# Full Report

# Analytics Comparison

Matis – U. Stirling – NOFIMA - Literature

Moisture, Oil, Protein, Ash and Salt Content, Carotenoid Pigment, Lipid Class, Fatty Acid, Fluoride and Total Volatile Nitrogen Analysis of Raw Fresh Frozen Krill

**Date of original report June 17, 2016**
**Date of edited report July 19, 2019**

## Conclusion

1. Krill oils and meals produced off Arctic seas krill species can compete in quality with Antarctic products.
2. EPA + DHA show a remarkable high content, higher to Antarctic's krill average level, even more as this come from April samples, the low-fat season.
3. These species have unique quality markers increasing the value of buyers' business model.
4. Resulting krill has a low fluoride content, making it a product with a special market niche positioning, a differentiating parameter[1].
5. Main components (e.g. polar lipids and Omega3) do not match with certain literature, but they remain within marketable levels.
6. This report is by any means final and conclusive.
7. Comparatively, Antarctic krill has more than 50 years of research[2].
8. Free fatty acids (FFA)[3] for April samples, although high[4], this is a physiological condition dependant on seasonality.

## Significant Parameters

1. EPA and DHA are high. It may become a differentiating parameter compared to Antarctic krill. Depending on seasonality, krill oil and meal EPA + DHA content will have a marketing plus.
2. Polar lipids (phospholipids) show to be lower in April, which is consistent with the low-fat part of the Arctic krill season. For January samples, results are consistent with the high-fat season, and polar lipid content are higher. In both cases, polar lipid content is similar to Antarctic's, or slightly lower.

[1] NOFIMA and Stirling labs match their fluoride content analysis.
[2] When Antarctic seas where seen "red" by whalers, whom abound in those years.
[3] It is an indication of deterioration.
[4] Antarctic fresh krill FFA levels range 5 to 20%

3. Being species *T. inermis* herbivorous, it can impact the resulting krill oil and meal quality granting unique markers vs. *E. Superba* which is Omnivorous. *T. rashii* is also omnivorous.
4. Fluoride content is remarkably lower compared Antarctic (250-300 vs. 700 – 2.000ppm). This is other marker for North seas krill, and a strong differentiating parameter for krill meal sales, and frozen meats.
5. High free fatty acids (FFA) for April samples is a physiological condition dependant on seasonality and normal for the resource.
6. The parameter that confirms above assumption is the low lyso-phophatidylcholine shown in all samples. The lower the value, lower the deterioration of the phosphatidylcholine, one of the valuable PLs.

**General Comments**

1. Results for fat, protein, moisture, EPA, DHA and ash are very similar between Stirling and Matis.
2. Pigments (carotenes) are a promising component, and naturally high.
3. Wax esters are a differentiating component. It can become an Arctic krill oil marker. Although its content is lower compared the literature (8 vs. 16%), still it is higher compared Antarctic's which has wax's at a trace level.
4. Depending on the source, the fluoride content has significant differences;

a) *E. superba*

- 13,000ppm (Mouthparts (Sands et al. 1998))
- 2,232ppm (Exoskeleton (Sands et al. 1998))
- 96ppm (Muscle (Sands et al. 1998))
- 1160 (Whole body (Moren et al. In press))

b*) E. crystallorophias* - 5,477 (Exoskeleton (Sands et al. 1998))

c) *M. norvegica* - 3,300 (Adelung et al. 1987)

## Comparative Table - Krill

| | Matis Iceland | | Stirling Iceland | RIMFROST Antarctic | N. Shibata (a) Antarctic | A. Clarke (b) Antarctic |
|---|---|---|---|---|---|---|
| | Jan.2016 | Apr.2016 | Apr.2016 | 1994-1997 | 1982 Dec–Feb. | 1980 Jan–Mar. |
| **Omega3 EPA+DHA** (% of total lipids) | 22 – 23 | 38 - 39 | 36 – 38 | 25 – 27 | 29 – 48 | 3 – 30 |
| **Total Omega3** (% of total lipids) | 26 – 27 | 40 - 42 | 40 – 44 | | | |
| **Total Lipids** (%) | 5 – 7 | 1.5 – 2.0 | 1.5 – 2.2 | 3 – 5 | 1.1 – 3.9 | 1.1 – 7 |
| **Neutral Lipids** (% of total lipids) | 55 – 60 | | 72 – 74 | | 5 – 30 | 59 - 60 |
| **Polar Lipids** (% of total lipids) | 33 – 36 | | 25 – 28 | | 40 – 63 | 35 – 40 |
| **Wax esters** (% of total lipids) | | | 8.7 – 8.8 | | | 1.9 |
| **Protein** (%) | 12 – 15 | 13 – 15 | 13 – 15 | 11 – 13 | | 10 – 18 |
| **Moisture** (%) | 75 – 80 | 80 – 82 | 80 – 82 | 79 – 80 | | 76 – 80 |
| **Total Astaxanthin** (ppm) | 52 - 65 | | 30 - 31 | | 28 – 42 | 22 – 33 |

