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SafeFish

SEAFOOD SAFETY FACT SHEETS

JANUARY 2015

Assisting the industry to resolve technical trade impediments in relation to food safety and hygiene.

SafeFish

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ABOUT SAFEFISH

SafeFish provides technical advice to support Australia's seafood trade and market access negotiations and helps to resolve barriers to trade. It does this by bringing together experts in food safety and hygiene to work with the industry and regulators to agree and prioritise technical issues impacting on free and fair market access for Australian seafood.

SafeFish has a record of success in reopening markets and in responding quickly when issues arise. By involving all relevant parties in discussions and, where necessary, commissioning additional research to fill any knowledge gaps, an agreed Australian position is reached that is technically sound and defensible. This robust process builds knowledge and relationships, and results in better outcomes for industry in maintaining fair market access and ensuring that the seafood they sell is safe.

WHAT WE DO

SafeFish supports the resolution of issues and challenges relating to the export, import and domestic trade of Australian seafood products. It does this by undertaking the following key functions:

- Developing technical advice for trade negotiations to assist in the resolution of market access and food safety issues.
- Developing technical briefs on high priority codex issues.
- Facilitating technical attendance at high priority Codex meetings and specific working groups.
- Identify & facilitate research into emerging market access issues.
- The provision of technical information and advice to support emergency incident response management.

INTRODUCTION

This SafeFish resource contains a collection of informative fact sheets for a number of food safety hazards that may affect seafood in Australia. These sheets include a short summary on the hazard, its prevalence of outbreaks in Australia, the dose required to cause illness, the symptoms associated with illness, inactivation and prevention strategies, detection methods and the Australian regulatory requirements for these hazards. This brochure is also freely available on the SafeFish website www.safefish.com.au.

AMNESIC SHELLFISH POISONS

Domoic acid (DA) is a neurotoxin produced by a group of marine microalgae known as diatoms, mostly of the genus *Pseudo-nitzschia*. The term "amnesic shellfish poisoning (ASP)" was coined to describe domoic acid intoxication, from the observation that many of the victims of the outbreak were affected by memory dysfunction. However, DA can cause a range of other severe neurological impacts, including chronic epilepsy, and can be found in many other marine food animals, including crustaceans, tunicates, fish, mammals and seabirds, as well as a range of gastropod and cephalopod molluscs.

WHAT ARE THE CAUSATIVE ORGANISMS?

In Australia the known causative diatoms are from the *Pseudo-nitzschia seriata* group (*P. multiseries* and *P. australis*) and the *P. delicatissima* group.

These species grow naturally in marine environments. When they are present in significant levels they may cause a hazard, particularly in bivalve shellfish as they are further concentrated through filter feeding.

WHAT OUTBREAKS HAVE OCCURRED?

The first DA outbreak occurred in Canada in 1987, when 107 people who had eaten DA-contaminated mussels were sickened, four of whom became comatose and subsequently died. Fourteen individuals suffered long-term neurological damage.

No reports of illness attributable to DA poisoning have been received in Australia.

Short-term mussel fishery closures have occurred in South Australia due to excess *Pseudo-nitzschia* counts. In 2010 a toxic *Pseudo-nitzschia* bloom in Wagonga Inlet on the New South Wales far south coast resulted in a four-month oyster harvesting closure.

HOW MUCH DOMOIC ACID IS A HARMFUL DOSE?

A dose of about 1milligram of domoic acid per kilogram body weight is thought capable of initiating symptoms of poisoning, i.e. around 65 milligrams for a 65kg adult. This equates to 325 milligrams DA per kg of seafood in a 200g portion.

WHAT ARE THE SYMPTOMS?

- Mild intoxication may involve only gastro-intestinal upset (nausea, vomiting, diarrhoea, gut pains).
- Symptoms of neuro-intoxication include headache, convulsive seizures, myoclonus (involuntary, irregular muscle contractions), cognitive impairment and disorientation, anterograde amnesia (inability to lay down new memories following neurological damage), respiratory difficulty and coma.

WHAT CAN BE DONE TO REDUCE OR MANAGE THE RISK?

