ICP-OES Risk Assessment of Heavy Metal Content in Consumed Seaweed sold by United States Retailers

Katherine Goostrey, Cosi Pearce
Food Science Program
Chapman University, Orange, CA

Introduction

- Asia produces 97% of the world's seaweed[1]
- Different species of seaweed absorb varying levels of heavy metals through ocean pollution and sewage waste ([2],Fig. 1)
- We hypothesize that Rhodophyta seaweed will have the highest heavy metal levels [3]

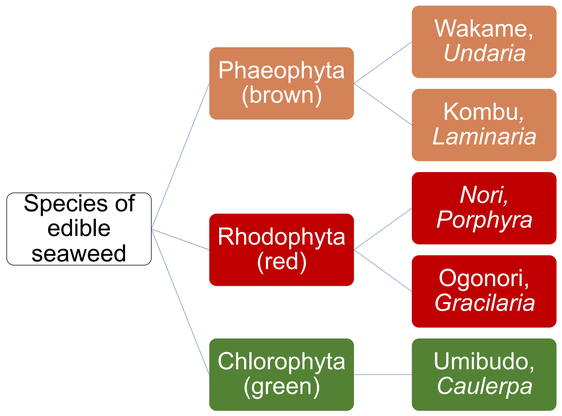


Fig 1. Different species of edible seaweed

- Human exposure to heavy metals leads to *in vitro* toxicity such as carcinogenicity[4]
- Studies on edible seaweed imported to and sold in the United States are scarce

Research questions

- Does species' and geographical source (Fig. 2) affect heavy metal absorption in seaweed?

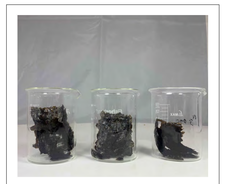
Figure 2. Sources of Edible Seaweed products tested

Objective

- Measure the heavy metal content of different edible seaweed species

Sample preparation and Analysis

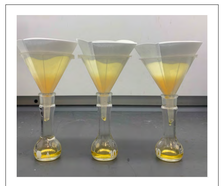
Wet digestion



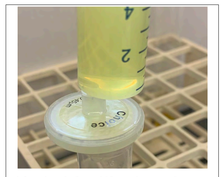
Mass 1g of seaweed

1) Add10mL HNO_3
2) heat to 60℃ until fully digested

Filtration

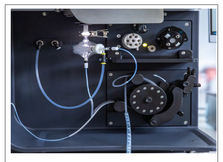


Filter through 9cm filter paper



1) 1:10 dilution in nano-pure water
2) 0.45 µm filtration

ICP-OES Analysis



Aerosolize samples for detection of trace metals

Key findings

- Brown seaweed has the highest overall As level (115.06ppm)
- Red seaweed has the greatest range of As and Cd levels (Fig. 3)
- Red seaweed has the highest Cd, Cr, and Pb levels (Fig. 4)
- Green seaweed samples were below the detection limit, possibly a result of packaging in water (Fig. 5)

Average Heavy Metal Content in Red, Brown, and Green Seaweed Species

Elements	Red seaweed (n=17) Mean ± SD (mg/kg)	Red seaweed (n=17) Range (mg/kg)	Brown seaweed (n=21) Mean ± SD (mg/kg)	Brown seaweed (n=21) Range (mg/kg)	Green seaweed (n=6) Mean ± SD (mg/kg)	Green seaweed (n=6) Range (mg/kg)
As	33.98 ± 13.43	16.28-51.53	60.25 ± 23.17	7.30-115.06	0.31 ± 0.19	0.11-0.67
Cd	1.89 ± 1.50	0.98-5.59	1.45 ± 1.40	0.66-4.64	BDL	BDL
Cr	0.74 ± 0.98	0.33-3.31	0.16 ± 0.44	0-1.99	BDL	BDL
Pb	0.47 ± 0.42	0.33-1.00	0.06 ± 0.20	0.661-0.662	BDL	BDL

Mean content ± standard deviation of elements in seaweed samples for different species of seaweeds (ppm)
*BDL = Below detection limit

