Evidence Brief: Control of parasites by freezing in fish for raw consumption

Key Messages

- Parasites are ubiquitous in aquatic and fresh water environments.
- Parasitic infection is a known risk from consuming raw or lightly cooked fish.
- Freezing provides an effective means of inactivating parasites in raw and undercooked fish.
- The effectiveness of killing parasites by freezing varies with the type of fish, type of parasite, temperature achieved, and length of time held at that temperature.

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Issue and Research Question

Raw or lightly cooked fish is consumed by the public in a variety of forms including sushi, sashimi, gravlax, boquerones en vinagre and lomi-lomi salmon. The consumption of raw or lightly cooked fish poses a potential risk of parasitic illness; however certain fishing and handling practices can mitigate that risk. This evidence brief examines the effectiveness of freezing as one of the mitigating factors to reduce the risk of parasitic infection associated with consumption of raw fish.

Methods

A review of the literature was done on MEDLINE and Food Science Source databases. The search was limited to literature published in English from January 1, 1946 to March 22, 2016. Terms in the search included: freezing, frozen food, temperature, fish products, seafood, food parasitology, parasite load, parasitic disease, tapeworm, roundworm, fluke, anisakis, cestode infection, Paragonimiasis, Diphyllobothrium and Opisthorchis. The search yielded 144 citations after duplicate records were removed.

Titles and abstracts were screened for relevance. Additional information was identified through cited reference searching of full-text articles. Papers were selected if they evaluated the effect of freezing for parasite inactivation in raw seafood.

A grey literature search was also performed using Google, and the first 100 hits were reviewed. Search terms included fish OR fishery-products OR seafood freezing OR freeze OR frozen parasite OR anisakis; fish OR fishery-products OR seafood raw OR sushi OR "lightly cooked" freezing OR freeze OR frozen parasite OR anisakis; and fish freezing-requirements.

In addition, a review of the evidence of parasitic outbreaks associated with raw seafood dishes was conducted through the Public Health Agency of Canada's "Publicly Available International Foodborne Outbreak database" (PAIFOD), between January 1, 1972 to March 22, 2016.

A total of 29 records are included in this report.

Main Findings

Parasites and parasitic infections are associated with the consumption of raw seafood.[1]

- Parasites are a natural part of the environment, and while the majority of species of parasites are not pathogenic to humans, more than 50 species of the worm-like helminth class of parasites do cause illness.[2,3] The classification of helminths and the species most commonly associated with human illness are highlighted in the box to the right.[4]
- A US survey of gastroenterologists in 2000 found that seafood-borne parasitic infections occur frequently in the United States.[5]
- The European Food Safety Authority (EFSA) states that all wild-caught marine and freshwater fish must be considered as potentially containing pathogenic parasites.[6]
- There are no marine fishing grounds considered to be free of Anisakis simplex, a type of nematode, though it has only been found in wild seafood and has not been found in farmed seafood, likely due to the control measures in place.[3,6]
- Fish may become infected with Anisakis or Diphyllobothrium when they consume infected crustaceans. For example fish are infected with Anisakis simplex when they eat crustaceans that have in turn ingested the free-swimming second larval stage (L2) of Anisakis. The L2 mature into third stage larvae (L3) in crustaceans. Fish become infected when they consume the L3 larvae. When the fish die the larvae will migrate from their intestines to the muscle tissues and can be transmitted to humans when consumed.[7]
- The risk of infection with parasites can be reduced when good aquaculture practices (GAPs) are implemented. For example, in farmed Atlantic salmon, if fish are reared in floating cages (raised off the sea bed) or in tanks (on-shore) and fed an artificial diet (e.g. pellets), the risk of infection will become negligible as there would be very little opportunity for the fish to be exposed to infective parasites or their larvae.[6]

