Shear-driven and Static Winterization of Algae Oil: Impact on crystal morphology and separation efficiency

Background and goals

The goal of the thesis was to investigate different winterization methods for fractionation of algae oil and evaluate their respective impact on crystal morphology and separation efficiency.

Results and discussion

Static winterization formed larger average crystal diameters compared to shear-driven winterization.
This may be attributed to dynamic winterization exceeding a critical shear-rate limit, which promotes the formation of smaller crystals through shattering crystals that form past a certain size.

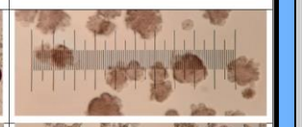
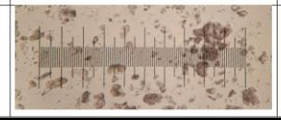
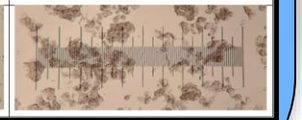
GC-analysis of the fractions generated during experiments showed that dynamic winterization yielded variable results with no clear trend, which may be a result of compound crystal formation. Static winterization on the other hand had a stable increase in PUFA content, and a decrease in SFA content for the liquid fractions. ω-3 content also increased.

Dynamic Winterization

Temperature range and fraction	S 50-20	S 20-15	S 15-12	S 12-10	S 10-8	L 50-20	L 20-15	L 15-12	L 12-10	L 10-8
SFA	57.21 %	53.25 %	53.00 %	51.11 %	51.31 %	72.06 %	56.80 %	64.05 %	62.24 %	59.67 %
PUFA	40.84 %	44.27 %	44.50 %	45.30 %	45.06 %	24.35 %	35.96 %	34.75 %	35.06 %	36.63 %
% *C20:3*	0.70%	0.81%	0.83%	0.91%	0.94%	0.70%	0.53%	0.47%	0.43%	0.56%
% *EPA (C20:5)*	0.50%	0.59%	0.57%	0.67%	0.69%	0.53%	0.39%	0.33%	0.30%	0.45%
% *DHA* (C22:6)	39.64 %	42.87 %	43.10 %	43.73 %	43.44 %	23.12 %	35.05 %	33.95 %	34.33 %	35.62 %

Static winterization

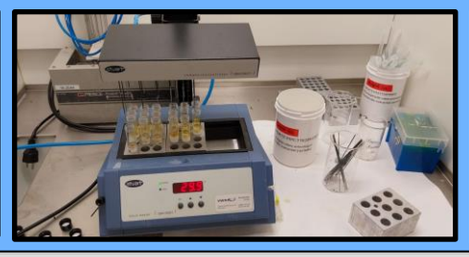
Temperature range and fraction	S 50-20	S 20-15	S 15-10	F 50-20	F 20-15	F 15-10	F 10-4
SFA	61.47%	60.10%	58.85%	49.77%	50.67%	48.16%	47.05%
PUFA	32.66%	35.82%	38.81%	35.74%	43.31%	46.70%	47.79%
% *C20:3*	0.57%	0.51%	0.65%	0.64%	0.90%	1.09%	1.19%
% *EPA (C20:5)*	0.42%	0.38%	0.48%	0.51%	0.72%	0.77%	0.86%
% *DHA* (C22:6)	31.67%	34.93%	37.68%	34.59%	41.70%	44.84%	45.74%

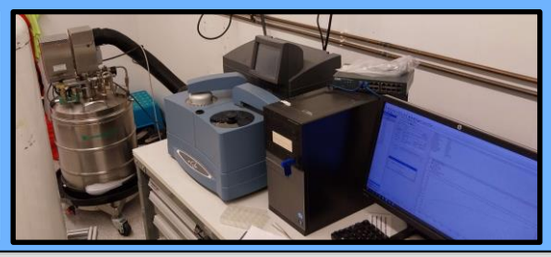
Temperature range	Dynamic winterization	Static winterization
50°C→20°C		
20°C→15°C		

Materials and method

Two methods of winterization was utilized to fractionate algae oil over several temperature ranges. These were shear-driven (dynamic) and static winterization. For the dynamic winterization, a magnetic stirrer was utilized to create shear-forces in-solution, while static winterization had no forces applied.

To investigate the thermodynamic properties and fatty acid composition of the fractions generated, Gas chromatography (GC) and differential scanning calorimetry (DSC) was performed.





Conclusion

Winterization performed with an absence of shear-forces proved to produce crystals with larger average diameters, and morphologies that were easier to separate. This increased separation efficiency. The results from GC-analysis strengthened this observation.

Applying shear-forces had a negative impact on separation efficiency and lead to smaller crystal formations, though this is thought to take place due to exceeding a critical shear-rate limit. If a lower shear-rate were utilized, the dynamic winterization might have had more beneficial results.

Acknowledgements

I want to thank Ignat Tolstorebrov and Kirill Mukhatov for their steadfast and invaluable guidance during this project. Thanks to G.C Rieber for providing the algae oil necessary for the project.

Author: Jørgen Skogstad

NTNU | Norwegian University of Science and Technology