

Background and Objectives

- Crude salmon oil contains high amounts of impurities such as high levels of Free Fatty Acids (FFA), phospholipids, pigments and other undesired compounds.
- The objective for this project was to design a physical refinement process for Scotia Garden Inc. to remove impurities from crude salmon oil.
- The process will improve the oil quality while increasing its market value.

Index	Content
Peroxide Value, PV	< 20
Free Fatty Acid, FFA (%)	< 1
Moisture and Insoluble Impurities	< 1
Unsaponifiable Matter (%)	< 2.5
Iodine Value, IV (cg/g)	130-180
Gardner Scale	< 15

Design Process

- Crude oil enters the feed at 10,000kg/day and undergoes Enzymatic Degumming. Phospholipids/soaps are removed with centrifugation.
- Pigments are removed in the bleaching vessel and is then sent to the filtration unit.
- The adsorbent is removed during filtration by the J-press separation.
- Finally, free fatty acids and volatile components were removed through the deodorization column and scrubber.

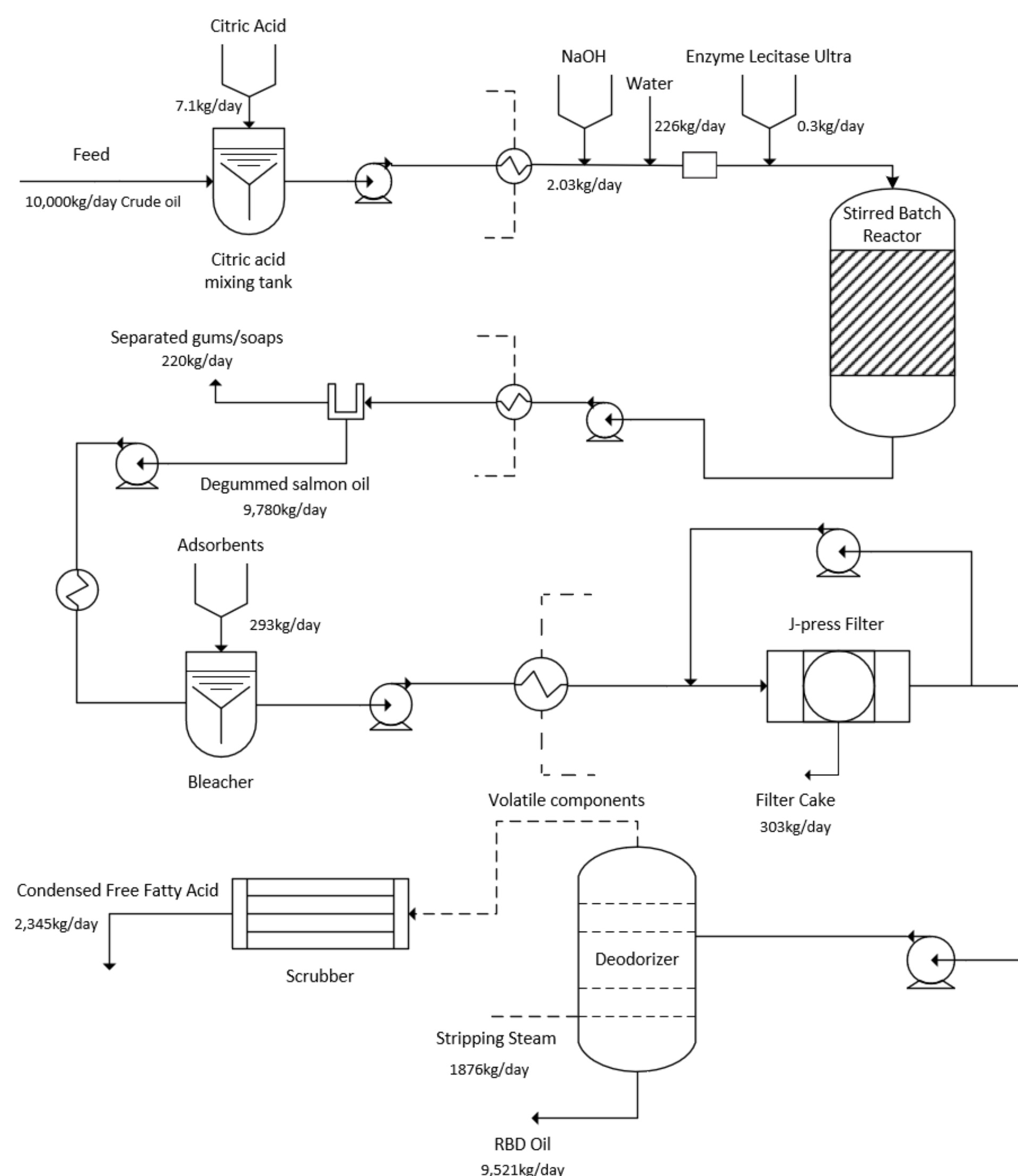
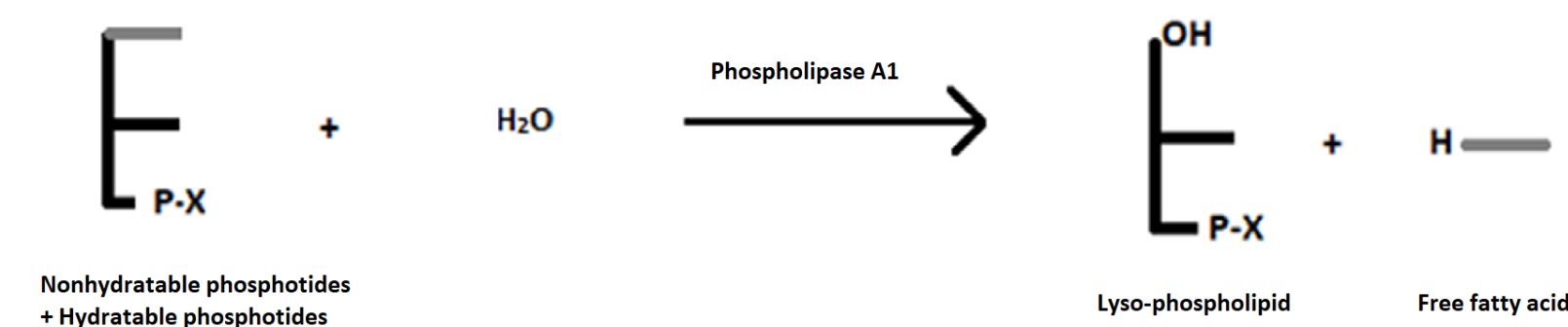


