



Objective

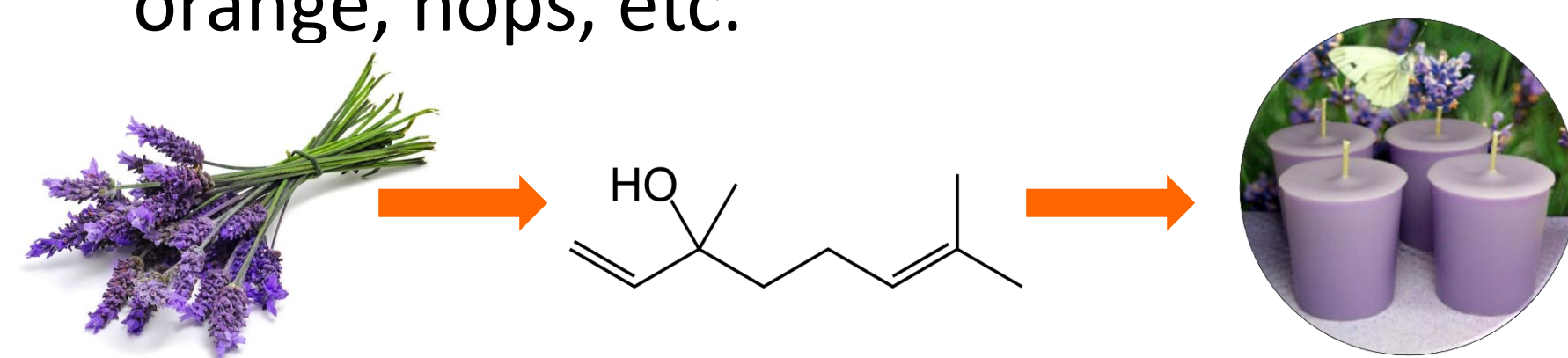
Collaborate with innovative start-up company, OilExTech, to increase yields and extractability of essential oils by adapting the EssenEx™ 100.

Proof-of-Concept: Design prototype pressurized unit to operate at elevated temperatures and assess performance for mint, hops, and orange.

Essential Oils

Essential oils are highly aromatic compounds found in seeds, flowers, and herbs.

- Uses:** perfumes, cleaners, aromatherapy, food flavoring, candles, etc.
- Examples:** lavender, rosemary, mint, orange, hops, etc.



