Low TMA in A****** Krill Products

Third party analysis of A****** krill products typically detect TMA values of <1mgN/100g. Such levels are considered to be an indication that:

1) Natural TMA levels found in our krill were initially low and have been efficiently removed during our processing steps
2) The PC is stable, since the breakdown product of choline (TMA) is nearly below detection limits.

These attributes are considered to be key components of why A****** krill products have high acceptability related to smell.

As part of A****** competitive market analysis, we submitted other krill products being sold in the marketplace to an independent lab for analysis of TMA. In these cases, TMA levels have been found to be as high as 451 mgN/100g

Company	TMA Value
A******	1mgN/100g
Competitor	451mgN/100g

For obvious reasons, A****** is unable to identify the company(ies) whose products were submitted for analysis. However, A****** recommends that any company interested in selecting a provider of krill oil for their customers, submit blind samples from the various krill providers for independent laboratory analysis of trimethylamine. This will allow for a fair comparison of the content of this tiny molecule that is known to have a considerable impact on product smell and acceptability.

Trimethylamine

Trimethylamine (TMA) is a small nitrogenous molecule. There are two key attributes of TMA that are important to understand, as they relate to finished krill oil products. These are:

1) TMAO as an Osmolyte
2) TMA as a Breakdown Product of Choline

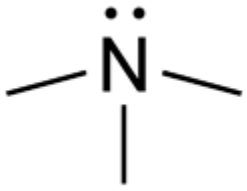

Figure 1. Trimethylamine Structure

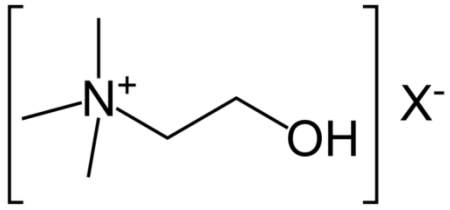

Figure 2. Choline Structure

TMA as an Osmolyte

In order for small crustaceans like krill and shrimp to survive the high salt environment of the ocean, they must possess certain charged molecules within their bodies. This ensures that the krill do not shrivel up from water rushing out of their bodies or swell up and burst because of water rushing into their bodies.

One of the key osmolytes (molecules that control the osmotic pressure) in krill is called trimethylamine oxide (TMAO). Krill produce this in response to the varying salt conditions of seawater, so that they maintain the proper cellular water balance. For the krill, TMAO is not a problem, but a solution.

TMA as a Breakdown Product of Choline

Choline forms the key head group of the phosphatidylcholine molecule (PC). In krill products, EPA- and DHA-enriched PC are what give krill its unique attributes as a supplement or medical therapeutic.

In a well-described biochemical reaction, choline is known to easily degrade to TMA. This is one reason why ingesting high levels of free choline can lead to "fishy" breath, "fishy" bowel gas, or "fishy" stools. As excess choline is broken down in the gut, TMA is formed, with its attendant fishy odor.

Trimethylamine can also form when the choline portion of PC breaks down in storage or processing. Thus, the presence of TMA in a finished product may indicate degradation (of the choline portion) of PC.

Why is TMA a Problem in Finished Krill Products

First, TMA is not a health problem (except for those with a rare disorder called trimethylaminuria). When you eat a shrimp cocktail at dinner, you get a fair amount of TMA. However, TMA has a very strong "fishy" smell. Thus, any finished krill product with high levels of TMA is going to have a "fishy" smell that is related to the amount of TMA in the product. This has certainly been shown to be a problem with encapsulators who must work with krill oil in their facilities. But it has also proven to be an issue for consumers, wherein the finished capsules they take daily can have a very strong fish smell. In short, keeping TMA levels as low as possible is the best way to keep encapsulators and consumers happy.

Why TMA May be Found in Finished Krill Products

The presence of residual TMA in a finished krill product may generally indicate one of two things. First, it may signal an incomplete extraction or purification (during processing) of the normal TMAO found in krill that must live in the high salinity of the ocean. In other words, the naturally-occurring TMA in live krill is not removed and carries over into the finished krill oil product. Second, the presence of TMA may indicate that the choline portion of the phospholipids (specifically PC) may be breaking down in storage. This would be a potential indication of product instability.

Thus, when TMA appears in a finished krill oil product, it may represent inefficiencies in either the raw materials or processing, or instability in storage that leads to the breakdown of the krill phospholipids. Our third party analysis of other krill products does not make it clear which of these conditions may be at work. It may be one or a combination of the above.