Figure 1: Process Flow Diagram of the refining process.

Details of Design

Enzymatic Degumming

- Enzymatic degumming converts non-hydratable phospholipids into hydratable lyso-phospholipids, being simpler to separate in the water phase [2].



- 7.1 kg of citric acid and 10,000 kg of oil mix for 30 minutes at 70°C to chelate metals and open phospholipid micelles.
- Lecitase Ultra is injected at 30ppm, with a reactor temperature of 50°C.
- 2.03kg of sodium hydroxide adjusts the pH to 4 for optimal enzyme performance.
- Enzyme reaction was modeled as a first-order reaction, by normal design principles for reaction tanks and heat transfer.

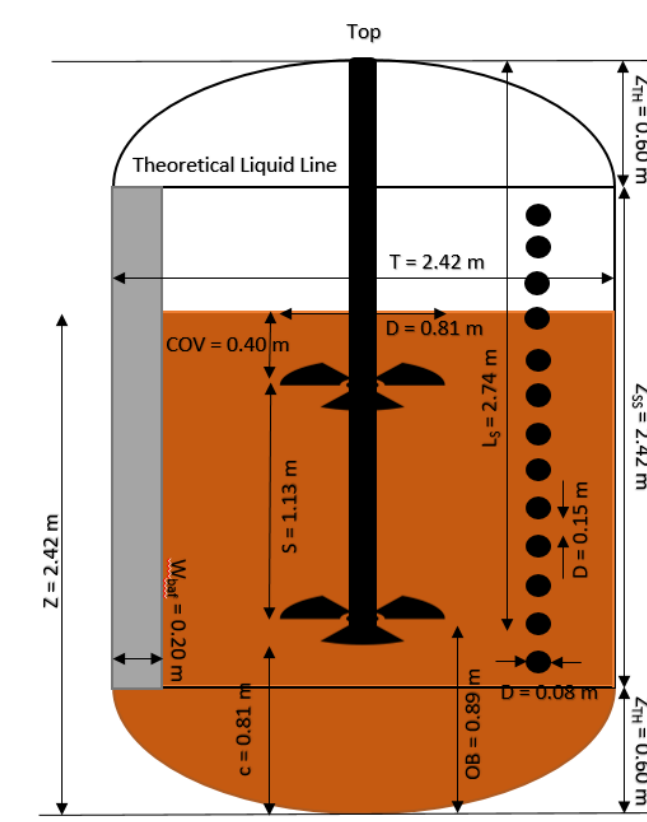


Figure 2: Dimensions of batch reactor.

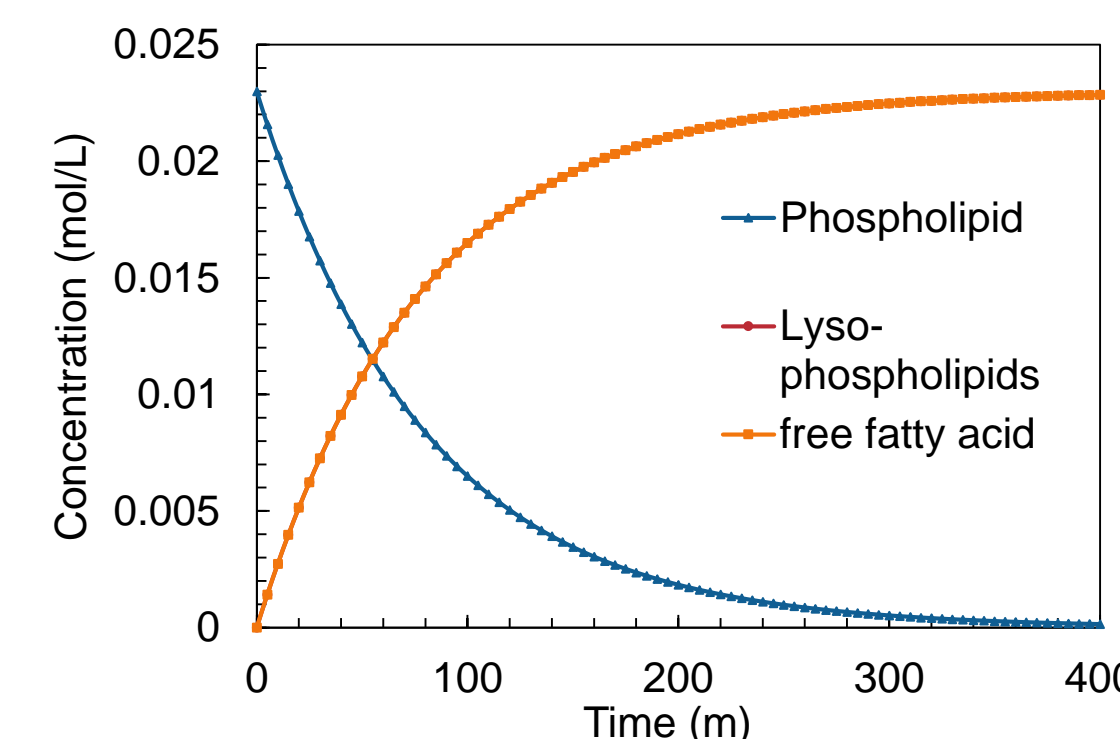


Figure 3: Conversion of phospholipids into hydratable lyso-phospholipids.