- A 2010 report estimated that more than 50 million people are infected with foodborne trematodes globally, with most infections resulting from consumption of contaminated raw or undercooked freshwater fishery products.[6]
- Over 2,000 cases of *Anisakis simplex* are diagnosed worldwide each year.[8]
- Between January 1, 1972 and March 22, 2016, 25 published reports of parasitic foodborne illnesses/outbreaks, associated with consumption of raw or under-cooked seafood, were documented in PAIFOD. A cestode was the causative agent in ten fish-borne illnesses/outbreaks; trematodes were implicated in nine and there were six

nematode-related illnesses/outbreaks. Three incidents were identified among Canadians[1,9]. The causative agent associated with the two Canadian illnesses (2005 and 2012) was *Diphyllobothrium*. *Anisakis* was the causative agent for the third Canadian case reported in 2015.[1]

Parasites of the helminth class are most associated with seafood causing human illness. They can be sub-classified as:

- **Nematodes (a.k.a. roundworms):** These are cylindrical parasites ranging in size. In fish, nematodes can vary in size from microscopic to a few centimetres. Examples include *Anisakis simplex* and *Pseudoterranova decipiens*.
- **Cestodes (a.k.a. tapeworms):** These are flattened, elongated, and segmented worms ranging in size from 2 millimetres up to 10 metres. The *Diphyllobothrium* species are part of this category.
- **Trematodes (a.k.a. flukes):** These are flattened, leaf-shaped, and range in size from 2 millimetres up to 8 centimetres. The *Heterophyidae, Opisthorchiidae,* and *Nanophyetidae* are most common in this category.[4]

Risk mitigating factors

Parasites are endemic in aquatic environments and infection of fish is unavoidable.

- In the seafood industry, freezing has been used to kill parasites. The requirements for killing depend on the type of parasite, temperature applied, length of time needed to reach the final temperature in all parts of fish tissue, the time fish is held at the set temperature, the species and source of the fish, and the fat content of the fish.[5,6] For example, tapeworms are more susceptible to freezing than are roundworms, and flukes are more resistant to freezing than roundworms. The freezing time and temperature required for eradication of parasites in particular seafood products can be found in Table 1.
- Freezing provides an effective means of inactivating parasites in raw and undercooked fish. Many jurisdictions have recommendations for the freezing of fish intended to be consumed raw. Table 2 provides a summary of freezing recommendations/requirements in different jurisdictions.
- GAPs in farmed fish have the potential to reduce and eliminate pathogenic loads in farmed fish, as mentioned above.[6]

Other risk mitigation measures that may reduce the parasitic load of fish based on their biology include:[5,10]

- Selective harvesting of younger fish among species where parasites accumulate during the life of the fish.
- Fishing outside marine mammal areas since fish from near-shore waters frequented by marine mammals often show a larger number of parasites.
- Rapid chilling and gutting following harvest to prevent worms from migrating from the viscera, where they mainly accumulate into the flesh which is consumed.
- Trimming away the belly flaps of fish and physically removing the parasites.
- Candling, a process by which the fish fillet is placed on a light table and parasites are physically removed. This method reduces the load but does not eliminate all parasites.

Discussion and Conclusions

Parasites are a natural part of the environment. They are commonly found in wild-caught marine and freshwater fish species.[2,5] Among humans, parasitic illnesses are often undiagnosed and under-reported. Three Canadian parasitic illnesses were identified in PHAC's Publically Available International Foodborne Outbreak Database.

Good aquaculture practices in farmed fish can reduce and eliminate parasitic load in farmed fish.[6] Specific practices such as selective harvesting, avoiding areas with known heavy parasitic loads, rapid chilling and gutting, and physical removal of visible parasites may also mitigate the risk of infection from fish that will be consumed raw.

Freezing mitigates the risk of human illness by inactivating parasites in fish that will be consumed raw or undercooked. The requirements for killing depend on the type of parasite, temperature achieved, length of time to reach a final temperature throughout the fish, time held at the optimum temperature, the species of fish, and fat content of the particular fish species. Recommendations for freezing of fish intended to be consumed raw are available in various jurisdictions.

Implications for Practice

Parasitic infection can occur after consuming raw or lightly cooked fish infected by parasites. For fish intended to be consumed raw, freezing is an effective way of mitigating the risk of human disease.

Other methods throughout the fish production process can also be helpful, and overall good aquaculture practices should be followed.