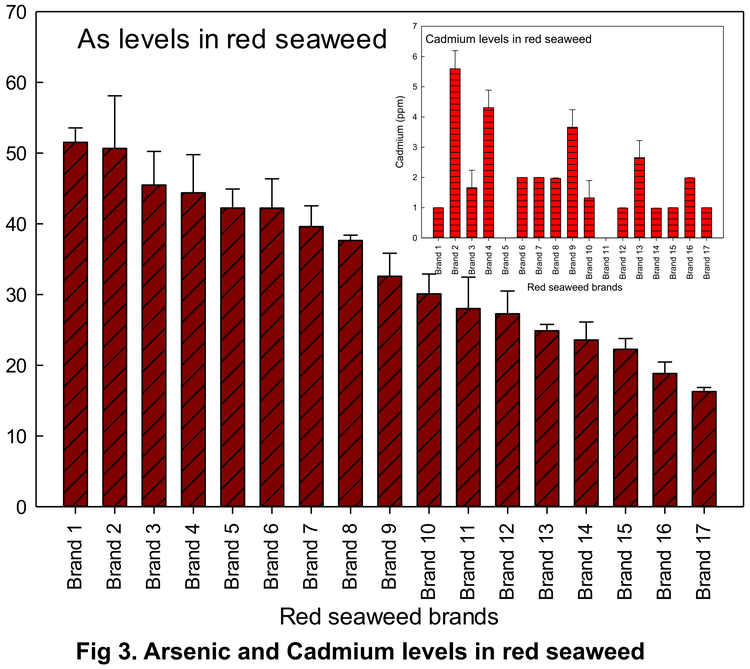
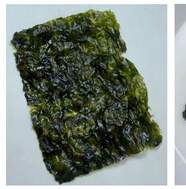


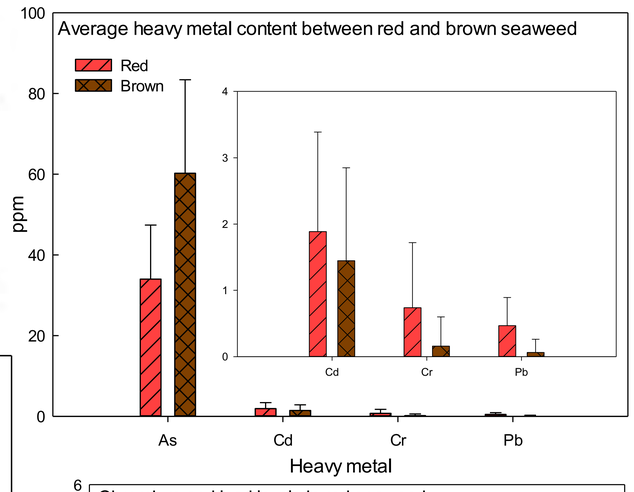
Fig 3. Arsenic and Cadmium levels in red seaweed



Red Seaweed

Green Seaweed

Fig. 5 Red seaweed, dried (left) and Green seaweed, packaged in water (right)



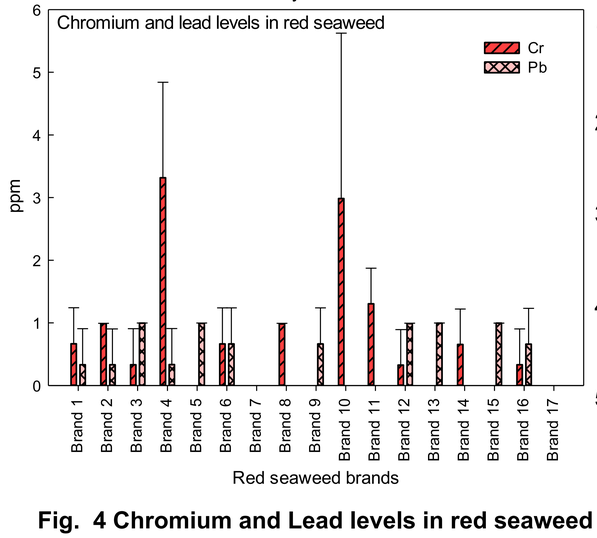


Fig. 4 Chromium and Lead levels in red seaweed

Conclusion

- Seaweed species, including pigmentation and cultivation depth, influenced heavy metal content
- No direct correlation between seaweed source's geography and heavy metal uptake could be determined

Significance of findings

- Only 36% of the seaweed brands collected were labeled with a Proposition 65 warning, meant to caution consumers about carcinogenicity and teratogenicity harm[5]
- The majority of red seaweed brands had the Proposition 65 label, Choi's1, a product of Korea, was not labeled despite having the highest As level of the red seaweeds
- Seaweed products imported to and distributed with the U.S. should be reassessed and properly labeled for consumer knowledge and legality

ACKNOWLEDGEMENTS

National Science Foundation for funding the research.
Lilian Were, Ph.D.
Christopher Kim, Ph.D.