- DA is heat-stable and therefore not degraded or destroyed by cooking, although some leaching into cooking water may be expected.
- Shellfish production in Australia requires adherence to algal biotoxin management plans to control this hazard. Each state monitors commercial shellfish areas for toxic algae in the water and/or toxins in the shellfish. Detection of either factor above compliance levels results in mandatory closure of fisheries until toxin concentrations return to safe levels.
- Longer term depuration treatments may facilitate the elimination of domoic acid, but should be confirmed with chemical and/or biological testing.
- Avoid consumption of crustacean tomalley ("mustard") during bloom events as crustaceans are known to concentrate domoic acid in the hepatopancreas.
- Public health authorities may caution or restrict recreational shellfishing when waters are affected by toxic microalgal blooms.

HOW CAN WE TEST FOR DOMOIC ACID?

- Microscopy technique can be used to detect the presence of potentially toxic diatoms in water samples.
- Antibody-based screening test kits or confirmatory chemical testing conducted by specialist analytical laboratories can be used to detect DA in seafood tissue samples.

REGULATORY STANDARDS

The Australian Regulatory limit for DA in bivalve molluscs is 20 milligrams per kg (http://www.foodstandards.gov.au/). State food safety regulators may apply this limit in the case of other seafood products found to be contaminated with DA.

International regulatory limits can be found in the Trade & Market Access Database, available at www.frdc.com.au/trade.

MORE INFORMATION

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CIGUATERA FISH POISONING

Ciguatera is a foodborne intoxication caused by consumption of ciguatoxins: a group of stable, fat-soluble chemical toxins that are found in particular fish species which spend some or most of their life-cycle on coral reefs. Precursor toxins to ciguatoxin are produced by dinoflagellate microalgae, and then modified as they move up marine food chains, for example as herbivorous fish are eaten by small carnivorous fish, which are in turn eaten by larger carnivorous fish. The transformed toxins that cause illness are mainly found in large carnivorous fish.

WHAT OUTBREAKS HAVE OCCURRED?

Ciguatera is the most common food poisoning event related to finfish consumption in Australia. Numerous cases and outbreaks, including some fatal intoxications, have occurred in Australia over many decades. These cases relate to both commercial and recreational catch and domestic and export products. Fish captured from coastal and oceanic waters in Queensland and the Northern Territory account for most cases and outbreaks of ciguatera from Australia.

Several ciguatera source regions are known around the world, including the South Pacific, Hawaii, the Caribbean and Gulf of Mexico, and the western Indian Ocean.

HOW MUCH CIGUATERA IS A HARMFUL DOSE?

Ciguatoxins are highly potent and are capable of initiating ciguatera poisoning in very low quantities.

Fish containing as little as one ten-thousandth of a gram of the most potent ciguatoxin per gram of fish flesh may cause illness.

WHAT ARE THE SYMPTOMS?

Mild intoxication may involve only gastro-intestinal upset (nausea, vomiting, diarrhoea, gut pains) which resolves in a day or two. More severe poisoning may cause one or more of the following neurological signs and symptoms:

- Itching, which may be intense and unrelenting for days or weeks.
- Alterations in sensory perception, where contact with cold surfaces or taking cold drinks may provoke burning or electric-shock-like sensations.
- Tingling or painful sensations in hands, feet or genitals.
- Dizziness, low blood pressure, cardiac abnormalities.
- Joint and/or muscle pain, lassitude.

Symptoms can last for days, weeks, months or (rarely) years following a single ciguatera poisoning incident.

WHAT CAN BE DONE TO REDUCE OR MANAGE THE RISK?

- It's recommended to be aware of ciguatera high risk areas and species size limits. The Sydney Fish Market's schedule lists fish to avoid: high risk species (Chinaman or Chinaman Snapper, Tripletail Maori Wrasse, Red Bass, Paddle-tail or Humped-back Red Snapper and Moray Eel), and specified fish from high risk areas (listed), or above specified size limits.
- Ciguatoxins are heat-stable, so are not destroyed by cooking or freezing.
- Ciguatoxins are tasteless and odourless, so fresh and visually-appealing fish may be toxic.
- If neurological symptoms occur within 24 hours of a fish meal, seek medical attention; request attending doctors inform public health authorities if ciguatera poisoning is diagnosed.

HOW CAN WE MONITOR CIGUATERA?

There is currently no technology that is reliable and cost-effective for testing fish prior to sale or consumption for ciguatoxins.

