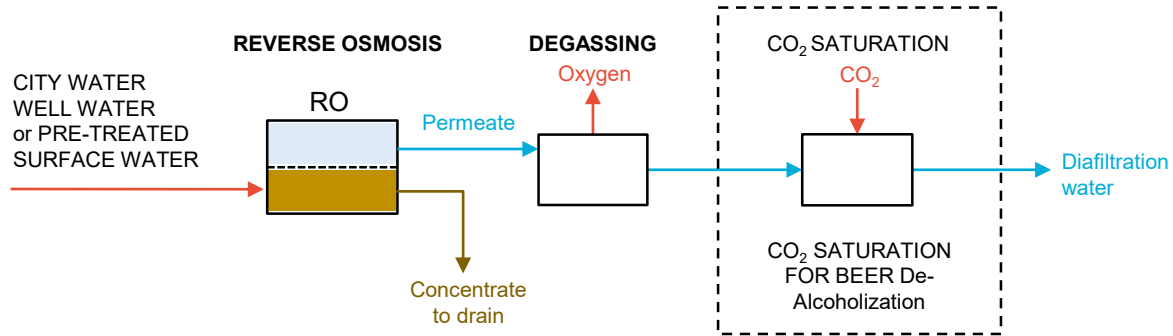


Proposed Hydranautics Solution (Continuous Process)



Number of loops depends on beverage type and required final alcohol content.

High Quality Diafiltration Water *(A must)*



Diafiltration water should be produced by RO. Degassing is needed for extended shelf life of the final product. For most types of feed waters **Energy Saving membranes (ESPA) and CPA** are sufficient to provide high quality diafiltration water.

Product Selection- De-alcoholized Beer



HYDRA-BEVNF for fast and energy efficient de-alcoholization. BEVNF elements have sanitary construction & necessary certification for food processing (i.e., FDA, NSF).



BEVNF allows for high alcohol removal with minimum loss of beer extract
(Trial Results: Czech Republic, USA, and Japan)



Expected diafiltration water consumption to achieve < 0.5 % ABV using BEVNF membrane is 150 % of the feed beer without water recovery RO
(150 liters of water for production of 100 liters of de-alcoholized beer)

Diafiltration water can be reduced by **REUSE**.

Low alcohol content diafiltration water can be reused directly.

Water recovery RO can reduce diafiltration water consumption by more than 50%.

Product Selection- De-alcoholized Wine



HYDRA-BEVRO membranes have been proved effective for wine de-alcoholization.

BEVRO elements also have the sanitary construction & necessary certification for food processing (i.e., FDA, NSF).



Dry and Semi sweet wines with richer taste are more suitable for de-alcoholization. The alcohol is part of the wine taste. Sparkling wines are also suitable.

Sweet wines are less suitable for de-alcoholization because of high osmotic pressure of sugars.



The expected diafiltration water consumption to achieve < 0.5 % ABV using BEVRO membrane is 400 - 500 % without the water recovery RO.

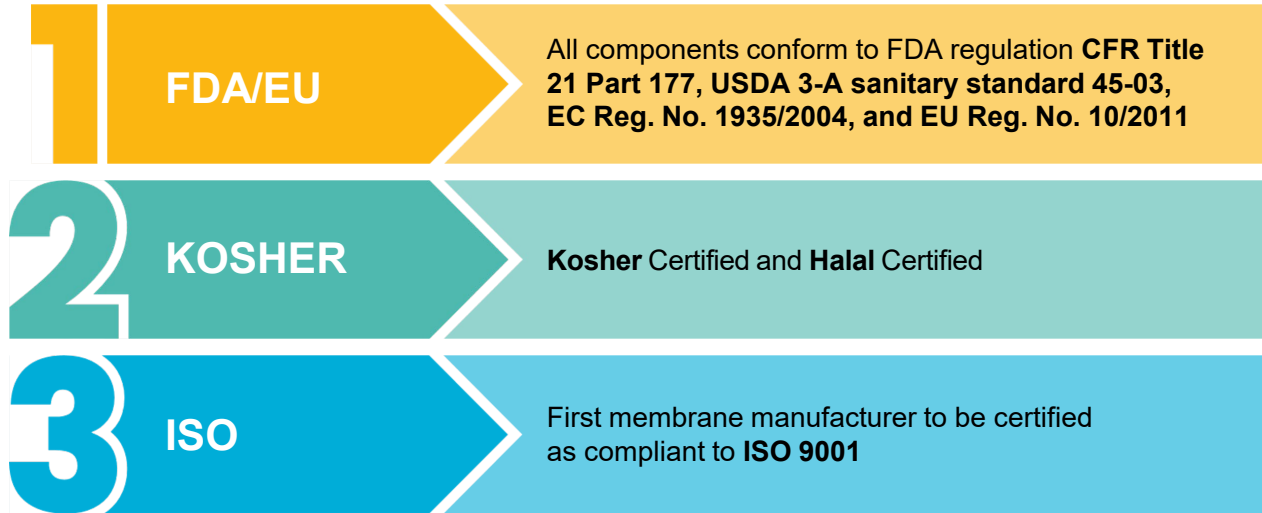
No need for CO2 atmosphere, but system should be enclosed.
Inert atmosphere in the holding tanks is recommended.

