In Vitro Bioaccessibility of Mercury and Selenium Among the Traditional Foods of Inuit in Nunavik, Québec

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ABSTRACT

The traditional foods that most contribute to the dietary intake of Se and Hg in Nunavik were digested using an in vitro gastrointestinal (GI) model that simulates the conditions of the human GI tract. Hg bioaccessibility (IVBA) of the country foods ranged between 9% (Arctic char) and 95% (Ringed seal meat). In contrast, the Hg IVBA in ringed seal liver, which typically is predominately present as inorganic mercury species, was considerably lower (25%) than observed in ringed seal meat. Interestingly, a large variation in Hg IVBA was observed between fish species (e.g. Arctic char 9.4%; Lake trout 56%). Future work shall elucidate whether these differences in mercury IVBA are associated with differences in mercury and selenium speciation.

INTRODUCTION

Selenium (Se) is an essential element highly present in the traditional marine diet of Inuit and their exposure to this element is among the highest in the world. In fish and marine mammal eating populations, there is increasing evidence suggesting that high Se intake may play a role in offsetting some deleterious effects of methylmercury (MeHg) exposure. However, a complete profile of Se and Hg concentrations in Nunavik country foods is lacking. Moreover, Se and Hg concentrations may be in influenced by several factors: traditional Inuit preparation of country foods, Se and Hg chemical forms found in country foods, and mutual interaction between Se and Hg in country foods.

Oral bioavailability refers to the percentage of contaminants and nutrients that are absorbed into systemic circulation. In contrast, *in vitro* bioaccessibility (IVBA) describes the percentage of a contaminant or nutrient that is dissolved into simulated gastrointestinal fluids. *In vitro* gastrointestinal models measure bioaccessibility as a surrogate for bioavailability. This interdisciplinary research project aims to investigate the effects of country foods on CVD risk factors and diabetes in Inuit adults from Nunavik and is divided into two parts.

■ *Part A* of the study aims to investigate relations between these new biomarkers of Se status and emerging health issues (*see M. Lemire Presentation, Friday 10:15 AM*).

■ *Part B* of the study aims to identify the concentrations and chemical forms of Se and Hg present in various Nunavik traditional foods and their respective bioavailability for humans (Current Poster).

For *Part B* of this project, we aim:

1. To collect selected country foods from several Nunavik villages in collaboration with community members and the Nunavik Research Center of the Makivik Corporation;

2. To measure total Se and Hg concentrations and Se and Hg species in country food samples;

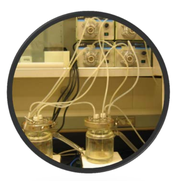
3. To study the bioaccessibility of Se and Hg in Inuit country food using a gastrointestinal model coupled with in vitro cell line (Caco-2) model;

METHODOLOGY

Selection of Traditional Foods

- Primary traditional food sources of Hg and Se for Nunavik Inuit, including: marine mammals, terrestrial wild game, birds, and fish were collected.
- Caribou and beluga meat were analyzed fresh as well as dried (common transformation prior to consumption)
- Sample collection years (2008, 2011, 2012)
- The samples were collected in the Nunavik region, northern Québec, specifically in Kangiqusuolujjaq, Koksoak River, Deception Bay (Salluit), Hudson strait and East Hudson Bay, Leaf River, Inukjuak, Quartaq, Lake Qamuttitsait

In Vitro Bioaccessibility



- Simulated GI fluids: Phase 1 (i.e. Stomach) , Phase 2 (Duodenum) for *in vitro* bioaccessibility
- Bioaccessible fractions were filtered and diluted for chemical analysis
- IVBA Hg was analyzed via TDA-AAS (Nippon Instruments, MA-3000) and IVBA Se was measured via ICP-MS (Agilent, 7700x)
- Speciation analysis for IVBA Hg and Se shall be analyzed via LC-ICP-MS.

