THE THAROS ADVANTAGE

CO_2 FOOTPRINT
EFFICIENCY MARKERS
SUSTAINABILITY

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Summary

THAROS' decades-long research confirm that cleanest, sustainable, low-cost, environmental-friendly, fresh, and nutritious krill products, for example oils enriched in (PL) phospholipids[1], are obtained when fresh raw krill is processed at-sea, directly where fishing operations takes place, in less than 2 hours from catch, on-board a factory trawler.

Why a solvent-free krill oil extracted this way matches such requirements;

- Protects krill's highly regulated habitat in the South Antarctic and North Atlantic krill fishing regions.
- 100% clean-label, getting rid of solvents, the ones commonly used in vegetable oils extraction, for example hexane.
- When extracted from an entirely physical-mechanical process:
    - Carbon emissions are cut 5 times vs traditional models
    - Works onboard in various types of fishing vessels
    - Reduces fluoride content, hence, human health risks
    - Reduces processing time-temp's, hence, trimming heat exhaust to the atmosphere, reducing the product thermal damage
    - Almost entirely eliminates oxidation by-products, which on traditional processes, adds additional processing and refining steps, hence, it is highly environmentally friendly.
    - Cuts the use of masking flavors, sometimes used to hide off-flavor/smell
- It takes place entirely at-sea, on-board factory vessels, where the fishing operation takes place.
- The krill oil is extracted in less than 2 hours after catch, from fresh raw krill.

[1] >35% PL w/w

- Unique freshness markers (THAROS' patent pending "*Phospholipids krill oil purification and freshness marker using solvent-free process*"). Current krill oil brands' PE[2] content circa 2.05 +/- 0,62 g/100 g of krill oil[3] [4], a clear sign of lipid degradation and oxidation.
- Operations that use frozen krill, dried krill meal or other ingredients from where the oil is extracted on-land, they take circa 6 months after the meal, frozen or other krill ingredients were manufactured at-sea. The oil is later extracted using solvents. Consequently, using at-sea a solvent-free extraction process, it offers:
    - Solvents usage and residues – 100% cut.
    - Bags and carton boxes – 100% cut.
    - Extraction costs - 85% cut vs. all traditional extraction processes.
    - Energy consumption - 80% cut.
    - Value chain – 70% cut.
    - Packaging waste – 80% cut.
    - Phosphatidylethanolamine (PE) - Up as much as 13%, vs. max 2% on traditional processes, low vs. high lipid oxidation[5] [6] [7].
    - Very low level of oxidation and negligible degradation[8].
    - Negligible levels of undesirable components such as TMAO, TMA, TVN, fluoride and salt.
    - Unmatched smell and taste parameters.
    - Unmatched shelf-life stability (THAROS' stability tests 2018-2021)

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[2] Phosphatidylethanolamine, a phospholipid used as a krill oil freshness marker

[3] https://patents.google.com/patent/US9556116/en17

[4] *Composition of Antarctic krill oil and method for its harvesting, production and qualitative and quantitative analysis. Hoem N., Aker Biomarine, 2013*

[5] https://www.researchgate.net/publication/259382915_Investigation_of_oxidative_degradation_and_non-enzymatic_browning_reactions_in_krill_and_fish_oils

[6] https://onlinelibrary.wiley.com/doi/full/10.1002/lite.201400027

[7] https://pubmed.ncbi.nlm.nih.gov/23790862/

[8] Tharos patent pending *"Solvent-free krill oil Concentration Process"*

How About Extracting Krill Oil From Frozen Raw Krill?

Some fishing companies are exploring this idea as it reduces at-sea investment CAPEX (processing and trawler), as the oil is extracted on-land.

When raw fresh krill is frozen, ice crystals are formed. It disrupts krill's anatomical structure, destroying tissue with the consequent loss of valuable nutritional components, no matter if the krill is slightly blanched prior freezing, or not.

Freezing krill is a state-of-the-art and well-established procedure (*Whittaker DK. 1984*[9]) when focusing on animal feeds for example. When krill oil extraction is the target, there is tissue disruption that can promote emulsification during processing, lowering krill oil extraction yields and phospholipids' deterioration. It triggers oxidation, throughout the freezing process, transportation and storage[10].

The freezing process affects lipid composition, phospholipids are decomposed and the amount of free fatty acids increased by a factor of up to 20. Monoglycerides, absent from fresh krill, appear.

When krill oil is obtained on land from frozen krill or krill meal, to match, for example, THAROS' low levels of undesirable components, that process should use several washing steps using protic solvents[11]. (*US Patent Nº 10,456,412 (Saebo, A. et al., 2019), Aker BioMarine Antarctic AS*).