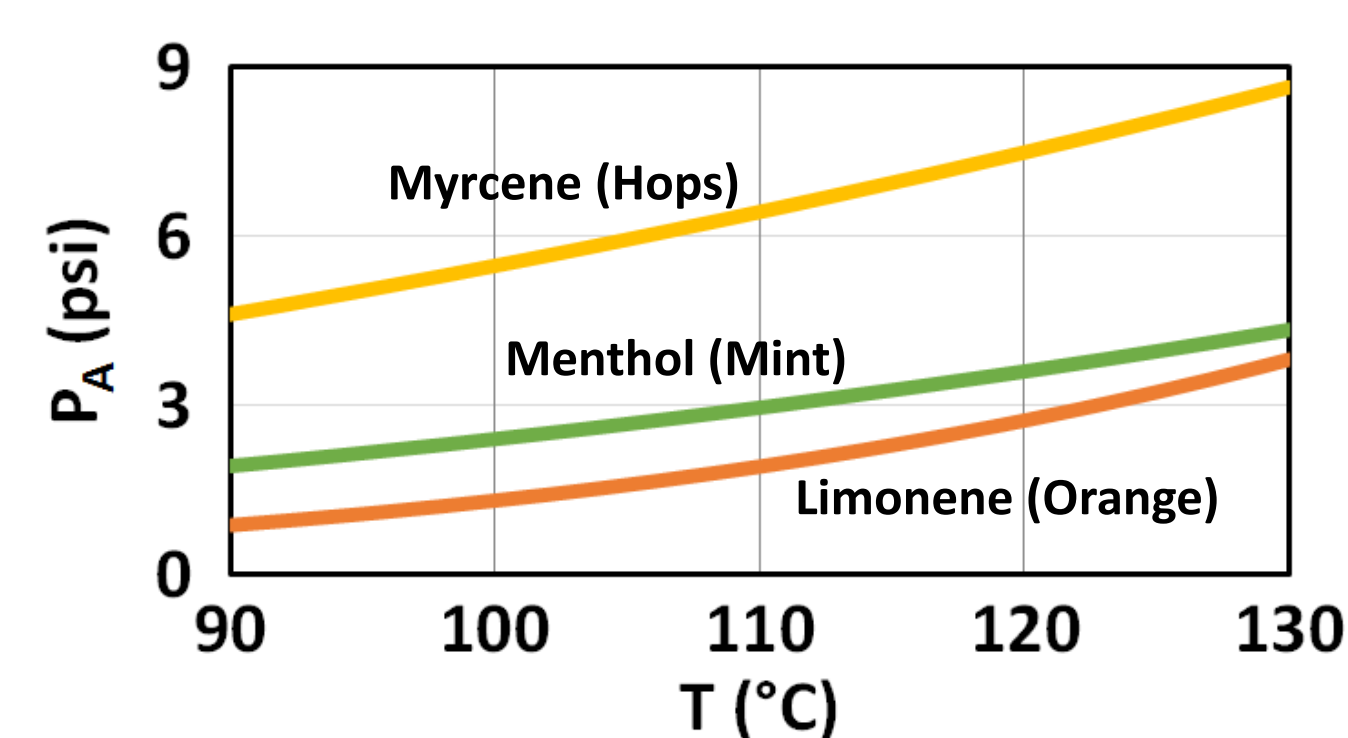
Hypothesis

Elevated pressure and temperature will improve oil extraction yield and efficiency.

- Increased Desorption:** Essential oil desorption from porous plant material can be modeled by Knudsen diffusion. Increased pressure causes swelling of plant pores, increasing diffusivity.

$$\text{Diffusivity, } D_{KA} \propto d_{\text{pore}} \sqrt{T}$$

- Increased Volatility:** Partial pressures of oil components increase at higher temperature (Antoine's equation)



Pressurized Essential Oil Extraction Design

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EssenEx™ 100: Solvent-Free Microwave Extraction

The EssenEx™ 100 is an essential oil extraction unit developed and sold by OilExTech for home and lab use. The unit utilizes solvent-free microwave extraction, which uses microwaves as the energy source. The combination of microwave heating and mass transfer phenomena has been proven to accelerate the process and obtain higher extraction yields.