SELECT REFERENCES

1. Cai J. Global status of seaweed production, trade and utilization. Food and Agriculture Organization of the United Nations. 2021
2. Filippini M, et al. Heavy metals and potential risks in edible seaweed on the market in Italy. Chemosphere. 2021:263:127983
3. Bellamy-Carter J, Sound JK, Leney AC. Probing heavy metal binding to phycobiliproteins. Fens Journal. 2022
4. Tchounwou PB, et al. Heavy metal toxicity and the environment. Experientia supplementum. 2012;101:133–164
5. Basra M. California's Proposition 65 and the Limits of Information Economics. Stanford Law Review. 1997;49:1223-1247

Alternate Text

Katherine Goostrey

Food Science Program

'ICP-OES Risk Assessment of Heavy Metal Content in Consumed Seaweed sold by United States Retailers'

Introduction: Asia produces 97% of the world's seaweed. Different species of seaweed absorb varying levels of heavy metals through ocean pollution and sewage waste (Fig. 1). We hypothesize that Rhodophyta seaweed will have the highest heavy metal levels.

Figure 1. Different species of edible seaweed.

Human exposure to heavy metals leads to in vitro toxicity such as carcinogenicity4 Studies on edible seaweed imported to and sold in the United States are scarce.

Research Questions: Does species' and geographical source (fig. 2) affect heavy metal absorption in seaweed?

Figure 2. Sources of Edible Seaweed products tested.

Objective: Measure the heavy metal content of different edible seaweed species.

Sample Preparation and Analysis: Includes four images labeled Mass 1g of seaweed, *Wet digestion:* add 10 mL HNO3, heat to 60 degrees Celsius until fully digested, *Filtration:* filter through 9cm filter paper, 1:10 dilution in nano-pure water, 0.45um filtration, *ICP-OES Analysis:* Aerosolize samples for detection of trace metals.

Key Findings: Brown seaweed has the highest overall As level (115.06ppm). Red seaweed has the greatest range of As and Cd levels (Fig. 3). Red seaweed has the highest Cd, Cr, and Pb levels (Fig. 4). Green seaweed samples were below the detection limit, possibly a result of packaging in water (Fig. 5).

Table titled Average heavy metal content in Red, Brown, and Green seaweed species.
Figure 3, Arsenic and Cadmium levels in red seaweed,
Figure 4, Chromium and Lead levels in red seaweed,
Figure 5, Red seaweed, dried (left) and Green seaweed, packaged in water (right),
with an additional relevant visual representation of data.

Conclusion: Seaweed species, including pigmentation and cultivation depth, influenced heavy metal content. No direct correlation between seaweed source's geography and heavy metal uptake could be determined.

Significance of findings: Only 36% of the seaweed brands collected were labeled with a Proposition 65 warning, meant to caution consumers about carcinogenicity and teratogenicity harm5. The majority of red seaweed brands had the Proposition 65 label, Choi's1, a product of Korea, was not labeled despite having the highest A's level of the red seaweeds. Seaweed products imported to and distributed with the U.S. should be reassessed and properly labeled for consumer knowledge and legality.

Acknowledgements: National Science Foundation for funding the research. Lilian Were, Ph.D. Christopher Kim, Ph.D.

References:

1.Cai J. Global status of seaweed production, trade and utilization. Food and Agriculture Organization of the United Nations. 2021. 2. Filippini M, et al. Heavy metals and potential risks in edible seaweed on the market in Italy. Chemosphere. 2021:263:127983. 3. Bellamy-Carter J, Sound JK, LeneyAC. Probing heavy metal binding to phycobiliproteins. Fens Journal. 2022 4. Tchounwou PB, et al. Heavy metal toxicity and the environment. Experientia supplementum. 2012;101:133–164. 5. Basra M. California's Proposition 65 and the Limits of Information Economics. Stanford Law Review. 1997;49:1223-1247.