Ciguatoxins in fish can be measured by some specialist laboratories, but the analysis is expensive and therefore currently only suitable for post-intoxication testing or research. Individual fish suspected of causing ciguatera cases or outbreaks should be retained or retrieved, and forwarded to local public health authorities.

REGULATORY STANDARDS

Current Australian seafood industry risk management protocols involve restrictions on sale based on maximum size limits, high risk species and capture location. See the Sydney Fish Market schedule for details.

There are currently no regulatory limits in Australia for ciguatoxin in seafood.

The US Food and Drug Administration have recently set action limits of 10 nanograms (ng) Pacific ciguatoxin and 100ng Caribbean ciguatoxin per kg fish tissue. EU regulations state that fish products containing ciguatoxins should not be marketed.

International regulatory limits can be found in the Trade & Market Access Database, available at www.frdc.com.au/trade.

MORE INFORMATION

Queensland Health food safety fact sheet: naturally occurring seafood toxins http://www.health.qld.gov.au/foodsafety/ documents/fs-37-sea-toxin.pdf

Stewart, I., et al., Emerging tropical diseases in Australia. part 2. Ciguatera fish poisoning. *Annals of Tropical Medicine and Parasitology*, 2010. **104(7)**:557-71.

Sydney Fish Market: schedule of ciguatera high-risk areas and species size limits http://www.sydneyfishmarket.com.au/portals/0/ciguatera_schedule.pdf

US Food and Drug Administration: Fish and fishery products hazards and controls guidance – 4th edition 2011 http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/Seafood/ ucm2018426.htm

CLOSTRIDIUM BOTULINUM

Clostridium botulinum is a naturally occurring bacterium and is one of the most important pathogens in foods. It can be characterised by its anaerobic growth requirements, ability to form heat resistant spores and potential for growth across a wide range of temperatures. Some strains are capable of producing a potent neurotoxin that can cause severe illness in humans and animals.

WHAT STRAINS ARE CONSIDERED A RISK IN SEAFOOD?

C. botulinum Type E is considered the most common form detected in freshly harvested seafood and has been associated with illnesses due to seafood consumption in other countries.

WHAT SEAFOOD PRESENTS THE HIGHEST RISK?

Packaging formats that contain environments that are conducive to anaerobic growth and allow production of the neurotoxin, such as improperly canned product, vacuum packaged and modified atmosphere packaged seafood.

WHAT OUTBREAKS HAVE OCCURRED?

There have been no documented cases of botulism from the consumption of Australian seafood. Furthermore, there have been no documented reports of this organism in Australian seafood.

HOW MUCH *C. BOTULINUM* IS A HARMFUL DOSE?

The dose response of the botulism neurotoxin is unknown.

For neurotoxins of *C. botulinum* Type E (the most common type associated with seafood), approximately 10 micrograms (µg) of toxin is estimated to result in death. However, the production of toxins depends on the strain, the numbers of spores present and the storage conditions.

WHO IS AT RISK?

All consumers are susceptible to the neurotoxins produced by *C. botulinum*, although the immuno-compromised, the elderly and young children may require less toxin to become ill.

WHAT ARE THE SYMPTOMS?

- Initial symptoms include nausea, vomiting and diarrhoea.
- Neurological symptoms following that begin with cranial nerve areas including eye, throat and mouth, followed by paralysis of motor nerves down the body.
- Constipation and abdominal pain persists throughout.
- Severe symptoms include lack of muscle co-ordination, fatigue and respiratory impairment and failure.

WHAT CAN BE DONE TO INACTIVATE OR ELIMINATE *C. BOTULINUM*?

- The first line of defence for products that are considered a risk is strict temperature control of the product by storage at temperatures at or below 3°C.
- For canned product, temperature profiles should be achieved during canning that will achieve a 12 log cycle reduction of *C. botulinum*.
- For lightly preserved and fresh product a 3% water phase salt content should be used.

HOW CAN WE TEST FOR *C. BOTULINUM*?

There is no Australian standard method for testing *C. botulinum*. However testing methods such as traditional culture, PCR and ELISA are available.

Neurotoxin detection can be performed by mouse bioassay, immunoassays and DNA based techniques.