Local health authorities may provide guidance or regulations regarding freezing of fish intended to be consumed raw.

Specifications and Limitations of Evidence Brief

The purpose of this Evidence Brief is to investigate a research question to help inform decision making. The Evidence Brief presents key findings based on a systematic search of the best available evidence near the time of publication, as well as systematic screening and extraction of data from that evidence. It does not report the same level of detail as a full systematic review. Every attempt has been made to incorporate the highest level of evidence on the topic. There may be relevant individual studies that are not included; however, it is important to consider at the time of use of this Evidence Brief whether individual studies would alter the conclusions drawn from the document.

References

1. Greig JD. Outbreaks associated with consumption of raw seafood, recorded in Publically Available International Foodborne Outbreak Database (PAIFOD). Guelph, ON: Public Health Agency of Canada, Laboratory for Foodborne Zoonoses; March 2016. [unpublished].

2. Gunderson J. Parasites of Freshwater Fish [Internet]. Duluth, MN: Sea Grant Minnesota; 2008 [cited 2016 Apr 19]. Available from: http://www.seagrant.umn.edu/fisheries/parasites

3. Huss HH, Embarek PK. Parasites. In: Hus HH, Ababouch L, Gram L, editors. Assessment and management of seafood safety and quality: current practices and emerging issues. Rome: Food and Agriculture Organization of the United Nations; 2004. p. 60. Available from: http://www.fao.org/3/a-i3215e.pdf

4. Castro GA. Helminths: structure, classification, growth, and development. Galveston, TX: University of Texas Medical Branch at Galveston; 1996. Available from: http://www.ncbi.nlm.nih.gov/books/NBK8282/

5. Center for Food Safety and Applied Nutrition, Food and Drug Administration. Fish and fishery products hazards and controls guidance. 4th ed. Montgomery, MD: Food and Drug Administration; 2011. Chapter 5: Parasites; p. 91-8. Available from: https://www.fda.gov/downloads/food/guidanceregulation/ucm252393.pdf

6. EFSA Panel on Biological Hazards (BIOHAZ). Scientific Opinion on risk assessment of parasites in fishery products. EFSA Journal. 2010;8(4):1543. Section 4.4.1.1, freezing treatment, p. 39-40. Available from: http://onlinelibrary.wiley.com/doi/10.2903/j.efsa.2010.1543/epdf

7. Centers for Disease Control and Prevention. Parasites - anisakiasis [Internet]. Atlanta, GA: US Government of Health and Human Services; 2015 [cited 2016 May 11]. Available from: http://www.cdc.gov/parasites/anisakiasis/biology.html

8. Pozio E. Integrating animal health surveillance and food safety: the example of anisakis. Rev Sci Tech. 2013;32(2):487–96. Available from: http://www.oie.int/doc/ged/D12790.PDF

9. Vaughan S, Sadler M, Jayakumar S, Missaghi B, Chan W, Church DL. An unusual case of abdominal pain. Can J Infect Dis Med Microbiol. 2015;26(6):297–8. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4692297/

10. Adams AM, Murrell KD, Cross JH. Parasites of fish and risks to public health. Rev Sci Tech. 1997;16(2):652–60. Available from: https://pdfs.semanticscholar.org/750d/ea6376172377f1540d1b59747563eeec5278.pdf

11. Youssef M, Mansour NS, Hammouda NA, Awadalla HN, Boulos LM. Effect of freezing and drilling on Pygidiopsis genata metacercariae in Tilapia. J Egypt Soc Parasitol. 1981;11(2):425–8.

12. Wiwanitkit V, Nithiuthai S, Suwansaksri J. Motility of minute intestinal fluke, Haplorchinae spp, metacercariae in fish dishes prepared by different uncooked methods. MedGenMed. 2002;4(1):8.

13. Wiwanitkit V. Motility of intestinal fluke, Echinostoma Spp, metacercariae in fish dishes prepared by different uncooked methods. Internet J Infect Dis. 2004;4(1):8. Available from: http://ispub.com/IJID/4/1/10875

14. El-Zawawy LA. Impact of several control measures on the encysted metacercariae of heterophyids. J Egypt Soc Parasitol. 2008;38(3):945–56.

