How Fresh is Your Krill Oil

Marker Parameters You Need to Know

Salt, Contaminants and
Tharos' Purification Process

Have you, dear consumer, ever tried to cut in half your krill oil capsule to smell and taste what's inside? If not, well, it is time to do so.

Fresh, clean, not oxidized and pure krill oils are manufactured when they are closest to the source, straight where the krill is captured. As this is not currently happening, you rely on re-processed krill oils that are all solvent-extracted, months after the fresh raw krill was converted at-sea to krill meal.

The recent South Korean sanitary authorities recall of several krill oil brands, remember us that not all krill oils are what they claim to be. Worrisome to know that some ***strictly banned*** solvents are still currently used [1].

What does it mean "*clean, purified fresh krill oil*", and how to get it. The primary goal is having them from a solvent-free, close-to-the source (at-sea) process. This is a mandatory condition to decrease undesired compounds known as TMAO[2], TMA[3], TVN[4], fluoride and salts. ***Cut in half your capsule and test your supplement.***

[1] http://www.fis-net.com/fis/worldnews/worldnews.asp?monthyear=6-2020&day=24&id=108316&l=e&country=161&special=&ndb=1&df=0
[2] Trimethylamine N-oxide
[3] Trimethylamine

Background

Krill oil contains salt and trimethylamine N-oxide (TMAO), a natural and nontoxic substance. High TMAO levels in krill, and crustaceans in general, are thought to increase osmotic concentration, thus decreasing the freezing point of the body fluids. It helps understand how krill species survive freezing waters.

Odor is one of the most important parameters used to evaluate marine oils (krill oil included) freshness. Volatile amines such as ammonia and TMA, a degradation product of TMAO, are the characteristic molecules responsible for the fishy odor and flavor present in krill oil in particular, and marine oils in general. Thus, TMAO is a precursor to TMA, and as such, it must be removed from krill oil to maintain its acceptability for human consumption.

Salt (NaCl) from seawater should be lowered as much as possible considering that it increases human blood pressure. The salt/seawater removal is crucial. In presence on high-temperature processes, it favors equipment corrosion. Check your krill oil how much salt it contains and will let you know how safe it is.

Fluoride is also a normal compound in the shell of krill, and crustaceans in general, which in high concentration cause bone weakening. Hence, fluoride should be lowered as much as possible. Will guide you on how safe it is.

[4] Total Volatile Nitrogen

Worldwide efforts are underway to produce krill oils high in phospholipids (PL), enriched in DHA and EPA, and low in undesired compounds, for example;

a) US Patents Nº 9.011.942 and US Patent Nº10.059.904 (*Tharos Ltd*) - Solvent-free extraction entirely run at-sea obtaining krill oils with negligible levels of undesired compounds.

b) US Patents Nº 9.814.256 (*Bruheim, I., 2017*) and Nº 10.499.673 (*Bruheim, I. et al., 2019*) - An enzymatic-hydrolysis at-sea combined with on-land supercritical and solvent extraction.

c) US Patent Nº 10.456.412 (*Saebo, A. et al., 2019*) - Marine-origin biomass lipid extraction using solvents, such as ethanol and methanol.

d) US Patent Nº 10.328.105 (*Bruheim, I., 2019*) - Extracts concentrated krill oils through solvents and/or sub or super-critical fluid extraction.

All current invention patents will show low (very low in some cases) levels of undesired compounds such as but not limited to TMAO, TMA and sodium chloride.

Regarding freshness, krill oils showing a high presence of phosphatidylethanolamine(PE) indicate a low (lipid) oxidation[5]. A Norwegian oil manufacturer shows PE at a low average level of 2.05g/100g krill oil[6], pointing to some lipid degradation and oxidation. Ask your oil provider for this information.

[5] *Impact of primary amine group from aminophospholipids and aminoacids on marine phospholipids stability: Non-enzymatic browning and lipid oxidation. F.S.H. Lu, et al. 2013*

[6] +/- 0,62, krill oil GRAS Notification FDA 2010)

Other freshness markers consider the ratio Lysophosphatidylcholine (LPC)/Phosphatidylcholine (PC), where LPC comes as a by-product of a partial hydrolysis (which damages the oil) of PC. A low LPC/PC ratio indicates a low lipid degradation and krill oil intactness.

Regarding the LPC/PC ratio, one Norwegian krill oil manufacturer shows a value of 4.84/21.25 that equals 22,8% lipid degradation (77.2% intactness).

A Norwegian krill oil brand that uses supercritical fluid extraction CO_2 and ethanol, the resulting krill oil shows a relatively low content of PE =< 2,6g/100g of krill oil, and a good LPC/PC ratio of 8% lipid degradation (92% intactness)[7].

Other krill oil freshness marker is astaxanthin (the red pigment seen in your oil capsule), being a high level a sign of low oxidation and a low thermal damage during processing. In general, krill oils extracted with solvents, sold as enriched in phospholipids, astaxanthin circa 100-400 mg/kg. Check this value in your bottle.

How About the Tharos' Purification Concept

Tharos' process sources a purified, solvent-free phospholipids-enriched krill oil[8], with negligible amounts of much undesired compounds TMAO, TMA, TVN, fluoride, and salts.

[7] *Olympic Seafood at Vitafoods 2014. Bruheim, I.*

[8] For human and pharma applications

Its fast process characterizes the model. Krill oils are obtained in less than 2 hours after fresh raw krill enters the process, reducing the development of undesirable oxidative compounds and phospholipids decomposition, securing a fresh and delicate marine smell.