REGULATORY STANDARDS

There is no specific Australian limit for *C. botulinum* Type E in seafood. although, other countries such as india and thailand do set limits for *C. botulinum*; International regulatory limits can be found in the Trade & Market Access Database, available at www.frdc.com.au/trade.

MORE INFORMATION

Bates, J. R. & Bodnaruk, P. W. 2003. *Clostridium botulinum*. In: Hocking, A. D. (ed.) Foodborne Microorganisms of Public Health Significance. Sixth ed. New South Wales: Australian Institute of Food Science and Technology Inc.

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LISTERIA MONOCYTOGENES

Listeria are naturally occurring bacteria that can be found in many environments including animals, soils, and processing facilities. *Listeria monocytogenes* is the only type of *Listeria* that is pathogenic to humans. The capability of *L. monocytogenes* to grow at refrigeration temperatures increases the risk from this pathogen.

WHAT SEAFOOD PRESENTS A RISK?

Seafood that possesses a long shelf-life is considered to present a higher-risk, for example smoked fish.

HOW DOES SEAFOOD BECOME CONTAMINATED?

L. monocytogenes is commonly associated with processing environments and can persist in drains, floors and wet areas. Cross-contamination from these areas is the usual source.

WHO IS AT RISK?

Some members of the population are considered as high risk groups including pregnant women and their foetuses, neonates, the elderly and the immuno-compromised.

WHAT OUTBREAKS HAVE OCCURRED?

There have been no recorded outbreaks in Australia attributed to *Listeria* in Australian-sourced seafood; however, there have been recall events of contaminated product. There have been illnesses associated with seafood overseas, including New Zealand.

HOW MUCH *L. MONOCYTOGENES* IS A HARMFUL DOSE?

A harmful dose can range from 102 to 106 cells dependent on strain and human host.

WHAT ARE THE SYMPTOMS?

Symptoms of listeriosis can vary, but can include:

- Influenza-like symptoms such as fever, headaches and muscle aches.
- Can be gastrointestinal illness – vomiting and diarrhoea, although this is less common.
- Septicaemia – fever, chills, rapid heart rate, breathing difficulties.

WHAT CAN BE DONE TO MANAGE *L. MONOCYTOGENES*?

- Educational efforts targeted at high-risk sectors of the population advising them against eating high risk products.
- Application of appropriate food processing technologies to high risk products.
- Effective cleaning and sanitation of processing areas. Particular care for floors, drains, walls, hollow rollers, conveyor strips, rubbers seals and inaccessible areas in equipment and machinery.
- Modern smooth surfaces and competent drainage have been found to reduce the risk of *Listeria* contamination.
- Effective HACCP-based food safety programs.
- Effective sampling plans for testing of *L. monocytogenes* in processing plants and end products.
- Separation of raw and processed product to prevent cross contamination.
- Good personal hygiene during processing in the factory.

HOW CAN WE TEST FOR *L. MONOCYTOGENES*?

Australian Standard method AS 5013.24.1-2009 for testing *Listeria monocytogenes* in food and animal stuff is based on ISO 11290-1:1996 method: Horizontal method for the detection and enumeration of *Listeria monocytogenes*.

For export products the Department of Agriculture has approved a number of rapid methods by using ELISA and PCR techniques.

It is not uncommon to detect non-pathogenic *Listeria* species during the first stage of culture based testing. These may not be a concern from a safety and regulatory perspective unless further stages of the testing confirm these as *L. monocytogenes*.

REGULATORY STANDARDS

Australia has standards for *Listeria monocytogenes* under the Australia New Zealand Food Standards Code for ready to eat processed fish and processed bivalve molluscs, available at http://www.foodstandards.gov.au.

International regulatory limits can be found in the Trade & Market Access Database, available at www.frdc.com.au/trade.

MORE INFORMATION

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CAC/GL 61 2007 guidelines on the application of general principles of food hygiene to the control of *Listeria monocytogenes* in foods.

ESCHERICHIA COLI

E. coli is a part of the normal microbial flora in the intestinal tracts of humans and other warm-blooded animals. Most *E. coli* strains are harmless; however some strains are pathogenic.

