FEBRUARY 2019

MICROBIAL RISKS AND CANADIAN REGULATIONS FOR SPECIALTY ETHNIC FOODS: CEVICHE

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WHAT IS CEVICHE?

Ceviche is a popular dish in Central and South America, and is rapidly gaining popularity in Canada and the US. Typically, raw fish or shellfish such as shrimp or scallops are marinated in lime or other citrus juices until the flesh firms up and turns opaque, although cooked seafood can also be used. It is then mixed with seasonings and other ingredients and eaten as a snack or appetizer.

HOW IS CEVICHE PREPARED?

Ceviche may be made from raw or pasteurized ingredients. Commercially prepared ceviche sold to retailers is made by pasteurizing the ingredients first. Typically, cut-up fish and shellfish are first blanched, then rapidly chilled to remove spoilage and pathogenic microbes. Ceviche is made with cut or ground up (raw or pasteurized) fish or shellfish that are marinated in lime juice or other citrus juices for a period of time ranging from a few minutes or up to 24 hours, until the flesh turns opaque.[1] The seafood can be used in a wide variety of ceviche recipes that vary across regions and countries. It is usually mixed with ingredients such as olive oil, vegetables, herbs, and spices.

POTENTIAL MICROBIAL FOOD SAFETY RISKS

Bacteria and Viruses

Several pathogens have been associated with fish and other seafood that are used in ceviche, including *Salmonella, Vibrio parahaemolyticus, Vibrio cholerae*, and parasites from the *Anisakidae* and *Gnathostoma* families.[2-5] In molluscan shellfish such as oysters, clams, mussels, and scallops, pathogens can also include *Shigella, Campylobacter jejuni*, hepatitis A virus, and norovirus.[6] Additionally, some seafood products are susceptible to processing-related pathogenic hazards, such as *Clostridium botulinum* and *Staphylococcus aureus*.[6]

Several control methods for pathogens at the retail level include controlling the pH level of the food item, managing the length of time the food item is exposed to temperatures that allow pathogen growth, and cooking or pasteurizing food items to kill pathogens.[6] In the context of ceviche, citrus juices contain citric acid, which has historically been used for its flavour and antimicrobial properties.[4] However, while the fish or shellfish turns opaque and may appear to be cooked, it is important to note that it has not undergone a cooking step and the citrus juices do not kill or inactivate all forms of pathogens that may be present in seafood.[1,7]

Mathur et al. demonstrated that lime juice was able to achieve an average of minimum 5-log reduction in *Vibrio parahaemolyticus* levels under all experimental conditions after 30 minutes.[4] These results corroborate an earlier study by Vanderzant et al, who found that at pH 5, *V. parahaemolyticus* could not be detected after 15 minutes of acid treatment.[8] Another study showed that within five minutes of marinating fish inoculated with Vibrio cholerae in lime juice, *V. cholerae* levels were reduced by more than 99.9%; after two hours in lime juice, V. cholerae were undetectable in the samples.[9]

Mathur et al. also measured the effectiveness of lime juice against *Salmonella*, and found that it had little impact on Salmonella levels in the fish samples. However, in experimental lime juice samples containing no fish, lime juice was able to effect a 5-log reduction in *Salmonella* levels within 15 minutes.[4]

While pH 4-8 is the optimal growth condition for many pathogens, some pathogens, such as *Salmonella* and *Escherichia coli*, are able to grow under acidic conditions.[10,11] Herrera et al. evaluated the effectiveness of lime juice against three different bacterial strains: *Aeromonas hydrophila, enterotoxigenic E. coli (ETEC),* and *V. parahaemolyticus.*[7] Fish filet samples previously inoculated with the bacterial strains were mixed with ceviche ingredients and marinated together with lime juice for 10 and 30 minutes. At 10 minutes, bacterial load for all three strains declined. However, at 30 minutes, bacterial growth appeared to have resumed and ETEC samples reached baseline levels.