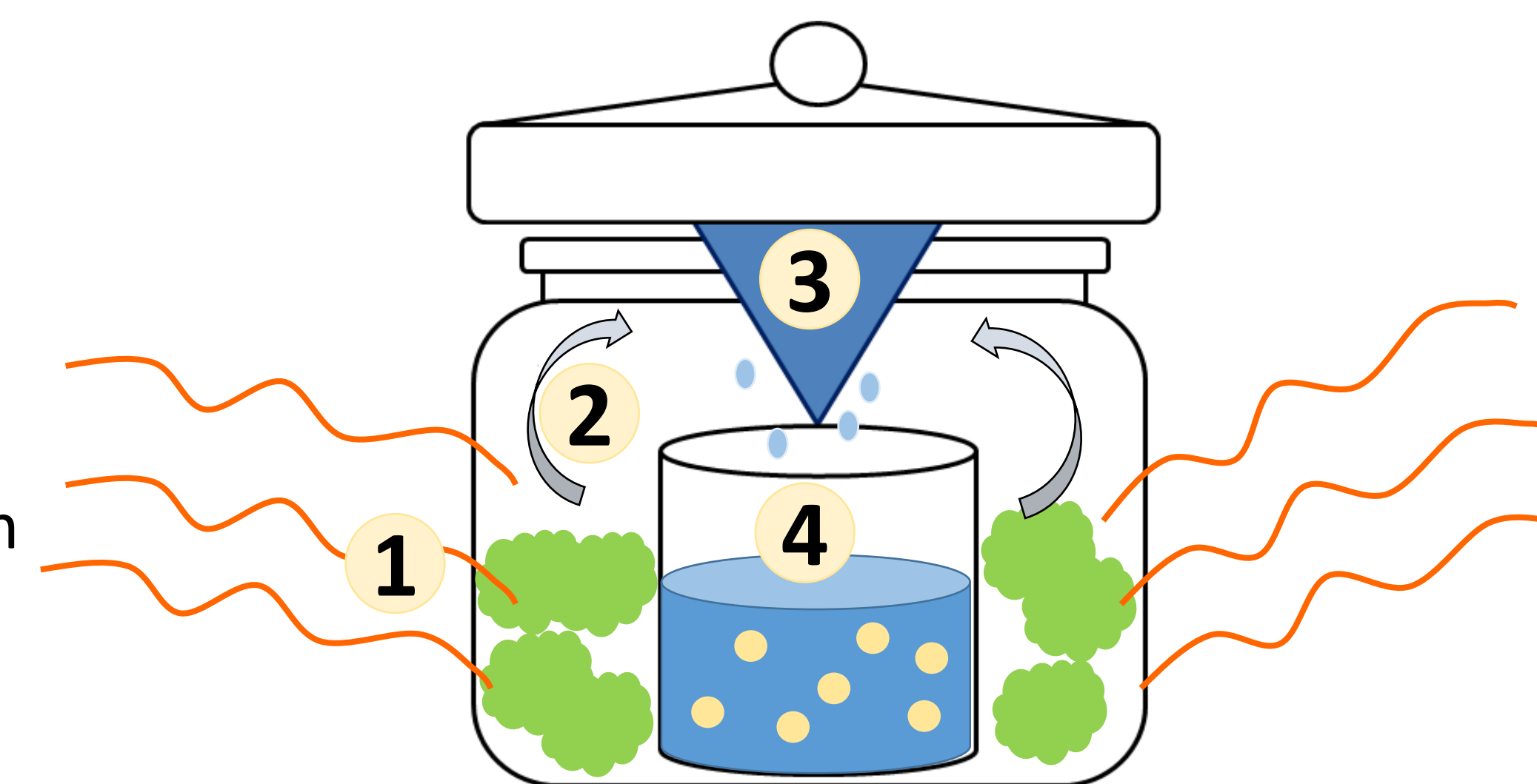
PROCESS SEQUENCE

- Microwave Absorption:** Water readily absorbs microwaves due to its high dielectric constant causing *in situ* water in the plant to heat up and vaporize. Microwaves simultaneously rupture oil glands and free oils.