15. Borges JN, Skov J, Bahlool QZM, Møller OS, Kania PW, Santos CP, et al. Viability of Cryptocotyle lingua metacercariae from Atlantic cod (Gadus morhua) after exposure to freezing and heating in the temperature range from −80 °C to 100 °C. Food Control. 2015;50:371–7. Available from: http://www.sciencedirect.com/science/article/pii/S0956713514005271

16. Salminen K. The infectiveness of heat and cold exposed *Diphylobothrium latum* plerocercoids on golden hamster. Acta Vet Scand. 1970;11:247–53.

17. Deardorff TL, Throm R. Commercial blast-freezing of third-stage Anisakis simplex larvae encapsulated in salmon and rockfish. J Parasitol. 1988;74(4):600–3.

18. Wharton DA, Aalders O. The response of Anisakis larvae to freezing. J Helminthol. 2002;76(4):363–8.

19. Adams AM, Ton MN, Wekell MM, MacKenzie AP, Dong FM. Survival of Anisakis simplex in arrowtooth flounder (*Atheresthes stomia*) during frozen storage. J Food Prot. 2005;68(7):1441–6.

20. Rodríguez-Mahillo AI, González-Muñoz M, Moneo I, Solas MT, Mendizábal A, de las Heras C, et al. Allergenic properties and cuticle microstructure of Anisakis simplex L3 after freezing and pepsin digestion. J Food Prot. 2008;71(12):2578–81.

21. Hamed MGE, Elias AN. Effect of food-processing methods upon survival of the Trematode Heterophyes sp. in flesh of mullet cought from Brackish Egyption waters. J Food Sci. 1970;35(4):386–8.

22. Álvarez-Guerrero C, Alba-Hurtado F. Effect of some physical factors on the viability of third-stage Gnathostoma binucleatum larvae. J Food Prot. 2011;74(5):844–8.

23. Alberta Health Services. Guidelines for the preparation of sushi products [Internet]. Edmonton, AB: Alberta Health Services; 2004 [cited 2017 Jun 14]. Available from: http://www.albertahealthservices.ca/assets/wf/eph/wf-eh-guidelines-for-sushi-prep.pdf

24. Nova Scotia Department of Agriculture. Sushi/sashimi preparation guidelines [Internet]. Halifax, NS: Nova Scotia Department of Agriculture; 2011 [cited 2107 Jun 14]. Available from: https://novascotia.ca/nse/food-protection/docs/sushi-guidelines.pdf

25. Manitoba Health. Food safety guidelines for the preparation of sushi [Internet]. Winnipeg, MB: Manitoba Health; 2013 [cited 2017 Jun 14]. Available from: https://www.gov.mb.ca/health/publichealth/environmentalhealth/protection/docs/sushi.pdf

26. BC Centre for Disease Control. Guideline for the exemption of certain species of tuna and farmed fish from the parasite destruction processes (freezing) prior to service in a raw or lightly cooked form [Internet]. Vancouver, BC: BC Centre for Disease Control; 2010 [cited 2017 Jun 14]. Available from: http://www.bccdc.ca/resource-gallery/Documents/GuidelineExemptionofFishSpeciesfromParasiteDestrProcessesJan2010.pdf

27. Canadian Food Inspection System Implementation Group. Canadian food retail and food services code [Internet]. Ottawa, ON: Canadian Food Inspection System Implementation Group; 2004 [cited 2017 Jun 14]. Available from: http://foodsafe.ca/resources/Food_Services_Code2004.pdf

28. Standing Committee on the Food Chain and Animal Health. Guidance on viable parasites in fishery products that may represent a risk to the health of the consumer [Internet]. Brussels, BE: European Commission; 2011 [cited 2017 Jun 14]. Available from: https://ec.europa.eu/food/sites/food/files/safety/docs/biosafety_fh_eu_food_establishments-20111214_scfcah_guidance_parasites_en.pdf