As fresh raw krill has a frail structure, when thawing frozen krill prior extracting the oil, it disrupts its structure with the consequent loss of abundant liquids, (drip-loss) of up to 20% of its weight, carrying with it lipids, natural antioxidant astaxanthin, and valuable proteins, hence, reducing extraction yields and the final quality of krill oil.

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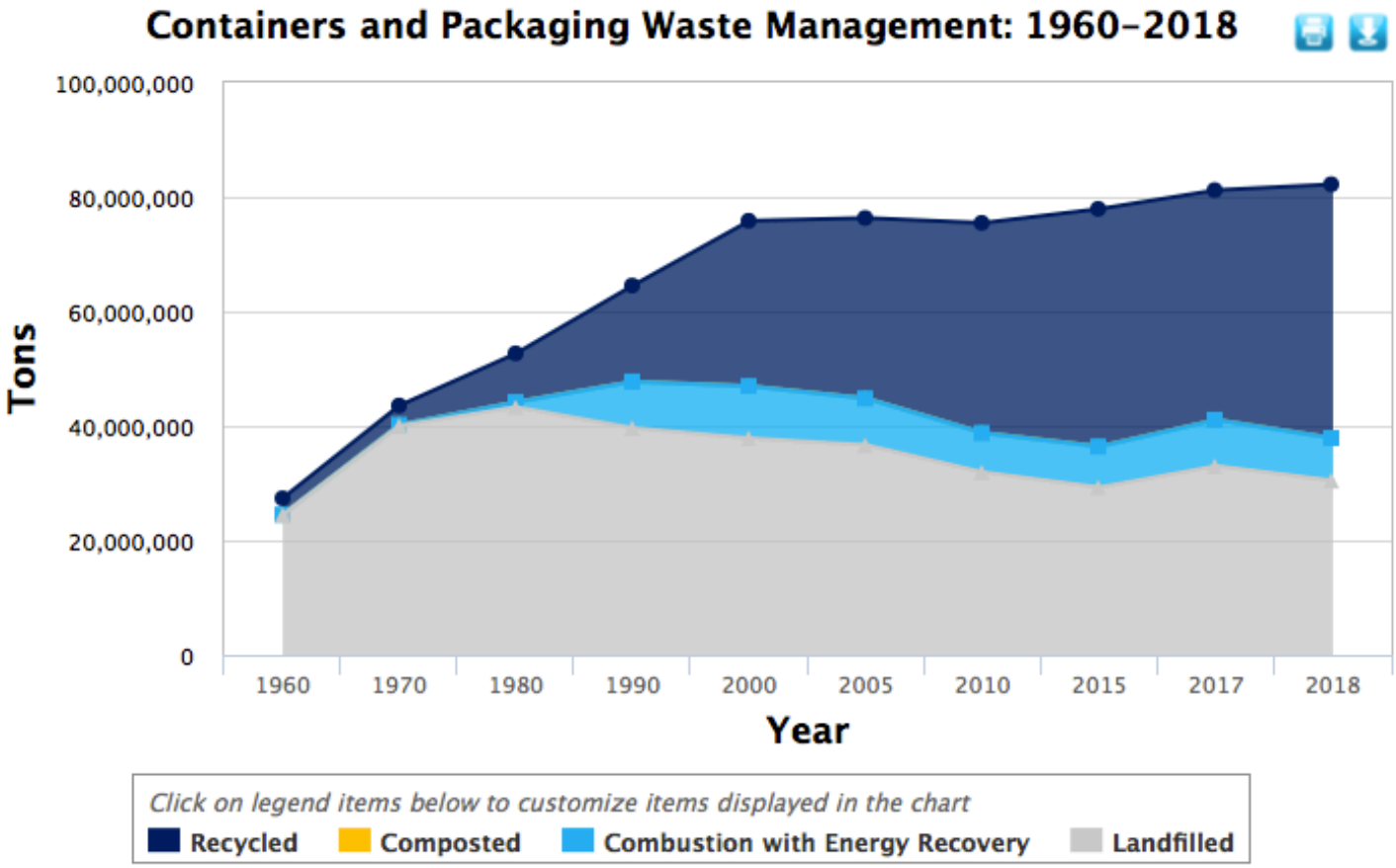
[9] https://pubmed.ncbi.nlm.nih.gov/6435496/
[10] https://pubmed.ncbi.nlm.nih.gov/3751323/
[11] https://www.akerbiomarine.com/news/aker-biomarine-granted-important-patent-for-its-purification-technology

Is Producing Krill Oil At-Sea The Best Model?