**(a) Nobukazu Shibata**

**(b) Andrew Clarke**

## Comparative Table – Other Species

| | Stirling Crustaceans | | Stirling Cephalopoda (c) | | |
|---|---|---|---|---|---|
| | Shrimp Residue (a) | Langostino Residue (b) | Eyes | Head | Viscera |
| **Omega3 EPA+DHA** (% of total lipids) | 18.35 | 29.14 | 32.46 | 39.11 | 32.93 |
| **Total Omega3-PUFA** (% of total lipids) | 23.77 | 40.94 | 42.18 | 41.45 | 36.72 |
| **Total Lipids** (%) | 4.39 | 1.14 | 2.61 | 1.76 | 2.61 |
| **Neutral Lipids** (% of total lipids) | 72.7 | 62.1 | 50.6 | 51.6 | 70.3 |
| **Polar Lipids** (% of total lipids) | 27.3 | 37.9 | 49.4 | 48.4 | 29.7 |
| **Wax esters** (% of total lipids) | 5.6 | 3.0 | | | |
| **Protein** (%) | 9.94 | 9.29 | 17.05 | 17.81 | 13.75 |
| **Moisture** (%) | 79.65 | 78.38 | 78.92 | 82.01 | 80.31 |
| **Total Astaxanthin** (ppm) | 100.23 | 50.32 | | | |

**(a)** Chilean Shrimp = ***Heterocarpus reedi***
**(b)** Chilean Langoustine = ***Cervimunida Johni***
**(c)** Squid = Jumbo squid or Humboldt squid = ***Dosidicus gigas***

## Other Sources of Information - Krill

| | *T. inermis* | *T. raschii* | *E. superba* |
|---|---|---|---|
| Length, Weight | 30-35mm<br>0.12-0.16g | 30-35mm<br>0.10-0.15g | 45-65mm<br>0.9-1.9g |
| Phospholipids | 5 – 20% (dry weight)<br><br>Kim L. 32-35%<br>Saether 37-56%<br>Harvey 83-98% | Kim L. 47-54%<br>Saether 37-56% | |
| Omega3s | EPA 27-34%<br>DHA 13-23%<br>(in PL fraction)<br><br>EPA 5-6%<br>DHA 1-2%<br>(in TG fraction)<br><br>Kim L.<br>EPA 14-16%<br>DHA 51-5.4% | EPA 26-30%<br>DHA 14-43%<br>(in PL fraction)<br><br>EPA 4-7%<br>DHA 1-2%<br>(in TG fraction)<br><br>Kim L.<br>EPA 13%<br>DHA 6.5% | EPA 24-31%<br>DHA 14-25%<br>(in PL fraction)<br><br>EPA 0.1-3%<br>DHA 1-3%<br>(in TG fraction) |
| Moisture | 68-84% (spring)<br>67-76% (summer) | 77-83% (spring)<br>72-81% (summer) | |
| Lipids | Total lipid (DW) 43-46%.<br>(spring and summer)<br><br>Saether and Harvey 15 to 50% (DW). | Total lipid (DW) 28%<br><br>Saether 12 to 44%<br>Harvey 22-30% | |
| Wax Esters | Kim L.<br>43% (of total lipids) | Kim L.<br>About 3% | Antarctic krill lacks wax esters, then the oil extracted from north krill (T. inermis mainly) have, potentially, in his lipids class composition, wax esters. It is then a different compound and patentable compared to Antarctic krill oil. |

**Sources**


- "Lipid of North Atlantic krill", Saether O. et al. 1986
- "Seasonal lipid storage of Antarctic krill" Hegen, W. et al. 1996
- "Physical & Biochemical properties of T. inermis , T. raschii, T. longipes in the Bering Sea", Harvey R. et al. 2012.
- "The Crown Estate, Scottish Association for Marine Science", Technical Report Draft Final(2) Aug.2007, Thomas A. Wilding
- "Fluoride content in the Antarctic krill (Euphausia superba Dana) in relation to its biological condition and to the fishery region" Piotr BYKOWSKI, Maria KOWALCZUK. 1986.
- "Krill in the Arctic and the Atlantic", Kim L. 2015.