➤ **Freed oil is vaporized and carried by the steam.**

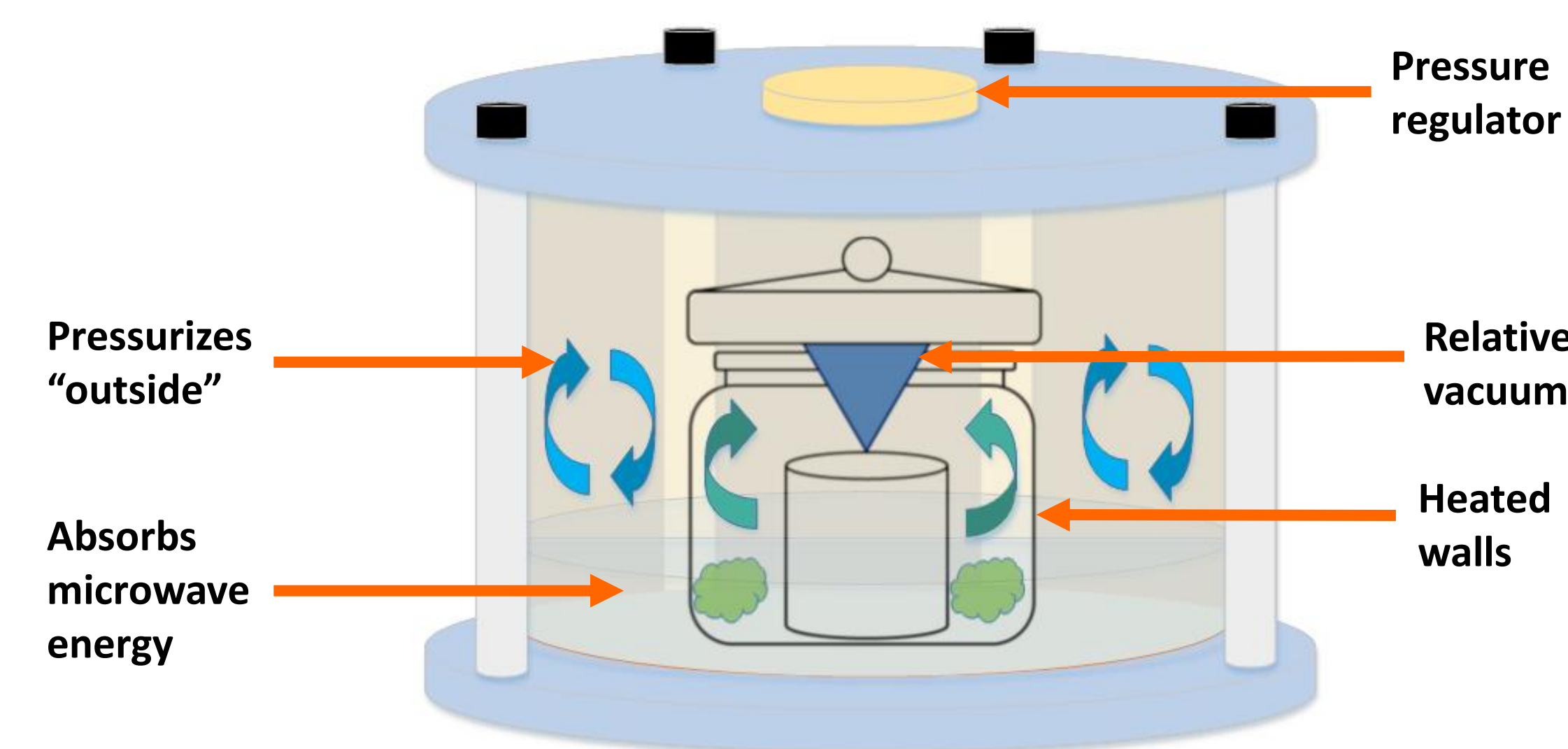
- Vapors Travel to Ice Core:** Vapor mixture is driven to ice core by temperature and concentration gradients.
- Condensation:** Vapor mixture condenses on ice core, which collects in the microwave-shielded beaker.
- Oil Separation:** Insoluble oil floats to the top of the water and is separated by decantation.