Pathogenic *E. coli* strains are classified into specific groups based on the mechanism by which they cause disease and clinical symptoms. These groups include:

- Enteropathogenic *E. coli* (EPEC)
- Enteroaggregative *E. coli* (EAEC)
- Enteroinvasive *E. coli* (EIEC)
- Enterotoxigenic *E. coli* (ETEC)
- Diffusely adhering *E. coli* (DAEC)
- Enterohaemorrhagic *E. coli* (EHEC)

All categories of *E. coli* may be shed in the faeces of infected humans, creating the potential to be spread to other humans, animals and the environment. *E. coli* is often used as an indicator of faecal pollution.

The Shiga toxin producing *E. coli* (STEC) strains are often associated with more severe illnesses. These belong to the EHEC group. Of these, O157:H7 is the most commonly reported in Australia.

WHAT OUTBREAKS HAVE OCCURRED?

Infection with STEC is a notifiable disease in all Australian states and territories. Seafood was not implicated in any Australian outbreaks between 1988 and 2010.

HOW IS *E.COLI* TRANSMITTED?

- Person-to person
- Cross-contamination
- Consumption of contaminated food or water
- Direct contact with infected animals

HOW MUCH *E. COLI* IS A HARMFUL DOSE?

Doses causing illness vary depending on the specific *E. coli* group and the immune response of individuals. The infectious dose (in healthy adults) ranges from 10-100 cells for EHEC to 10 million to 10 billion cells for ETEC and EPEC.

WHAT ARE THE SYMPTOMS?

Symptoms from STEC usually begin three to four days after exposure and most patients recover within ten days. Infections may range from asymptomatic (no clinical symptoms) or can cause:

- Diarrhoea, abdominal cramps, vomiting and fever.
- In some cases haemorrhagic colitis (characterised by severe abdominal cramps and bloody diarrhoea).
- Haemolytic uremic syndrome (a combination of anemia, low platelet count and acute kidney failure) which can result in death.

WHAT CAN BE DONE TO MANAGE *E. COLI* IN SEAFOOD?

Hazards from *E. coli* can be prevented by:

- Not harvesting from contaminated waters.
- Prevention of contamination during processing by Good Manufacturing Practice (e.g. wearing gloves and proper personal protection), good personal hygiene, proper sanitisation of food contact surfaces and utensils, and prohibiting people that are ill from working in food operations.
- Adequately cooking seafood to eliminate pathogens (e.g. heating to an internal temperature of 72°C and maintaining for 1 minute).
- Maintaining seafood below 6.5°C or above 49.4°C to prevent growth.

USE OF *E.COLI* FOR MANAGING SHELLFISH FOOD SAFETY?

Due to their prevalence as gut flora, general *E.coli* are used widely in shellfish growing area management as indicators of faecal pollution. They are used to classify production areas as to suitability for direct harvest, and to determine when the risks of faecal pollution are high, prompting closure of harvest areas. In this case they are acting as indicators for a wide range of bacterial and viral pathogens that can be difficult to monitor directly.

HOW CAN WE TEST FOR *E. COLI*?

E. coli can be measured through a variety of laboratory techniques that may be either culture based or DNA based. The technique chosen depends on the level of specificity required (i.e. whether you are looking for total *E. coli* or specific strains). DAFF provides different testing methods for general *E. coli*, *E. coli* non-O157 (STEC) and *E. coli* O157:H7.

REGULATORY STANDARDS

The Australian regulatory limit for *E. coli* can be found in Section 1.6.1 of the Australia New Zealand Food Standards Code, available at http://www.foodstandards.gov.au.

International regulatory limits can be found in the Trade & Market Access Database, available at www.frdc.com.au/trade.

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FSANZ. 2013. Shiga toxin-producing *Escherichia coli* (STEC). In: Agents of Foodbourne Illness. 2nd Ed. Food Standards Australia New Zealand, Canberra.

HEPATITIS A VIRUS (HAV)

Hepatitis A virus (HAV) is a human enteric virus which causes acute infectious disease of the liver, known as hepatitis. Hepatitis is a generic term for inflammation of the liver and can also be caused by chemicals, drugs or other viral infections. HAV is a non-enveloped, spherical (approximately 30 nanometers (nm) in diameter), positive stranded RNA virus.

HOW IS HAV TRANSMITTED?

HAV spreads via the faecal to oral route, either by direct contact with a HAV infected person or by ingestion of HAV contaminated food or water.

Foodborne illness accounts for approximately 5% of all HAV cases worldwide. HAV can enter the aquatic environment from septic tank leachates, boat discharges, sewage discharges and people defecating or vomiting into waterways.