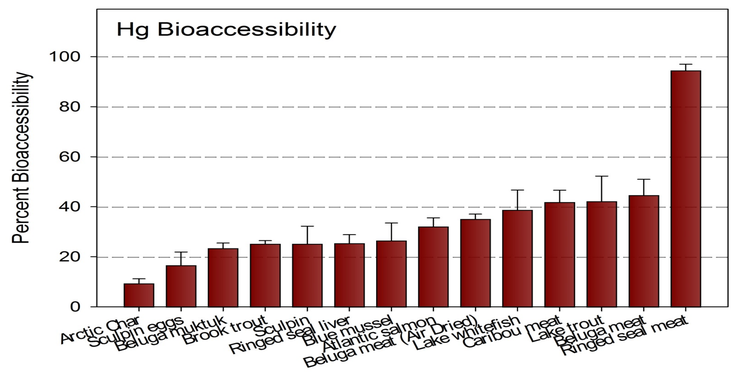
Caco-2 Bioavailability

- Transwell epithelial model: Caco-2 monolayer for *in vitro* bioavailability
- Trans-Epithelial Electrical Resistance (TEER) measured to monitor monolayer integrity
- Percent transport (Apical-to-Basolateral) of Hg was analyzed via TDA-AAS (Nippon Instruments, MA-3000)
- Percent transport (Apical-to-Basolateral) of IVBA Se was measured via ICP-MS (Agilent, 7700x)

RESULTS & DISCUSSION

FIGURE 1

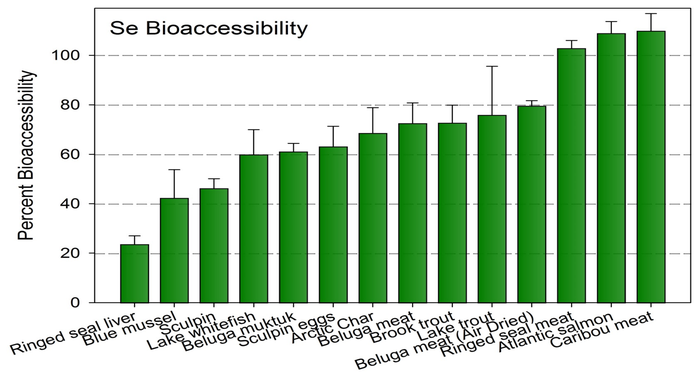
Mercury Bioaccessibility of Country Foods



- For all foods but Ringed seal meat, Hg bioaccessibility was relatively low (i.e. < 50%).
- Ringed seal meat was the only country food for which Hg bioaccessibility approached 100%.
- The low Hg bioaccessibility observed for ringed seal liver (25%) may offset in part the high Hg concentrations observed in ringed seal liver.
- Large differences in Hg bioaccessibility were observed between types of fish (e.g. Arctic char 9.4% vs Lake trout 42%).
- Air-drying beluga meat increased Hg concentration (Table 1) but did not affect Hg IVBA.

FIGURE 2

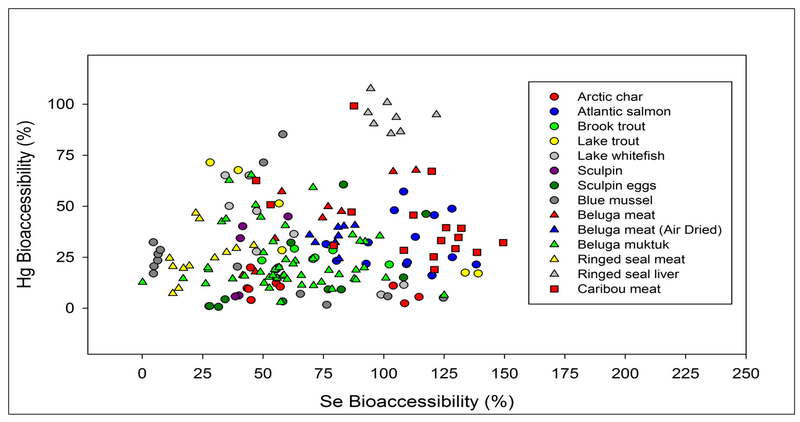
Selenium Bioaccessibility of Country Foods



- The bioaccessibility of Se (Figure 1) was typically higher than observed for Hg (Figure 2). The only two exceptions to this trend were observed for Ringed seal meat and Ringed seal liver.
- Se bioaccessibility reached 100% for three food types (Ringed seal meat, Atlantic salmon and Caribou meat).
- Air-drying beluga meat increased Se concentration (Table 1) but did not affect Se IVBA.