Diafiltration water can be reduced by **REUSE**.

Low alcohol content diafiltration water from last phase can be reused directly used in the next phase.

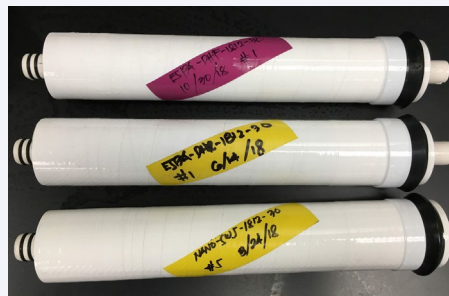
Water recovery RO can reduce diafiltration water consumption by more than 50%.

Certifications available on our Products



Lab Studies: USA, Japan

- Various RO and NF membranes tested 2018 - 2021



Permeate ↓ Concentrate
Feed



“Alcohol meter”
Kyoto electronics manufacturing
CO., LTD

insent Intelligent Sensor Technology, Inc.
Taste Sensing System
TS-5000Z

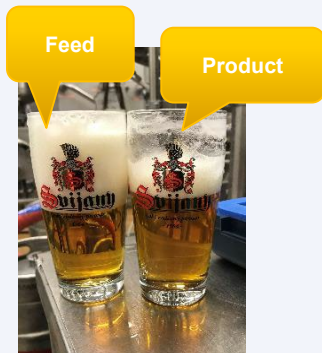
The Taste Sensing System TS-5000Z, which employs the same mechanism as that of the human tongue, converts the taste of various substances such as food and drugs into numerical data.

Using unique aftertaste measurement technology,

Intelligent Sensor
Technology, Inc.

Pilot test: Beer De-alcoholization (Current Process: Interrupted Fermentation)

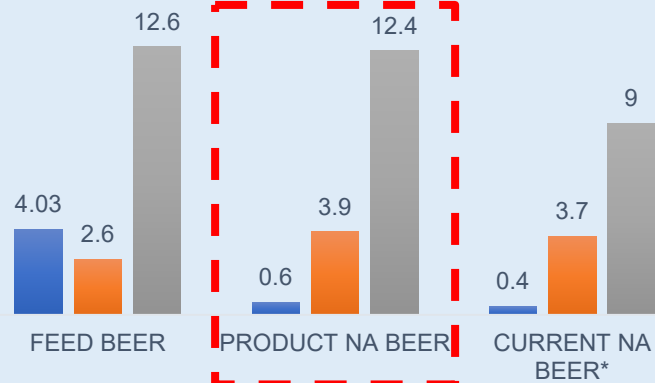
- BEVNF tested at medium sized brewery in Czech Republic in 2021
- Used 10° Lager with alcohol content 4.03% vol. Batch of 50 litres
- Based on previous testing adjusted amount of diafiltration water to 150%



Trial Snippets

BEER DE-ALC. TEST

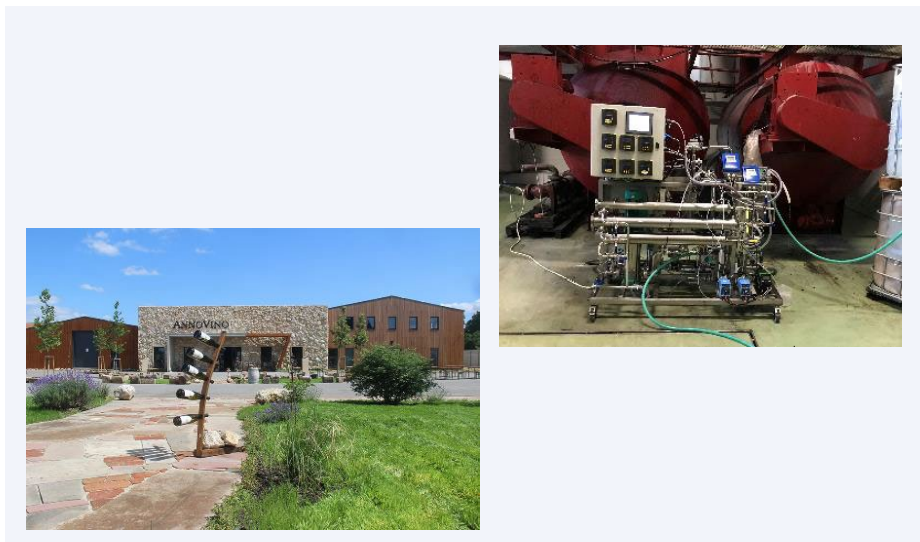
■ Alcohol [% vol.] ■ Extract [%] ■ Color [EBC]