Filtration

- A J-Press filter press manufactured by Evoqua was chosen for the filtration process (Height of 1.16 m and width of 0.84 m).
- The minimum and maximum length of the J-Press is 1.04 m and 2.36 m respectively. The length can be varied to vary the number of filter plates.

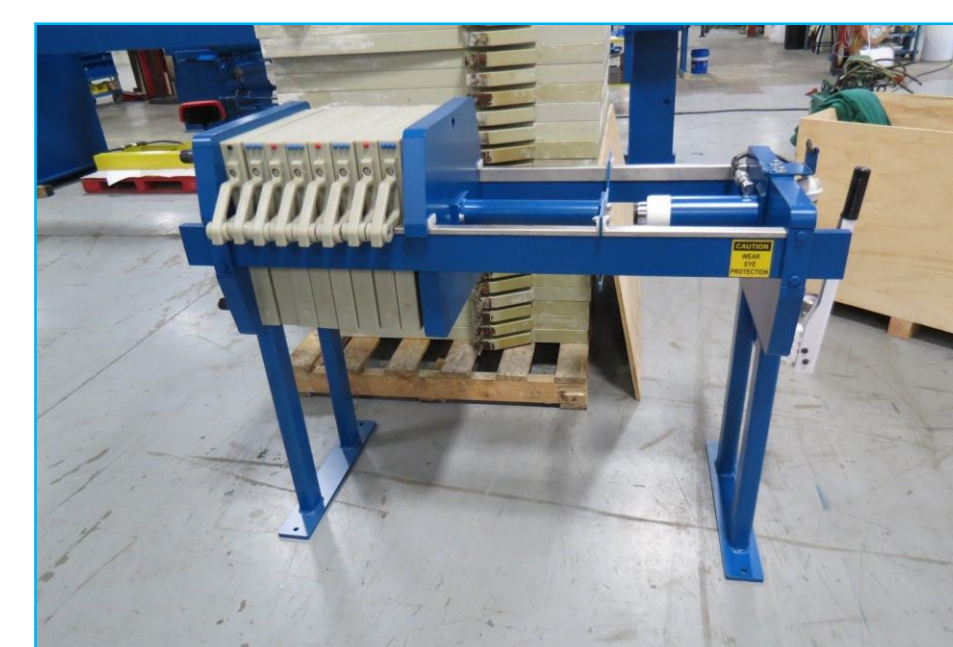


Figure 6: J-press filter press [3].

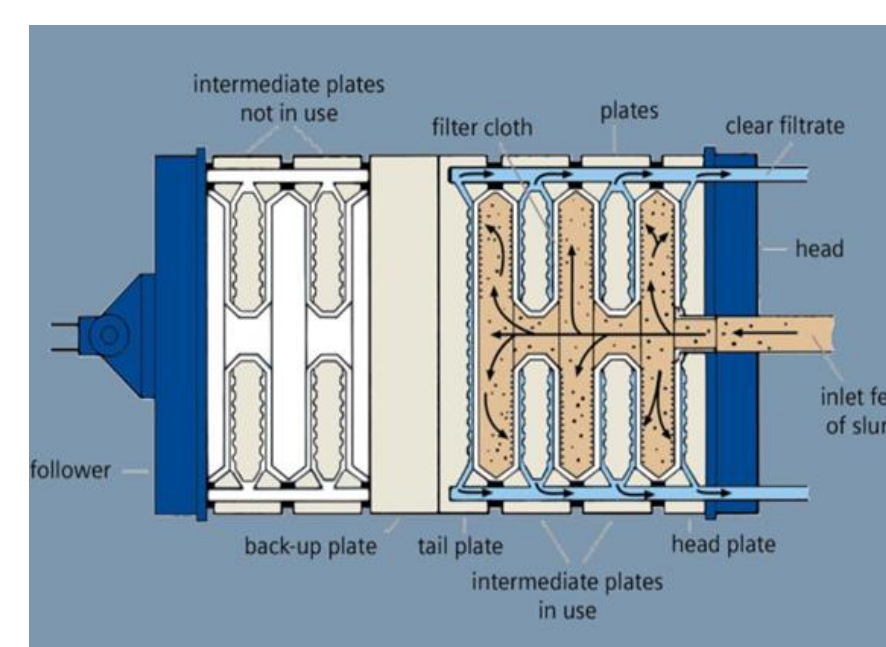


Figure 7: Schematic of Internal flow in J-press filter press [3].