FIGURE 3

Mercury Bioaccessibility vs. Selenium Bioaccessibility



- Correlation between Hg and Se bioaccessibility varied according to food type (Fish: R = -0.02, P = 0.89; Marine Mammal: R = 0.45 P<0.0001; Wild Game: R = -0.48, P = 0.05)
- The positive relationship between Hg and Se bioaccessibility observed for marine mammal-derived foods may be a function of Hg and Se species found within these samples
- To date, Caribou meat is the only wild game processed for Hg and Se bioaccessibility. Testing on a greater diversity of samples will be required to confirm the presence of a negative correlation between Hg and Se bioaccessibility for wild game.

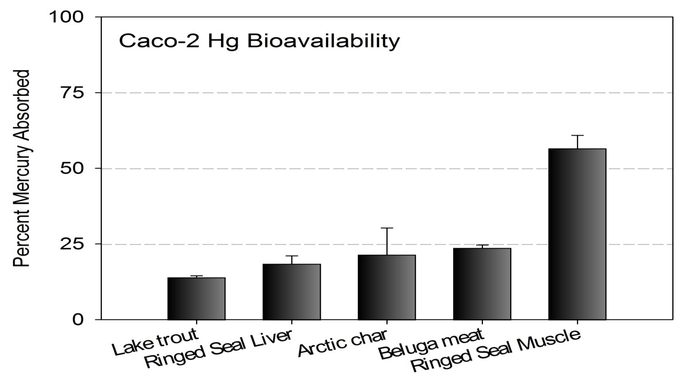
TABLE 1

Mercury and Selenium Concentrations in Nunavik Inuit Traditional Foods

Food Item	n	Hg (µg g-1, w.w.)	Se (µg g-1, w.w.)
Arctic Char	9	0.0499	0.396
Atlantic salmon	14	0.0481	0.259
Beluga meat	10	0.593	0.740
Beluga meat (air-dried)	8	3.94	1.08
Beluga muktuk	51	0.547	4.44
Blue mussel	14	0.00508	0.435
Brook trout	6	0.0923	0.235
Caribou meat	29	0.0253	0.183
Lake trout	10	1.16	0.168
Lake whitefish	8	0.169	0.298
Ringed seal liver	12	26.3	12.7
Ringed seal meat	8	0.331	0.450
Sculpin	6	0.217	0.435
Sculpin eggs	13	0.0390	1.40

FIGURE 4

Percent Transport of Hg from Select Country Foods (Preliminary Caco-2 Results)



- TEER values reached > 1000 Ω·cm² over a 3 week period post-confluence
- *In vitro* extracts of each food had to be diluted to at least 30% with complete media for Caco-2 viability after 24-hr exposure.
- Over 24 hours, apical-to-basolateral transport of Hg was generally less than 24%. The lone exception was ringed seal muscle (57%).
- These Hg absorption rates are considerably lower than expected and may underestimate relative bioavailability. Model validation will be crucial to results interpretation.
- Differences in transport between food types may reflect differences in Hg and/or Se speciation.

FUTURE WORK...

Over the proceeding 9 months, we shall:

1. Complete Hg and Se bioaccessibility and speciation tests for eight additional food types (willow ptarmigan, rock ptarmigan, walrus, goose meat, eider eggs, seagull eggs, Canada goose eggs, and snowshoe hare).
2. Measure selenium apical-to-basolateral transport for each of the country foods shown in Figure 4.
3. Analyze mercury and selenium speciation in each of the original, undigested food items.
4. Analyze mercury and selenium speciation in each *in vitro* extract.
5. Assess the correlation between bioaccessible Hg and Se intake with their respective biomarker(s) evaluated during Part A of the project.
6. Evaluate whether co-ingestion of berries, seaweed, and Labrador tea affect Hg and Se bioaccessibility.

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