Tharos

**Fatty acid composition (% total fatty acids and mg FA.100g$^{-1}$) of total lipid from Crustacean Residues**

| Fatty acid | HYMS - Shrimp Residue | | HYML - Langoustine Residue | |
|---|---|---|---|---|
| | % | mg. 100g$^{-1}$ | % | mg. 100g$^{-1}$ |
| 14:0 | 2.39 | 51.87 | 1.96 | 10.63 |
| Anteiso 15:0 | 0.18 | 3.90 | 0.35 | 1.92 |
| Iso 15:0 | 0.07 | 1.46 | 0.24 | 1.31 |
| 15:0 | 0.30 | 6.56 | 0.63 | 3.43 |
| Iso 16:0 | 0.10 | 2.13 | 0.49 | 2.65 |
| 16:0 | 15.90 | 345.36 | 16.32 | 88.45 |
| Anteiso 17:0 | 0.37 | 8.03 | 0.86 | 4.65 |
| Iso 17:0 | 0.23 | 4.92 | 0.75 | 4.06 |
| Iso 18:0 | 0.28 | 6.13 | 0.61 | 3.30 |
| 18:0 | 7.20 | 156.39 | 3.90 | 21.12 |
| 20:0 | 0.43 | 9.36 | 0.42 | 2.27 |
| 22:0 | 0.21 | 4.54 | 0.53 | 2.88 |
| 24:0 | 0.10 | 2.15 | 0.20 | 1.06 |
| **Total saturated** | **27.75** | **602.80** | **27.25** | **147.71** |
| 14:1 | 0.10 | 2.26 | 0.49 | 2.63 |
| 16:1n-9 | 0.19 | 4.18 | 0.40 | 2.18 |
| 16:1n-7 | 11.07 | 240.46 | 4.34 | 23.51 |
| 16:1 | 0.06 | 1.31 | 0.34 | 1.85 |
| 17:1 | 0.38 | 8.33 | 0.68 | 3.67 |
| 18:1n-9 | 22.84 | 496.24 | 13.22 | 71.67 |
| 18:1n-7 | 7.99 | 173.49 | 5.13 | 27.78 |
| 18:1 | 0.28 | 6.05 | 0.32 | 1.75 |
| 20:1n-11 | 0.31 | 6.82 | 0.46 | 2.50 |
| 20:1n-9 | 1.62 | 35.21 | 0.87 | 4.71 |
| 20:1n-7 | 1.02 | 22.13 | 0.92 | 4.98 |
| 22:1n-11 | 0.15 | 3.31 | 0.38 | 2.06 |
| 22:1n-9cis | 0.66 | 14.33 | 0.71 | 3.84 |
| 22:1 | 0.48 | 10.44 | 0.53 | 2.87 |
| 24:1n-9 | 0.62 | 13.54 | 0.17 | 0.90 |
| **Total monounsaturated** | **47.78** | **1038.09** | **28.95** | **156.91** |
| 18:2n-6 | 0.81 | 17.56 | 1.42 | 7.68 |
| 18:3n-6 | 0.13 | 2.79 | 0.27 | 1.47 |
| 20:2n-6 | 0.24 | 5.28 | 0.68 | 3.68 |
| 20:3n-6 | <LOQ | <LOQ | 0.18 | 0.96 |
| 20:4n-6 | 1.06 | 23.05 | 5.16 | 27.98 |
| 22:4n-6 | 0.10 | 2.13 | 0.29 | 1.57 |
| 22:5n-6 | 0.28 | 6.03 | 0.64 | 3.46 |
| **Total n-6 PUFA** | **2.62** | **56.85** | **8.64** | **46.80** |
| 18:3n-3 | 0.42 | 9.13 | 0.48 | 2.60 |
| 18:4n-3 | 0.61 | 13.18 | 0.50 | 2.72 |
| 20:3n-3 | 0.11 | 2.49 | 0.16 | 0.86 |
| 20:4n-3 | 0.25 | 5.41 | 0.32 | 1.74 |
| 20:5n-3 | 8.89 | 193.08 | 14.18 | 76.85 |
| 22:5n-3 | 0.79 | 17.21 | 1.34 | 7.28 |
| 22:6n-3 | 9.46 | 205.44 | 14.96 | 81.11 |
| **Total n-3 PUFA** | **20.53** | **445.93** | **31.95** | **173.16** |
| 16:2 | 0.30 | 6.59 | 0.21 | 1.15 |
| 16:3 | 0.09 | 2.05 | 0.14 | 0.77 |