UNCOVERING THE CHEMICAL SECRETS OF BELUGAS: CAN YOU SOLVE THE MYSTERY?

This is a quiz!
Answer the questions in order, and use the QR code to submit your final answers. After answering each question, reveal the answer underneath to get clues on how to proceed to the next question.
If you do not wish to do the quiz, feel free to read the abstract / main findings section

AUTHORS

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QUIZ

INTRODUCTION

1 THIS IS SELENO AND ERGO : What are the main differences between them ?

- Seleno and Ergo are **structurally identical**, except that:
  - Seleno contains selenium
  - Ergo contains sulfur
- Ergo is **well-known,** having been discovered in 1909 by Tanret. In contrast, Seleno is a **newly** discovered molecule, identified only recently in 2010 by Yamashita (1)
- Both Seleno and Ergo are produced by microorganisms and acquired through our diets (2)
- They are transported by **the Ergothioneine Transporter (ETT)** in our cells (3).
- We consider Seleno to be the "marine version" of Ergo because:
  - Ergo is found in land food sources such as mushrooms, beans, and meat (4)
  - Seleno, on the other hand, is found in marine food sources, including tuna and marine mammals (1, 5)

2 What kind of molecules are seleno and ergo ?

- Seleno and Ergo are both strong antioxidants
- Seleno may have the added benefit of helping to detoxify methylmercury (6), the organic form of mercury, which is a contaminant of concern for the Inuit of Nunavik

3 Inuit have some of the highest seleno and ergo blood concentrations known in the world

What's the main predictor of seleno in their diet ?

- Beluga mattaaq (skin and blubber) was found to contribute to almost 50% of the blood seleno concentrations, making it the primary predictor of seleno levels in Inuit blood (5)
- Since Inuit are not known to consume large amounts of mushrooms and beans, the source of their dietary ergo concentrations remains unclear

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OBJECTIVE AND METHODOLOGY

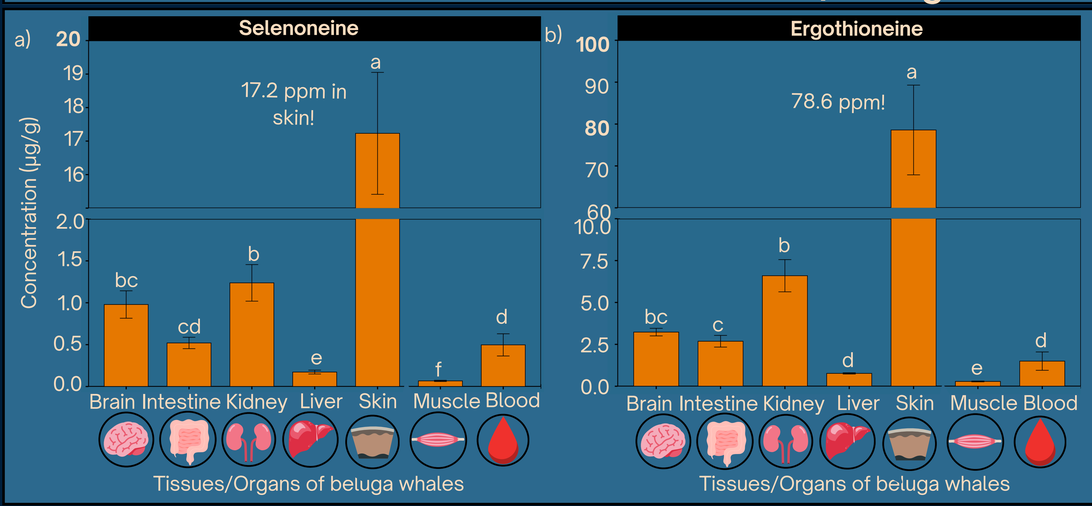
4 How and why will this be accomplished ?

Why?
- Investigating the organs and tissues of belugas consumed by Inuit will help determine if beluga, as a country food, could be a source of marine Ergo for the Inuit diet. This would be the first discovery of a marine source of Ergo, as it has long been believed to exist only in land-based food sources.
- Studying organs and tissues not heavily consumed in Nunavik is also valuable for understanding how Seleno and Ergo are distributed in beluga whales. This research provides insights into their mechanisms and potential benefits for marine mammals.