Parasites

Anisakidae (including *Anisakis simplex* and *Pseudoterranova decipiens*) and *Gnathostoma* nematodes are emerging health risks due to the increasing consumption of raw or undercooked fishes that contain the nematode larvae.[2,3] *Anisakidae* larvae can penetrate the walls in the digestive tract and cause nausea, vomiting, diarrhea, and abdominal pain.[2] Gnathostomiasis involves ingestion of only one *Gnathostoma* larvae which penetrates the intestines, leading to gastric pain, nausea, and vomiting. Clinical manifestations of gnathostomiasis include cutaneous disease with nodules and swellings containing a larvae; liver or gastrointestinal disease; cerebral gnathostomiasis; and ocular gnathostomiasis.[3]

Freezing is a common practice used to inactivate parasites found in fish that can cause human illness.[12] However, the length of time and the temperatures required differ depending on the fish species and the type of parasite.[12] Good aquaculture practices in farmed fish reduce the likelihood of exposing fish to infective parasites or their larvae.[12] Other methods at the fishing and harvesting stage include selective harvesting of younger fish, fishing outside marine mammal areas, rapid chilling and gutting immediately after harvesting, and physical removal of parasites by trimming and candling.[12]

Experimental results from multiple studies reveal that although lime juice provides an acidified environment for seafood in ceviche dishes, it is inadequate to kill or inactivate all forms of pathogens and parasites that may be present in fish and molluscan shellfish used in ceviche. Therefore proper precautions and safe food handling practices must be observed.

ASSOCIATED OUTBREAKS

In 2016, a *Vibrio cholerae* outbreak occurred in Minnesota from consumption of ceviche made with raw shrimp and raw oysters. Six cases fell ill with watery diarrhea, vomiting, abdominal cramps, and headache. The restaurant operator was advised to marinate raw food items in lime juice before being served instead of serving them immediately after adding lime juice.[13]

FOOD SAFETY RECOMMENDATIONS

Based on available guidance information, it is advised that vulnerable populations such as seniors, pregnant women, people with compromised immune systems, and children ages five and under avoid consuming raw or undercooked seafood.[21,22] Travelers to developing countries are advised to avoid consuming raw seafood such as ceviche to prevent traveler's diarrhea.[23,24] Raw or undercooked seafood should not be served at a food establishment that caters to a highly susceptible population.[25] Seafood should be purchased from a licensed and approved source with documentation to ensure that the seafood was harvested from an approved area and was properly processed.[26,27]

The required times and temperatures to kill/inactivate parasites differ depending on the species of parasites and the development stage.[12] Certain species of tuna do not require freezing as they do not harbour parasites. These include albacore, yellowfin (ahi), blackfin, bluefin, and bigeye.[28] The following prevention and control measures can be used by the seafood processor or at the retail restaurant level to kill or remove parasites:[2,29]

Freezing:

- At -20°C or below for 7 days
- At -35°C until solid, then for 15 hours at -35°C or below
- At -35°C until solid, then for 24 hours at -20°C or below
- Candling, which involves visual examination of fish filets over an illuminated surface for physical removal of larvae. However this method does not guarantee removal of all parasites.[12]

For more details on species-specific time and temperature requirements, as well as province- and country-specific requirements, please see Appendix 1 of this evidence brief produced by Public Health Ontario.

A case of a 60 year-old woman who presented with illness after consuming ceviche made with lemon juice and peppers was reported in 2006.[14] A three-centimetre white larva was found adhered to the mucosa of the digestive tract, which was later identified as a stage IV larva of *Pseudoterranova spp*.[14]

A multi-state *Salmonella* outbreak associated with an imported frozen raw yellowfin tuna product known as Nakaochi Scrape occurred in 2012.[15] In total, 425 cases were reported from 28 states and the District of Columbia, with 55 cases requiring hospitalization. Nakaochi Scrape is tuna backmeat scraped from the bones of the tuna, and may be used in raw dishes such as sushi, sashimi, and ceviche. Several cases reported consuming sushi, sashimi, or ceviche made with raw fish or shellfish prior to illness onset.[15]