Filter feeding bivalve molluscan shellfish can acquire HAV from their aquatic environment. Other seafood products may become contaminated via infected workers during processing if good hygiene practices are not followed.

WHAT SHELLFISH RELATED OUTBREAKS HAVE OCCURRED?

HAV has been widely linked to consumption of contaminated shellfish worldwide. The first documented shellfish related outbreak of "infectious hepatitis" occurred in Sweden in 1955. The most significant shellfish related outbreak of HAV occurred in 1988 in Shanghai, China, resulting in approximately 300,000 cases of illness.

Australia has only reported one shellfish related outbreak of HAV; in 1997 consumption of contaminated oysters from Wallis Lakes, New South Wales, resulted in 444 illnesses, including one death.

WHAT ARE THE SYMPTOMS?

- HAV is an acute illness with moderate onset of symptoms (fever, malaise, anorexia, nausea, abdominal discomfort, dark urine) and jaundice.
- The incubation period of HAV ranges from 15-50 days.
- Illness generally lasts for two months, but can be longer.
- HAV is shed in high quantities in the faeces of infected people two weeks prior to the onset of symptoms, and for at least four weeks during symptomatic infection.
- Effective vaccination against HAV is possible.

HOW MUCH HAV IS A HARMFUL DOSE?

The infectious dose of HAV is low, presumed to be 10-100 virus particles.

WHAT CAN BE DONE TO INACTIVATE OR ELIMINATE HAV?

- Freezing and refrigeration does not significantly reduce viral load in shellfish.
- Depuration is ineffective in controlling viruses in shellfish.
- Pasteurisation of shellfish is unlikely to inactivate HAV.
- Human enteric viruses are very stable at low pH levels. A greater than 3 log10 inactivation of HAV may occur at pH < 3; however, this may render the sensory quality of food unacceptable.
- Ultraviolet (UV) irradiation is ineffective in reducing viral loads in or on food.
- Cooking shellfish at temperatures exceeding 90 °C for greater than 90 seconds is likely to significantly reduce the level of infectious HAV

WHAT CAN BE DONE TO MANAGE HAV IN SEAFOOD?

- Regular sanitary/pollution source surveys of shellfish growing areas to identity potential faecal inputs and manage harvests accordingly.
- Regulation of shellfish harvesting areas to ensure adequate periods of closure following a faecal contamination event.
- Use of extended relay periods to cleanse shellfish grown in poor or unknown water quality.
- Prevention of contamination during processing of seafood through good hygiene and manufacturing practices.

HOW CAN WE TEST FOR HAV?

Only molecular biology (real time RT-PCR) methods are sensitive enough to detect and quantify HAV in shellfish. The limit of detection of the method is approximately 100 genomes per gram of shellfish gut. The method used cannot distinguish between infectious and non-infectious virus particles. Recently an ISO technical specification for the detection of HAV in shellfish was released (ISO/TS15216, 2012).

REGULATORY STANDARDS

There are currently no formal regulatory criteria for HAV. Codex has developed guidelines on how to control viruses in foods, available at http://www.codexalimentarius.org, and testing for HAV following high risk events is recommended.

International regulatory limits can be found in the Trade & Market Access Database, available at www.frdc.com.au/trade.

MORE INFORMATION

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FDA 2012. Bad Bug Book, Foodborne Pathogenic Microorganisms and Natural Toxins, USA, Food and Drug Administration.

Grohmann, G. & Lee, A. 2003. Viruses, Food and Environment. In: Hocking, A. D. (ed.) Foodborne Microorganisms of Public Health Significance. Sixth ed. New South Wales: Australian Institute of Food Science and Technology Inc.

ISO 2012. ISO/TS15216: Microbiology of food and animal feed - Horizontal method for determination of hepatitis A virus and norovirus in food using real-time RT-PCR.

HISTAMINE POISONING

Scombroid food poisoning is caused by ingestion of histamine, a product of the degradation of the amino acid histidine. Histidine can be found freely in the muscles of some fish species and can be degraded to histamine by enzymatic action of some naturally occurring bacteria.

WHICH TYPES OF FISH CAN BE IMPLICATED?

