



**Arsenic in Irish marine macroalgae
- implications for Industry**

October 2015



Marine Institute
Foras na Mara



Himanthalia elongata (Sea Spaghetti)

Introduction

There is a long tradition of using seaweeds from Irish waters as food, fertiliser and animal feed. Both nationally and globally, there is a renewed interest in using this resource for a host of products in the food, feed, agricultural, cosmetics and biotechnology sectors. According to

SeaChange¹ the estimated worth for the Irish seaweed sector is predicted to increase significantly by 2020. One barrier to developing seaweed-based industries relates to reported high levels of arsenic for many types of seaweed including some species of interest to Irish companies.

What is arsenic, why is it an issue?

Arsenic (As) is a chemical element that raises concern from both an environmental and a human health perspective. Arsenic exists in a number of inorganic and organic forms. Inorganic arsenic (As_i) is much more toxic than organic forms, many of which are considered to exhibit little or no toxicity to humans².

Globally, large quantities of arsenic compounds are released into the environment from natural cycling and anthropogenic sources^{3,4}. Long-term oral exposure to low levels of As_i may cause a variety of health effects including an increased risk of certain cancers^{5,6}.

Forms of Arsenic (species)

Inorganic (As_i)

Organic (As_o)

Examples:

- Arsenobetaine (AB, predominant form in fish)
- Arsenosugars
- Arsenolipids
- Monomethylarsonic acid (MMA)
- Dimethylarsinic acid (DMA)

Arsenic in seaweed

Seafood is a primary dietary source of arsenic contributing over 50% of total daily dietary intake⁷. In seafood arsenic predominantly occurs, with some exceptions, as relatively low or non-toxic organic forms, but the actual risk to consumers cannot be assessed without reliable data on the presence of toxic inorganic forms⁸. Total arsenic (As_t) is the sum of all arsenic species present in a sample. While marine algae can contain high levels of As_t , they are generally considered to contain very low levels of inorganic arsenic (As_i), but for some species of brown algae, high As_i contents have been reported⁹.

Total arsenic (As_t) concentrations ranging from 17 to 88 mg/kg dry weight (dw) have been detected in commercially available seaweeds from British Columbia, Norway and Japan¹⁰. A recent collaborative Marine Institute/ National University of Ireland Galway project determined distinct inter-species differences in As_t , with some brown algae, especially a kelp species (*Laminaria digitata*), revealing higher levels than red or green algae from Irish coastal waters^{11,12}.



Fucus serratus (Serrated Wrack)

Concentrations of As_i in some brown seaweeds often exceed the maximum allowable limit for animal feeds. Preliminary testing has suggested generally low concentrations of As_i in most seaweeds although distinct differences were noted between different parts of the kelp; this requires further investigation as a priority¹¹.

What legislation governs arsenic in seaweed?

Directive 2002/32/EC, as amended, sets maximum limits for total arsenic (As_t) for animal feed. The maximum content for seaweed meal and in animal feed materials derived from seaweed is 40 mg/kg (12% moisture). Currently there are no EC regulatory limits set for arsenic in seafood and seaweed although new limits for inorganic arsenic (As_i) are anticipated³. This requires that agreed methodologies for routine determination be in place¹³. In Ireland, there is a general limit of 1 mg/kg for As_t in food for human consumption (SI No. 44 of 1972), although the legislation specifically states that *any fish, edible seaweed or any product containing fish or edible seaweed may contain arsenic in a proportion exceeding one part per million where such arsenic is naturally present in that fish or edible seaweed or, as the case may be, in that product by reason of its fish or edible seaweed content*. SI No. 432 of 2009 implements European food and feed hygiene legislation in Ireland and places the onus on producers to produce food and feed that is safe for consumption.

³ Commission Regulation 1881/2006/EC

What are the current implications for industry?

Non-compliance of algal-based feed products with EC regulatory limits for total arsenic (As_t) presents a problem for developing Ireland's seaweed industry. Measurements of As_t levels in seafood or marine feed products are of limited value for assessing risk to consumers. While As_t can be naturally high in some seaweed species, arsenic occurs predominantly in organic forms such as arsenosugars, generally considered to have a relatively low, though poorly characterised, toxicity. The determination of different forms of arsenic, and in particular inorganic arsenic (As_i), in Irish seaweeds will provide valuable information to industry and consumers. Industry are also encouraged to measure As_t and As_i in their seaweed products, using suitably specialised laboratories. Any future review of legislation is likely to require submission of data on the toxic As_i fraction so such additional information would be invaluable to developing more practical regulation.



Laminaria digitata (Oar Weed)

The AsMARA research project – Arsenic in Irish seaweeds

The Department of Agriculture, Food and the Marine have awarded funding, through the Food Institutional Research Measure (FIRM), to a project entitled '*Arsenic in marine macroalgae, implications for Industry (AsMARA)*' which aims to:

- » Develop and validate a sensitive, quality controlled method to differentiate between toxic inorganic and less toxic organic forms of arsenic using high performance liquid chromatography – inductively coupled plasma-mass spectrometry (LC-ICP-MS).
- » Conduct a survey of total and inorganic arsenic in commercially important seaweeds from Irish waters.
- » Assess potential variability and fluctuations in seaweeds by studying the effects of season and environmental factors on arsenic content.
- » Study the potential effects of processing and storage on arsenic content.
- » Provide information and recommendations.

The 36-month project started in May 2015. The information generated within this project will support industry in developing strategies to minimise arsenic concentrations in products and assist policy makers in risk management and developing practical regulation for consumer protection.

Where can I get more information?

Marine Institute: <http://www.marine.ie/Home/AsMARA>

AsMARA project: jenny.ronan@marine.ie

National University of Ireland Galway: dagmar.stengel@nuigalway.ie

Department of Agriculture, Food and the Marine: www.agriculture.gov.ie

Further reading

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Alaria esculenta (Dabberlocks)



Acknowledgements

This project is funded under the Department of Agriculture, Food and the Marine's Competitive research programmes. Reference number I4 SF 860. All photos by D. Stengel.



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Published: 05 10 2015

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