Two important questions for your krill oil provider:

a) If the oil was solvent-free extracted throughout its entire process.
b) If the oil was entirely manufactured at-sea, on-board the factory trawler.

Comparatively, which are Tharos' Purification Process Results

The current state of the art was obtained from Tharos' krill operations in the South and North Atlantic krill fisheries.

The North Atlantic predominant krill species are *Thysanoessa raschii* and *Thysanoessa inermis*, arriving alive to the processing line, *Euphausia superba* the South Antarctic dominant species, all processed within 90 minutes from catch.

When we talk about extracting the oil from fresh raw krill immediately processed after capture, how it looks a fresh raw krill:

Table 1 - North raw krill – Fatty season composition

North Atlantic raw krill specification									
Sample Nº	**Production Date**	**Length (mm)**	**Moisture (%)**	**Total Lipids (%)**	**Polar Lipids (% of total Lipids)**	**Salt (%)**	**TVN (mg/100g)**	**Wax esters (%)**	**Fluoride (mg/kg)**
1	**09-sept**	**15 - 23**	**74.1**	**5.1**	**15.9**	**0.8**	**n/a**	**5.7**	**380**
2	**11-sept**	**18 - 24**	**73.5**	**5.0**	**18.6**	**1.1**	**48.1**	**5.6**	**470**
3	**30-sept**	**15 - 22**	**73.8**	**5.2**	**11.1**	**1.2**	**48.5**	**9.4**	**440**
4	**01-oct**	**16 - 24**	**72.2**	**7.7**	**12.2**	**0.9**	**n/a**	**6.2**	**450**

How it compares North Atlantic vs. its Antarctic krill cousin;

a) Length is much smaller, Antarctica's 30 - 70 mm;

b) Fluoride is much lower, Antarctica's 1 000 - 2 000 mg/kg;

c) Polar lipids (phospholipids) is lower, Antarctica's 40-60%;

d) Total lipids are similar to Antarctica's for the fatty season period;

e) It has a very high content of wax esters, which Antarctica's has none

Table 2 – How it looks Tharos' processed North Atlantic krill oil

North Atlantic krill oil									
Sample Nº	**Date of production**	**Polar Lipids (a)**	**Total Carotenoid (b)**	**Peroxide Value (c)**	**Salt (%) (d)**	**TVN (mg/100g) (d)**	**TMA (mg N/100g) (d)**	**TMAO (mg N/100g)**	**Fluoride (mg/kg)**
1	**09-sept**	**10.4**	**1 307**	**1,80**	**0,09**	**<10**	**<1**	**<1**	**<10**
2	**11-sept**	**21,8**	**1 017**	**n/d**	**0,47**	**<10**	**<1**	**<1**	**<10**
3	**30-sept**	**13,1**	**1 152**	**n/d**	**0,004**	**<10**	**<1**	**<1**	**<10**
4	**01-oct**	**13,1**	**1 077**	**n/d**	**0,01**	**<10**	**<1**	**<1**	**n/d**

n/d = not detected

(a) % of total lipids

(b) mg/kg

(c) meq peroxide/kg sample

(d) Antartica's referential data salt 1% - TVN <10 mg/100g - TMA <1mgN2/100g

Why there is less phospholipids (PL) in the North Atlantic krill oil: It is explained by the low PL potential of the fresh raw krill compared with Antarctic krill, the latter generally containing 40-60%. This situation is explained by normal low levels of polar lipids in the North raw fresh krill, as shown in Table 1.

The total carotenoid level (natural antioxidant pigment) is very high, at par with the minimal thermal damage during the process, being carotenoids very thermolabile.

Peroxides are not detected, signaling the freshness of the raw material, neither oxidized throughout the process, helped by the short time elapsed between capture and processing, and by the incorporation of a inert gas (nitrogen) throughout the entire process.

Salt content is low confirming that Tharos' proprietary raw material washing model helps this outcome.

TMAO, TMA, TVN and fluoride in the final krill oil are low as the Tharos' process prevents their formation.

Table 3 North Atlantic krill oil lipid class composition

LIPID CLASS COMPOSITION (% total lipid) OF KRILL OIL		
LIPID CLASS		
	Sample 1	**Sample 2**
Production date 2018	09-Sep	11-Sep
Wax/Sterol esters	9.1	8.2
Triacylglycerols	58.3	46.1
Free fatty acids	2.0	5.6
Cholesterol/sterols	14.2	12.2
Diacyglycerol	6.0	6.1
Total neutral lipids	***89.6***	***78.2***
Unknown glycolipid*	<LOQ	<LOQ
Phosphatidylethanolamine	2.5	6.6
Phosphatidic acid/Phosphatidylglycerol/cardiolipin	<LOQ	<LOQ
Phosphatidylinositol	1.3	1.6
Phosphatidylserine	<LOQ	<LOQ
Phosphatidylcholine	5.7	12.6
Sphingomyelin	<LOQ	<LOQ
Lysophosphatidylcholine	<LOQ	0.6
Pigmented material	0.9	0.4
Total polar lipids	***10.4***	***21.8***
LPC/PC ratio (% of PC degradation).	**0.0**	**4.8**
Above values calculated from analyses performed in duplicate, as determined by HPTLC		

North krill oil shows a very good level of phosphatidylethanolamine (PE) and the ratio lysophosphatidylcholine (PE)/phosphatidylcholine (PC), indicating that PC is almost intact, without degradation. These freshness indices reveal that this oil has no oxidative damage, produced from fresh krill, immediately after capture.