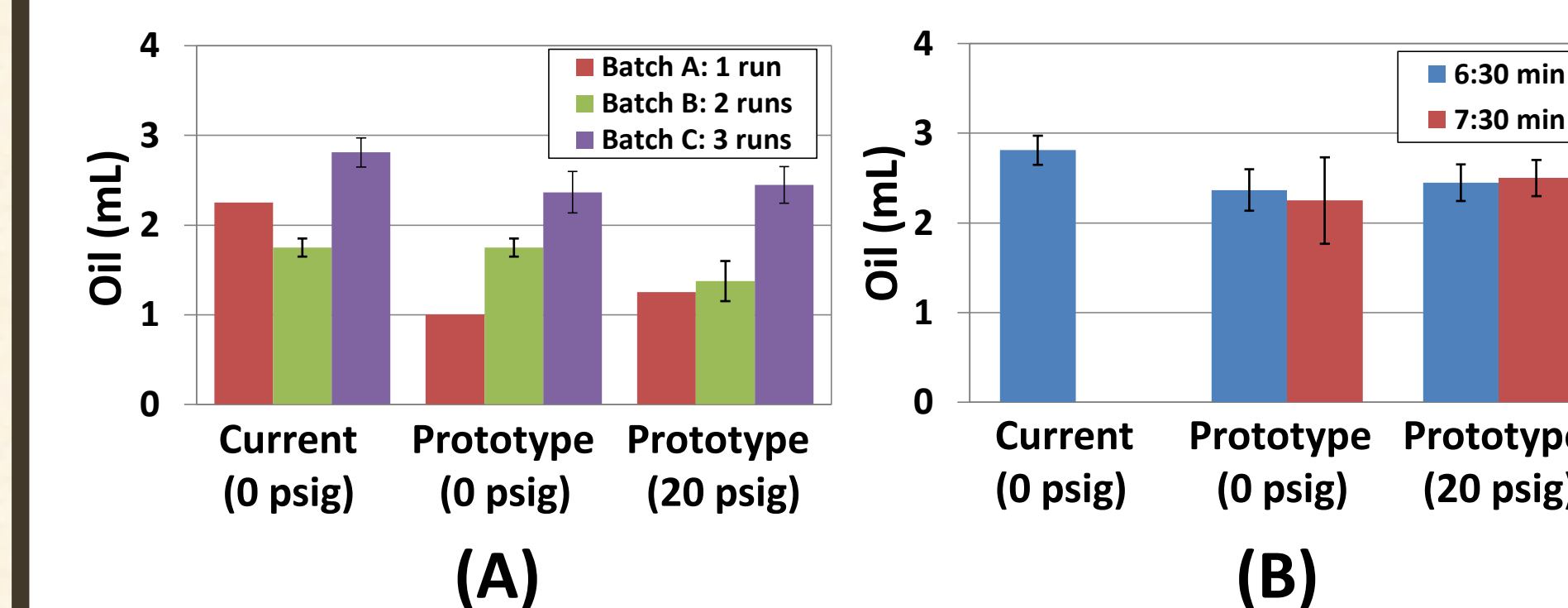
Prototype: Pressurized Microwave Extraction

Pressurization is obtained by placing the EssenEx™ 100 inside a closed vessel designed to hold a maximum pressure of **20 psig** and withstand temperatures up to **125 °C** during microwave extraction.

- Extraction in a Closed Vessel:** Steam production pressurizes the system and water boiling temperature increases. Pressure is regulated with calibrated weight on relief orifice.
 - *Extraction at higher temperature and pressure = increased yield*
- Water Reservoir Inside Vessel:** 200 mL added to serve as steam source to pressurize vessel, absorb excess microwave energy, and reduce product loss.
 - *Prevents vaporized oils from escaping unit*
 - *Heats walls to minimize condensation on glass*



Orange Zest Results



Plot A Results: Constant 6.5 min extraction time from three orange zest batches.

- Variations between batches and runs are larger than variation between systems.
- Conclusive comparisons between systems cannot be made from different batches of orange zest.

Plot B Results: 6.5 and 7.5 min extraction times from single batch (Batch C).

- Variation between systems was insignificant compared to variation between runs.
- Overall effects of elevated temperature and pressure are insignificant for orange zest, suggesting the EssenEx™ 100 may already be providing optimal conditions and higher yields could not be obtained.

Future Work

Test plant materials that are more difficult to extract oil from in the EssenEx™ 100.

- Fresh Mint or Fresh Hops
- Lavender
- Rosemary

Develop a lighter, stronger, and more robust lightweight pressurization vessel

- Stiffer plastic that withstands higher pressure and temperature
- Multiple weights for variable pressure

Acknowledgements

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