- The filter cloth is made from polyester to enhance the durability and spun-staple yarn is used as weaving pattern.
- The used adsorbents cannot be regenerated as it is more economical to purchase new adsorbents and safely dispose the used filter cakes.

Bleaching

- A bleaching unit is used to remove the unwanted pigments from the salmon oil.
- Inside the bleaching tank the salmon oil is heated to 105 °C, at which point the adsorbent is added to the mixing vessel.



Figure 4: Gardner color scale (ASTM-D1544).

- The temperature of 105 °C was determined from literature review and experimental testing.
- A critical speed was calculated to achieve uniform mixing of the adsorption particles using a hydrofoil impeller.

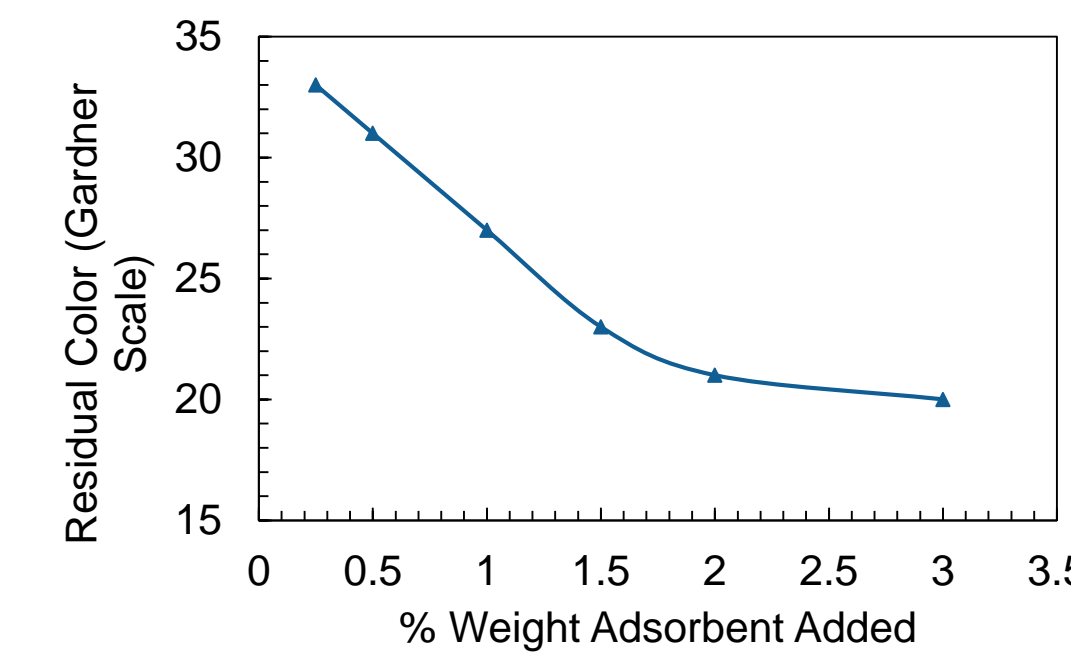


Figure 5: Comparing residual colour with amount of adsorbent added.

Deodorization

- Deodorization removes FFA and other volatile components from salmon oil using superheated steam at vacuum conditions [4].
- The amount of steam required is dependent on the temperature and pressure inside the vessel.