29. Food Standards Agency. Freezing requirements for fishery products intended to be eaten raw or lightly cooked [Internet]. London, UK: Food Standards Agency; 2015 [2017 Jun 14]. Available from: https://www.food.gov.uk/business-industry/fish-shellfish/freezing-requirements-guidance

Appendix 1

Table 1: Freezing time/temperature required for eradication of parasites in seafood

Organism	Product	Temperature	Time	Source
Pygidiopsis genata metacercariae	Tilapia	-4°C	10 days	Youssef et al. (1981)[11]
Haplochinae spp. metacercariae	Freshwater fish, *Cyclochelichtys armatus*	-20°C	5 h	Wiwanitkit et al. (2002)[12]
Echinostoma spp. metacercariae	Freshwater fish, *Cyclochelichtys armatus*	-20°C	10 h	Wiwanitkit (2004)[13]
Pygidiopsis genata metacercariae	Tilapia	-4°C -20°C	10 days 10 days	El-Zawawy (2008)[14]
Heterophyid trematode, *Cryptocoyle lingua*	Atlantic Cod	-20°C	• 2 h (metacercariae mounted between cod tissue) or, • 6 h (metacercariae kept in situ as infection in cod tissue during incubation)	Borges et al. (2015)[15]
Diphyllobothrium latum	Pike	-18°C	1 day	Salminen (1970)[16]
Anisakis simplex larvae	Sockeye salmon and canary rockfish	Blast frozen to -35°C	24 h	Deardorff and Throm (1988)[17]
Anisakis simplex L3	Barracouta (*Thyristes atun*)	-15°C (all parts of product)	NA	Wharton and Alder (2002)[18]
Anisakis simplex larvae	Arrowtooth flounder	-15°C -20°C -30°C -40°C	96 h 60 h 12 h 9 h	Adams et al. (2005)[19]
Anisakis simplex larvae	Larva isolated from Hake (*Merluccius merluccius*)	-20°C	2 h	Rodriguez-Mhillo et al. (2008)[20]
Heterophyes spp.	Mullet	-10°C -20°C	33 h 33 h	Hamed and Elias (1970)[21]
Gnathostoma binucleatum L3	Fish meatball (made from estuarine fish and turtles)	-20°C -10°C	24 h 48 h	Alvarez-Guerrero and Alva-Hurtado (2011)[22]

Appendix 1 (continued)

Table 2: Freezing time/temperature recommendations for fish intended to be eaten raw or lightly cooked in different jurisdictions

Jurisdiction	Temperature/time	Source
Alberta	-20°C for 7 days or -35°C or below for 15 hours	Alberta Health Services, (2011)[23]
Nova Scotia	-20°C for 7 days or Below -35°C for 15 hours (in a blast freezer)	Nova Scotia Department of Agriculture (2011)[24]
Manitoba	-20°C or below for 7 days or -35°C or below until solid and storing at -35°C or below for 15 hours or, -35°C or below until solid and storing at -20°C or below for 24 hours	Manitoba Health (2013)[25]
British Columbia	-20°C for 7 days or -35°C or below for 15 hours, or Frozen at -35°C until solid and stored at -20°C or below	BC Centre for Disease Control (2010)[26]
Canada	-20°C for 7 days or Below -35°C for 15 hours (in a blast freezer)	Canadian Food Inspection System Implementation Group, (2004)[27]
United States	-35°C or below (in a blast freezer) until solid and hold at -20°C or below for 24 hours	Centre for Food Safety and Applied Nutrition, Food and Drug Administration (2011)[5]
European Commission	For parasites (other than trematodes) temperature in all parts of product to: • -20°C or lower for no less than 24 hours, or • -35°C or lower for no less than 15 hours. For trematodes metacercariae of *Opisthorchis* spp. and *Clonorchis* spp.: • -10°C for 5 days • -20°C for 3-4 days • -28°C for 32 hours	Standing Committee on the Food Chain and Animal Health, (2011)[28]
United Kingdom	-20°C for 7 days or -35°C or below for 15 hours, or previously frozen to -18°C for at least 4 days for storage, transport and distribution purposes.	Food Standards Agency (2011)[29]

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