Apart from outbreaks associated with ceviche, 25 cases of parasitic foodborne illnesses/outbreaks associated with consumption of raw or undercooked seafood were recorded between 1972 and 2016.[12]

RELEVANT CANADIAN LEGISLATION

Since January 2019, the *Safe Food for Canadians Act* and the *Safe Food for Canadians Regulations* consolidated the *Canada Agricultural Products Act*, the *Consumer Packaging and Labelling Act*, the *Fish Inspection Act*, and the *Meat Inspection Act* in order to strengthen the safety of imported and exported foods, as well as foods traded inter-provincially.[16] One of the main focuses of the Act is to streamline and improving food safety oversight and legislative authority.[16] The *Safe Food for Canadians Regulations* govern topics including licensing, food business preventive controls and plans, food traceability, labelling and grading, organic products, and food packaging containers.[17] Since the repeal of the *Fish Inspection Act*, the Safe Food for Canadians Regulations now includes stipulations for importing, inter-provincial trading, packaging, labelling and grading, and storage of live, raw, and frozen fish and other seafood.[18]

Administered by the Canadian Food Inspection Agency, Environment and Climate Change Canada, and Fisheries and Oceans Canada, the Canadian Shellfish Sanitation Program requires all shellfish to be processed through federally registered plants to prevent illnesses associated with consumption of contaminated shellfish.[19] The Program regulates the safety of shellfish from import/export through to processing, and storage of shellfish, as well as the identification and monitoring of safe shellfish harvest areas in Canada.[19,20]

Within provinces and territories, provincial/territorial governments have the jurisdiction to enact legislation and guidelines governing inspection of fish and other seafood processing plants and safe food handling in food service facilities. At the provincial/territorial level, regulations such as the *BC Fish and Seafood Licensing Regulation* provide processing and handling requirements for provincial seafood processing plants. Provincial/territorial or regional health organizations provide guidelines to assist operators in ensuring food safety of raw seafood. As an example, Alberta's *Guidelines for Preparing Sushi Products* provides information on raw seafood source and preparation to ensure food safety. In the US, the Food and Drug Administration's *Food Code and Fish and Fishery Products Hazards and Controls Guidance* provide information on the types of biological and chemical hazards present in seafood products as well as prevention and control methods for these hazards.[6]

Health Canada's most current guidance states that fish should be cooked to an internal temperature of 70°C and shellfish should be cooked to an internal temperature of 74°C.[30] However, guidance from the

National Advisory Committee on Microbiological Criteria For Foods (NACMCF) suggests that to eliminate viruses from shellfish, a minimum cooking temperature of 90°C for 90 seconds is required to achieve a 4-log reduction for hepatitis[31], and that uncertainty still remains in determining a safe cooking temperature to eliminate norovirus from seafood.[32]

Ceviche is considered to be a potentially hazardous food. Raw fish and shellfish, as well as other ingredients used in ceviche may harbour pathogens which may cause foodborne illness. While citrus juices may have bactericidal properties, they are not effective against all pathogens that may be found in seafood. Therefore ceviche should be treated as any other raw seafood dish and proper food processing and handling should be observed. If the ceviche dish is made with raw or undercooked seafood, disclosure should be provided to consumers that the dish contains raw or undercooked seafood and consumption may increase the risk of foodborne illness.[25]

ACKNOWLEDGEMENTS

The author would like to thank Lorraine McIntyre (BC Centre for Disease Control), Aljosa Trmcic (BC Centre for Disease Control), and Naghmeh Parto (Public Health Ontario) for their review and invaluable feedback for this document.

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ISBN : 978-1-988234-29-8

This document can be cited as:
Chen, T. Microbial Risks and Canadian Regulations For Specialty Ethnic Foods: Ceviche. Vancouver, BC. National Collaborating Centre for Environmental Health. 2019 Feb.

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