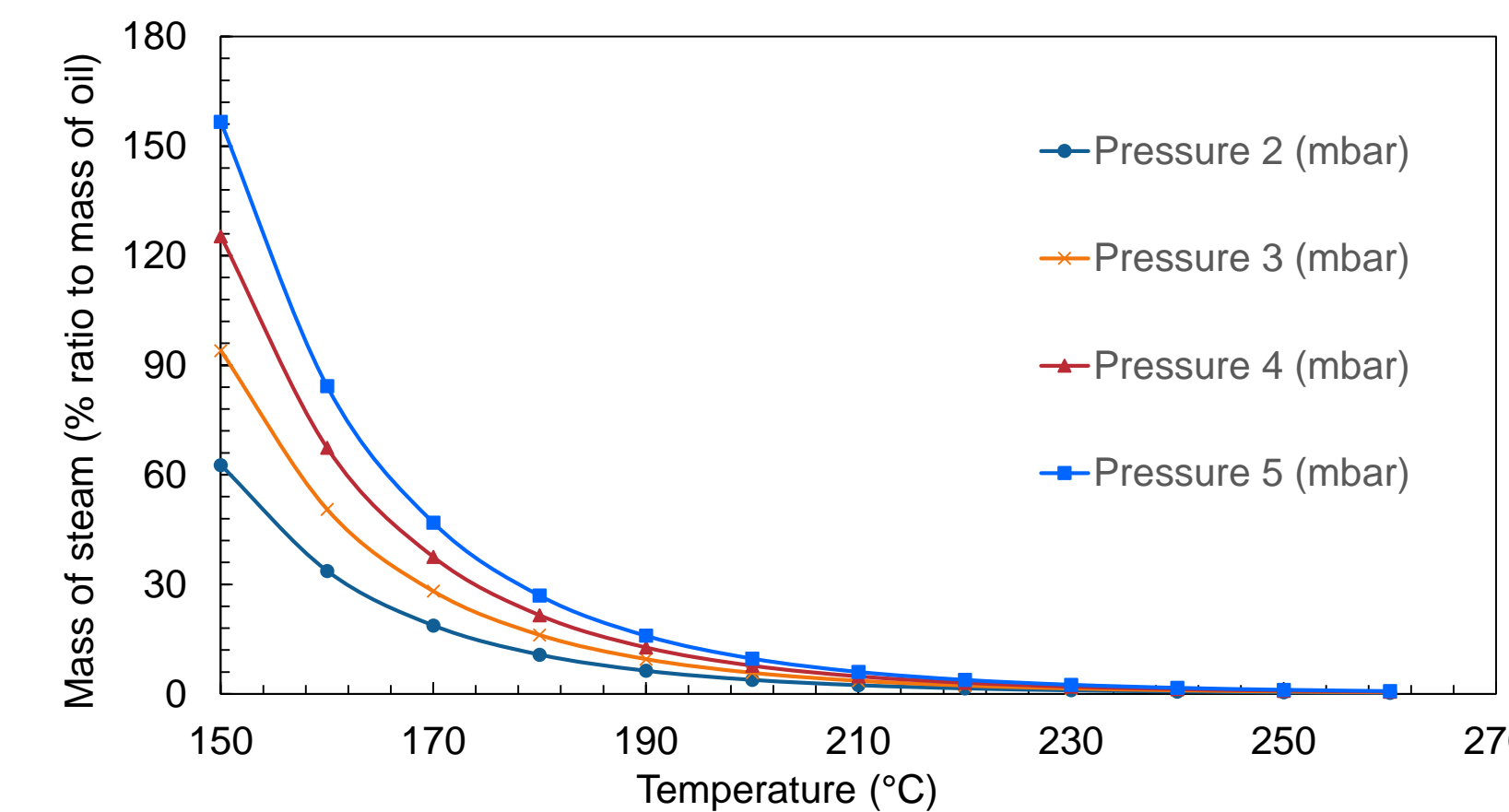


Figure 8: Mass of steam required at various operating pressures.

- The most cost-effective operating conditions are 2 mbar and 170°C.
- The deodorizer vessel designed for this process will be made out of stainless steel with a diameter of 2.5 m and a height of 5 m.