How?
- We used isotope dilution-liquid chromatography-tandem mass spectrometry (ID-LC-MS/MS) to quantify Seleno and Ergo in various organs and tissues.
- Additionally, we employed immunofluorescence to observe the Ergothioneine Transporter (ETT), which transports both Seleno and Ergo within cells. By studying its distribution in skin, we aim to better understand how these compounds are distributed in tissues.

RESULTS AND DISCUSSION

5 Is ergo found in beluga ? If so, what organ/tissue is the most concentrated in seleno and/or ergo?



- Skin has, by far, the highest concentration of Seleno and Ergo
- The kidneys and brain have the highest Seleno and Ergo concentrations among internal organs
- Ergo is approximately six times more concentrated than Seleno in all organs, except for the kidney (7:1) and brain (4:1)
- The distribution of Seleno and Ergo among organs is similar, as both are transported by the same transporter (ETT)

6 Based on this photo, in which layer is the ETT transporter located? Given this, in which layer is the highest concentrations of ergo/seleno?

Seleno and Ergo concentrations tend to increase toward the outer layers of the skin (segments A and B), whereas the transporter is located deeper within the skin tissue (segments C and D).

- This can be explained by the fact that Seleno and Ergo are taken up by the transporter from blood vessels in the dermis. Their concentrations increase toward the surface as they become trapped in skin cells where the transporter is absent, and because cell density increases toward the outer layers of the skin.

Skin segment	Skin segment description	Selenoneine Concentration (mean µg/g)	Ergothioneine Concentration (mean µg/g)
A	Stratum externum	31.5 ± 3.76	161 ± 29.1
B	Upper stratum spinosum	23.2 ± 5.03	100 ± 22.1
C	Lower epidermal layer (lower stratum spinosum and stratum basale)	17.2 ± 2.46	78.3 ± 11.7
D	Dermis	7.54 ± 3.05	41.9 ± 16.9

7 What function could seleno and ergo serve in beluga skin ?

- Seleno and Ergo are both strong antioxidants, meaning they act as cytoprotectants, specifically in mitochondria
- Seleno could help excrete methylmercury through the molting process if it binds with blood mercury concentrations
- Ergo has been shown to protect against UV damage in human skin. Since belugas are white, they are more prone to sun damage than other whales, which could explain the high concentration of Ergo in the top layers of their skin

CONCLUSION

- This is the first report of the presence of ergothioneine in the marine environment
- The accumulation of both ergothioneine and selenoneine in the skin at parts-per-million levels may help protect both belugas and Inuit from physical and chemical stressors in the northern environment

Abstract / Main results (spoiler alert!)

Selenoneine is a key antioxidant that accumulates in red blood cells of Inuit living in Nunavik (northern Quebec), potentially protecting them from methylmercury toxicity. While beluga skin (mattaaq) consumption was previously identified as the main dietary source of selenoneine, little is known regarding ergothioneine, the sulfur isologue of selenoneine, whose presence in wild foods consumed by Inuit has yet to be reported.
Here, we quantified selenoneine, ergothioneine, and their metabolites in various organs/tissues from 14 adult beluga whales (Delphinapterus leucas) harvested in 2018-2019 by Inuit hunters in Quaqtaq.
Using isotope-dilution liquid chromatography-tandem mass spectrometry, we detected both compounds in all tissues and demonstrated transplacental transfer. Notably, the skin showed an average of 17.1 µg/g selenoneine and 82.6 µg/g ergothioneine, significantly surpassing internal tissue levels and displaying an outwardly increasing gradient. Immunofluorescence staining against the ergothioneine transporter revealed its primary location in the basal epidermal layer, suggesting that these antioxidants may protect against sun damage and facilitate mercury excretion through molting.
This is the first report of the presence of ergothioneine in the marine environment. The concomitant accumulation of ergothioneine and selenoneine in the skin may help protect both belugas and Inuit against physical and chemical aggressors of the northern environment.

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