The scombrid fish (*Scombridae*) such as tuna and mackerel are traditionally considered to present the highest risk. However, other species have also been associated with histamine poisoning; e.g. Anchovies, Sardines, Yellowtail Kingfish, Amberjack and Australian Salmon, Mahi Mahi and Escolar.

WHICH BACTERIA ARE INVOLVED?

A variety of bacterial genera have been implicated in the formation of histamine; e.g. *Clostridium*, *Morganella*, *Pseudomonas*, *Photobacterium*, *Brochothrix* and *Carnobacterium*.

WHAT OUTBREAKS HAVE OCCURRED?

In Australia, 38 outbreaks (148 cases) of Histamine poisoning were reported between 1988 and 2010. Many of the outbreaks were associated with Tuna, however other implicated non-scombroid species included Mahi Mahi, Sardines, Escolar, Anchovies and Australian Salmon. Both domestically harvested and imported fish have been implicated with disease. Illnesses occurred from seafood consumed both from restaurants and also from in a home setting.

HOW MUCH HISTAMINE IS A HARMFUL DOSE?

A threshold dose is considered to be 90mg/100g. Although, levels as low as 5-20mg/100g could possibly be toxic, particularly in susceptible individuals.

WHAT ARE THE SYMPTOMS?

Initial symptoms resemble some allergic reactions which include sweating, nausea, headache and tingling or peppery sensation in the mouth and throat.

Other symptoms include urticarial rash (hives), localised skin inflammation, vomiting, diarrhoea, abdominal cramps, flushing of the face and low blood pressure.

Severe symptoms include blurred vision, severe respiratory distress and swelling of the tongue.

WHAT CAN BE DONE TO MANAGE HISTAMINE IN SEAFOOD?

- Histamine levels can increase over a wide range of storage temperatures. However, histamine production is highest over 21.8°C. Once the enzyme is present in the fish, it can continue to produce histamine at refrigeration temperatures.
- Preventing the degradation of histidine to histamine by rapid chilling of fish immediately after death followed by good temperature control in the supply chain is the most appropriate control. Although, a novel strain of Morganella has been demonstrated to possess the ability for growth at 0-2°C. Thus, temperature control may not eliminate risks in all circumstances.

HOW CAN WE TEST FOR HISTAMINE?

- There are several analytical techniques that have been described by the AOAC including: a biological method (AOAC 954.04), a chemical method (AOAC 957.07) and a fluorometric method (AOAC 977.13).
- Commercially available ELISA based kits can be used.
- Histamine concentration can vary considerably between anatomical locations and this should be considered in sampling plans.

REGULATORY STANDARDS

The Australian regulatory limit for histamine can be found in Section 1.4.1 of the Australia New Zealand Food Standards Code, available at http://www.foodstandards.gov.au.

Codex Alimentarius sets decomposition and also hygiene and handling limits for a variety of seafood products including sardines and sardine-type products; canned fish; salted herring and sprat; frozen finfish and products comprised of finfish; crumbed or battered fish and fish portions; boiled dry salted anchovies; and fish sauce.

International regulatory limits can be found in the Trade & Market Access Database, available at www.frdc.com.au/trade.

MORE INFORMATION

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NOROVIRUS (NOV)

Noroviruses (NoV) are small, round (approximately 27-35 nanometers (nm) in diameter), non-enveloped viruses which have a single stranded RNA genome. NoV are very diverse, with over 25 different strains which infect humans. NoV strains are grouped into at least five different genogroups, of which genogroup I, II and IV most commonly infect humans. Human NoV is the leading cause of non-bacterial gastroenteritis worldwide.

Immunity to the virus is often short lived and new pandemics appear every two to three years. No effective vaccine to human NoV is currently available.

HOW IS NOROVIRUS TRANSMITTED?

NoV is highly contagious and spreads via the faecal to oral route. Transmission can be person-to-person, through contaminated surfaces or through consumption of contaminated food and water. Foodborne illness accounts for 12-47% of all NoV cases worldwide.

NoV can enter the aquatic environment via septic tank leachates, boat discharges, sewage discharges and people defecating or vomiting directly into waterways. Once NoV enters the aquatic environment, bivalve shellfish accumulate the viruses through the act of filter feeding.