Laboratory Experiment

- Bleaching on a bench scale was performed to determine the optimal type of adsorbent for adsorption purification.
- Perform 4000 was the chosen adsorbent trialed at different concentrations. This was then added to crude salmon oil at 105°C for 20 minutes with agitation.



Figure 9: Effect of beaching earth on salmon oil.



Figure 10: Perform 4000 (bleaching clay) from Oil-Dri Corp.

Economics

Equipment Cost	
Bleacher	\$393,000.00
Degumming	\$141,756.97
Deodorizer	\$396,000.00
Filtration	\$119,960.00

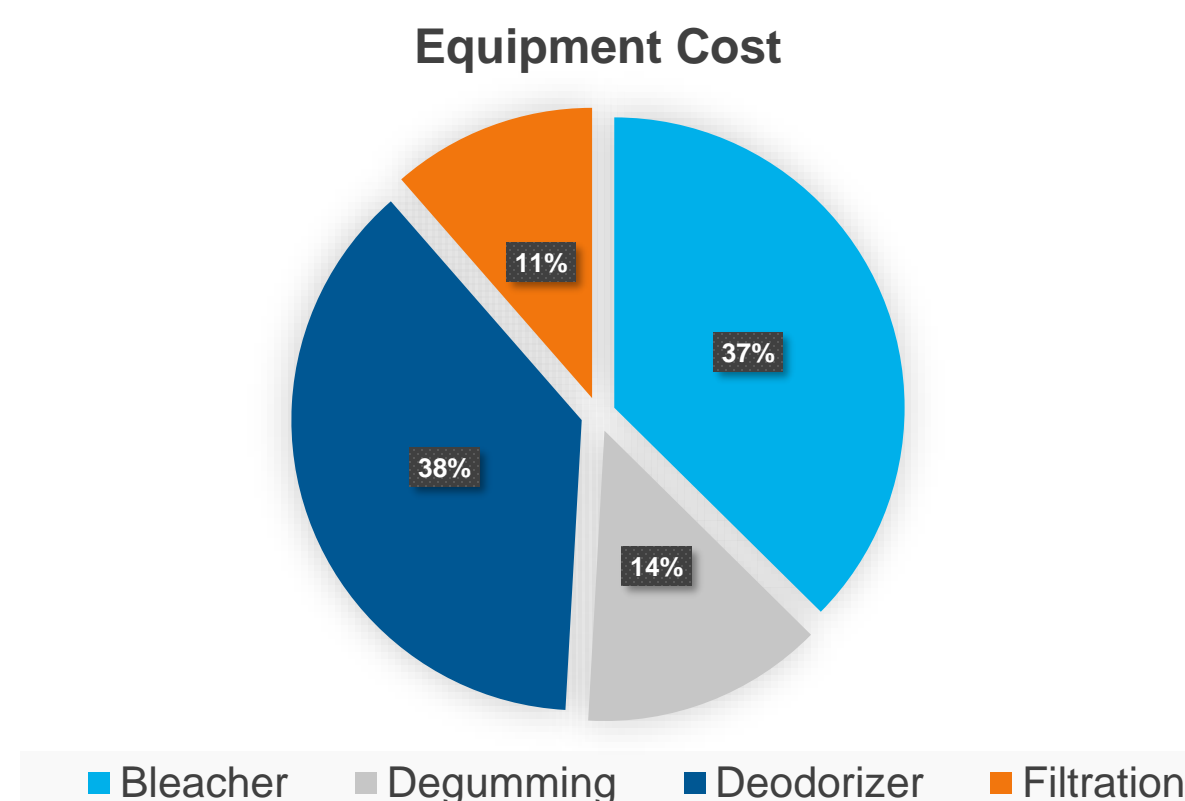


Figure 10: Pie chart illustrating equipment costs.