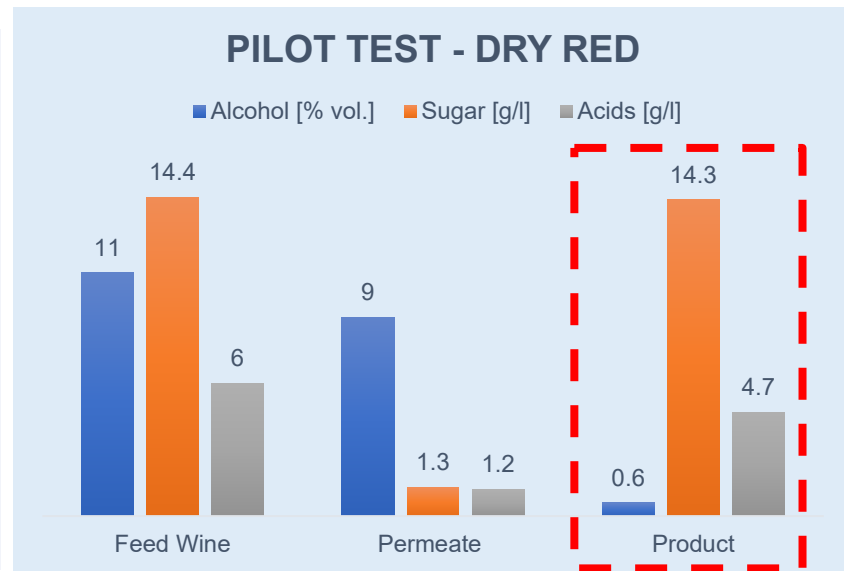
Test Results

Pilot test: Wine De-alcoholization

- Extensive wine de-alcoholization testing conducted at winery in Czech Republic in 2021
- Very good performance obtained with BEVRO
- Based on previous testing adjusted amount of diafiltration water to 400%. Water recovery possible.
- Good taste of the products confirmed by the winery representatives. More aromatic wine provide better tasting product.



Trial Snippets

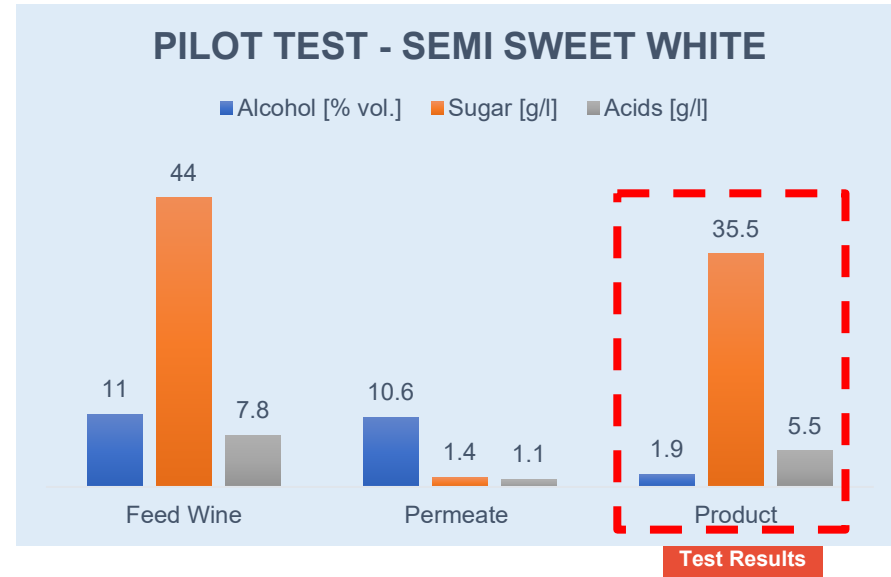
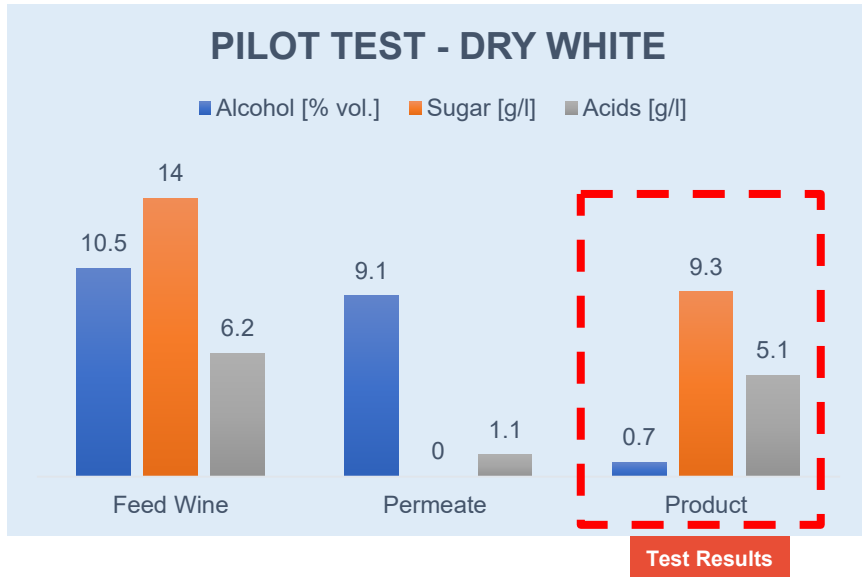