- https://www.worldfishing.net/news101/Comment/analysis/producing-krill-oil-at-sea-improves-quality-and-saves-costs
- http://www.tharos.biz/why-is-it-better-to-manufacture-phospholipids-enriched-krill-oils-at-sea/

Processing on-board (at-sea) cuts 100% the use of bags and carton boxes when extracting the oil on-land from dried krill meal or any other krill product.

USA's FDA warns about the increasing amount of waste generated which has impacted on consumer choices of products that come from businessed conducted in a sustainable and less contamination way.



Source: USA EPA - https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/containers-and-packaging-product-specific-data

FDA defines containers and packaging as products that are assumed to be discarded the same year the products they contain are purchased. Containers and packaging make up a major portion of USA's municipal solid waste (MSW), amounting to 82.2 million tons of generation in 2018 (28.1 percent of total generation).

They are used to wrap or protect goods, including food, beverages, medications, cosmetic products, containers and packaging used in the shipping, storage and protection of products.

Management Pathway	1960	1970	1980	1990	2000	2005	2010	2015	2017	2018
Generated	27,370	43,560	52,670	64,530	75,840	76,330	75,470	77,920	81,200	82,220
Recycled	2,870	3,350	8,490	16,780	28,870	31,500	36,680	41,490	40,140	44,330
Composted	-	-	-	-	-	-	-	-	-	-
Combustion with Energy Recovery	-	150	880	8,110	9,110	8,160	6,870	7,160	8,050	7,420
Landfilled	24,500	40,060	43,300	39,640	37,860	36,670	31,920	29,270	33,010	30,470

Note: Values in millions

Container and packaging products, especially corrugated boxes, are among frequently recycled products. In 2018, the recycling rate of generated packaging and containers was 53.9 percent in the US. They are made of several materials: paper and paperboard, glass, steel, aluminum, plastics, wood, and small amounts of other materials.

Are Green Solvents the solution for current krill oil extraction models?

Conventional technologies used for oil extraction out of oilseeds, use solvent extraction models, where *n*-hexane is used as a solvent for its attributes such as simple recovery, non-polar nature, low latent heat of vaporization (330 kJ/kg) and high selectivity to solvents. However, usage of hexane has led to several repercussions such as air pollution, toxicity and harmfulness that prompted to look for alternative options.

Green solvents and technologies like aqueous assisted enzyme extraction are better solutions for oil extraction from oilseeds. Enzyme mediated extraction is eco-friendly, it can obtain reasonably good yields, are cost-effective and aids in obtaining co-products without major damages. Similarly, *green solvents* such as terpenes and ionic liquids have solvent properties that enable to extract the oil in a more eco-friendly manner.

These green solvents and technologies are considered green owing to the attributes of energy reduction, eco-friendliness, non-toxicity and non-harmfulness. If they are finally used on krill oil extraction, it stresses the already high cost structure that conventional solvent-extracted process has.

How About Krill Oil Processes Carbon Footprint?

Several krill fishing corporations redesigned their WEB sites to address how important the "*sustainability*" concept has become in their business model, and how they are handling krill-sustainability.

Sustainability is a key factor in krill fishing operations as krill species is the backbone of the Antarctic ecosystem. Industry players are embracing circularity and carbon reduction as part of the outcome companies must embrace, beyond financial ratios.

We have calculated THAROS' process carbon footprint. It details the krill oil extraction step only, not what it takes to operate the fishing trawler where the process takes place.

With circa 3.5 tons CO_2 per ton of fishing krill oil, it is almost 5-times more effective vs. current models which we estimate have circa 17 tons CO_2 per ton of fishing krill oil.

Value Chain Comparison THAROS' vs. TRADITIONAL models
(expressed as tons of input required to manufacture 1 ton of krill oil)

CARBON EMISSION IMPACT			
FUEL CONSUMPTION (a)		CO2 EMISSION (b)	
THAROS	TRADITIONAL	THAROS	TRADITIONAL
1.30	6.18	3.50	16.62

FUEL CONSUMPTION		CO2 EMISSION
PL production (*), fuel per ton PL oil	0.30	0.81
Oil transport to land (sea vessel)	0.96	2.58
Port handling + trucking to warehouse	0.02	0.05
Dry warehouse (transhipment port)	0.00	0.00
Port handling + trucking from warehouse	0.02	0.05
TOTAL		3.50

(*) Phospholipids-enriched krill oil

Comparative Value Chains