Annual Utility Cost	
Bleacher	\$19,070.00
Degumming	\$1,460.00
Deodorizer	\$253,291.00
Filtration	\$1,621.00

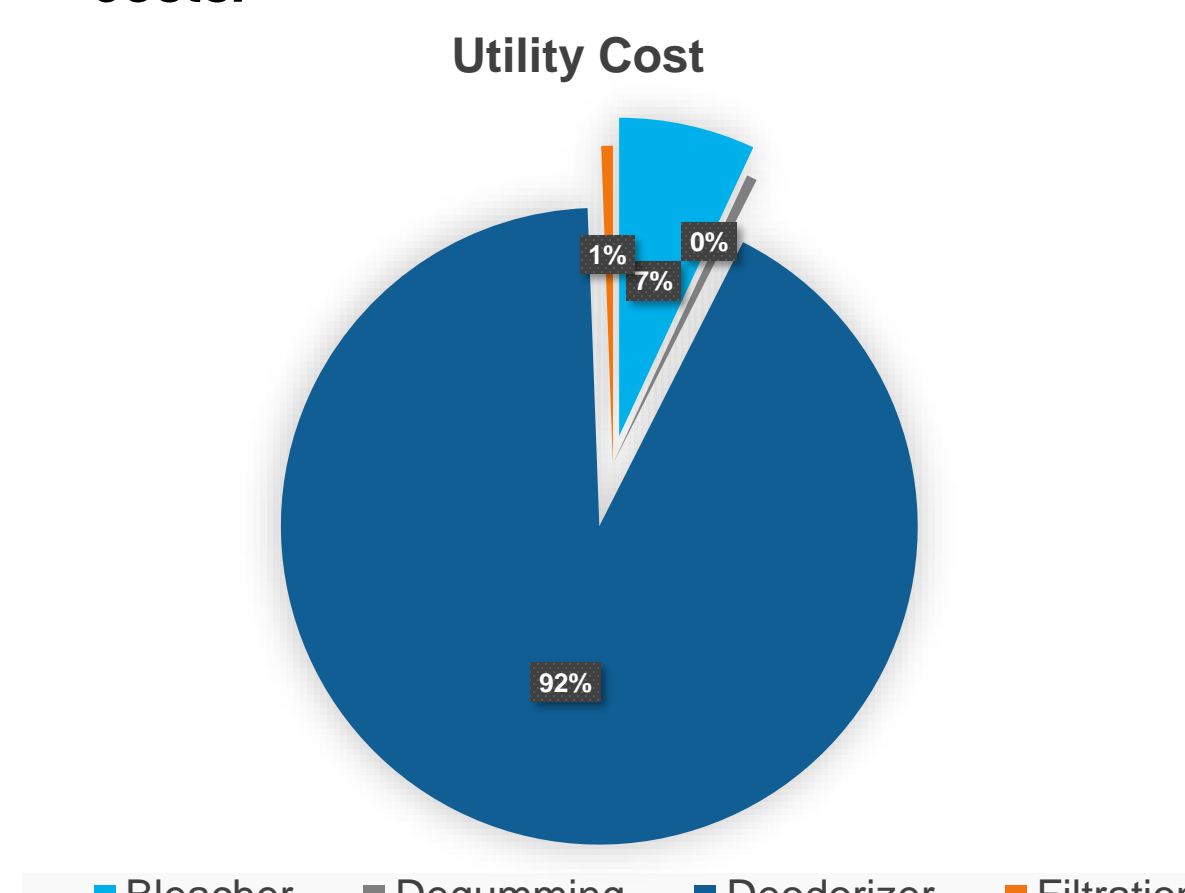


Figure 11: Pie chart illustrating utility costs.

Conclusion and Recommendations

- The purification of salmon oil was successfully achieved with the process designed for Scotia Garden Seafood Inc. The laboratory test to analyze the performance of adsorbents proved to be successful.
- The designed process can be altered and some unit operations can be bypassed according to the varying quality of the oil.
- It is necessary for the exact operating conditions in terms of temperature, pressure, and mixing time for each unit to be met as to achieve desired results.

References

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