*Permeate obtained during concentration phase

Test Results

Pilot test: Wine De-alcoholization

- Extensive wine de-alcoholization testing conducted at winery in Czech Republic in 2021
- Very good performance obtained with BEVRO
- Based on previous testing adjusted amount of diafiltration water to 400%. Water recovery possible.
- Good taste of the products confirmed by the winery representatives. More aromatic wine provide better tasting product.



*Permeate obtained during concentration phase

Pilot test: Flavored Malt Beverage

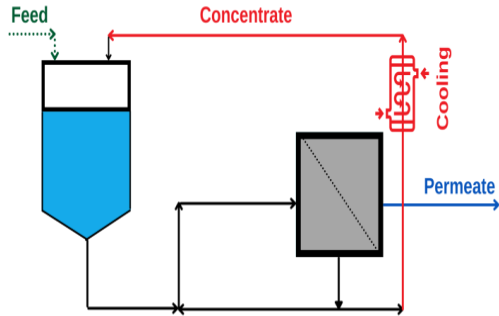
- Fermentation of water/sugar/yeast from either
 corn sugar base
 cane sugar base
- Highly colored base product
- Desire to remove color, odor, and off-tastes from the base with minimal alcohol loss
- The product (permeate) is inspected for alcohol, color, aroma, and flavor
- Flavorings added to create “hard seltzer” or “cocktails”



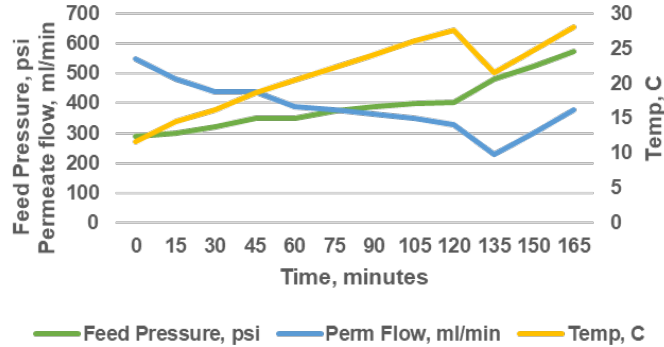
Pilot test: Flavored Malt Beverage

HYDRACoRe Performance: Sensory Evaluation

- Clarity: reduction in haze and color is excellent
- Flavor: reduction in non-neutral flavor is moderate
- Aroma: reduction in non-neutral odor is minimal



HYDRACORE50 3838-30 Performance FMB Pilot Test June 2020



Feed/Conc
15.5% abv

Product
15.6% abv

Reference – Hard Seltzer Production in India

- Beer concentration and production of free alcohol base for production of Hard Seltzer using BEVNF and activated carbon.
- Concentrate (non-alcoholic beer) is currently not being used
- Commissioned in 2023
- Capacity 50 hl/hour of free alcohol base
- 12 pc. 8" BEVNF membranes installed
- Skid prepared for an extension to 75 hl/h (18 pc. 8" elements)

FEED BEER / NF PERMEATE / ACF OUTLET





Energy, Water, and Cost Savings

- Low operating temperature
- Low operating pressure
- Low CAPEX
- Solution for diafiltration water recovery
- Valuable by-product – Hard Seltzer



Consistent Flavor and Taste Profile

- Use of fully fermented feed beverage
- Operate at low temperature. Volatile substances stay in the product
- Hygienic design
- No oxygen pickup
- CO2 pressurization possible



Great Flexibility

- High energy efficient membranes and short cycle time process provides greater flexibility in terms of production capacity
- Easy scale-up
- Real time alcohol monitoring
- Solutions for craft brewers
- Full automatization possible

Nitto

Innovation for Customers