NoV is accumulated and retained within the digestive tissues of bivalves, persisting in tissues long after bacterial indicators of sewage contamination are detectable. Other seafood products may become contaminated by infected workers during processing if good hygiene practice is not followed.

WHAT OUTBREAKS HAVE OCCURRED?

Between 2001-2010, 17 Australian outbreaks of suspected shellfish related NoV illness were reported to OzFoodNet. Recent Australian outbreaks reported were in:

- 2008 following consumption of oysters from the Kalang River (NSW) causing illness in 40 people; and
- 2013 following consumption of oysters from Tasmania causing illness in over 500 people.

WHAT ARE THE SYMPTOMS?

- The incubation period is 10 – 50 hrs and symptoms generally last 24 – 60 hrs.
- Vomiting (projectile in >50% of cases), stomach cramps, watery non-bloody diarrhoea, abdominal pain, low grade fever (< 50% of cases) and headaches.

- Infected humans excrete high levels of NoV in their faeces (≤1011 virus particles/g faeces) for up to two to three weeks, long after symptoms have ceased.

HOW MUCH IS A HARMFUL DOSE?

The median infectious dose of NoV is estimated to be very low (18 virus particles), although the probability of becoming ill in susceptible individuals is dose-dependent.

WHAT CAN BE DONE TO MINIMISE RISK?

- Freezing and refrigeration does not eliminate NoV.
- Depuration is ineffective in eliminating viruses from shellfish.
- Cooking shellfish at temperatures exceeding 90°C for greater than 90 seconds is likely to significantly reduce the level of infectious NoV, although heating at 60°C for 30 minutes and pasteurisation are not sufficient to eliminate viruses.

WHAT CAN BE DONE TO MANAGE NOROVIRUS IN SEAFOOD?

- Regular sanitary/pollution source surveys of shellfish growing areas to identity potential faecal inputs and manage harvest accordingly.
- Regulation of shellfish harvesting areas to ensure adequate periods of closure following a faecal contamination event.
- Use of extended relay periods to cleanse shellfish grown in poor or unknown water quality.
- Prevention of contamination during processing of seafood through good hygiene and manufacturing practices.

HOW CAN WE TEST FOR NOROVIRUS?

Only molecular biology (real time RT-PCR) methods are able to detect and quantify NoV in shellfish. The limit of detection of the method is approximately 100 viral genomes per gram of shellfish gut. The method used cannot distinguish between infectious and non-infectious virus particles. Recently an ISO technical specification for the detection of NoV in shellfish was released (ISO/TS15216, 2012).

REGULATORY STANDARDS

There are currently no formal regulatory criteria for NoV in Australia. Codex Alimentarius has developed guidelines on how to control viruses in foods, available at http://www.codexalimentarius.org, and testing for NoV following high risk events is recommended.

International regulatory limits can be found in the Trade & Market Access Database, available at www.frdc.com.au/trade.

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OKADAIC ACIDS/DIARRHETIC SHELLFISH POISONS

Okadaic acids (OA) and *Dinophysistoxins (DTXs)* are also known as Diarrhetic Shellfish Toxins (DST's). They are a group of chemically-related lipophilic toxins that can contaminate shellfish and other seafood items and cause acute gastro-intestinal illness in humans, often referred to as diarrhetic shellfish poisoning (DSP).

Pectenotoxin, an unrelated lipophilic toxin that is often detected with OA, is included in DST's for regulatory purposes in Australia, but there is some controversy over its toxicity to humans.

WHAT ARE THE CAUSATIVE ORGANISMS?

DSTs are produced by marine microalgae known as dinoflagellates. In Australia the known causative species are *Dinophysis acuminata*, *D. acuta*, *D. caudata*, *D. fortii* and *Prorocentrum lima*.

These species grow naturally in marine environments. When they are present in significant levels they may cause a hazard in bivalve shellfish as they are further concentrated through filter feeding.

DST producing species are found in all states in Australia at various levels.

WHAT OUTBREAKS HAVE OCCURRED?

Outbreaks of gastro-intestinal illness suspected to have been caused by consumption of pipis (*Plebidonax deltoides*) contaminated by heat-stable toxins have occurred in NSW.

A six-week shellfish harvesting ban was imposed on leases in Smoky Bay, South Australia, after OA toxins were detected following a dinoflagellate bloom in 2003.

A permanent ban on recreational harvesting of pipis from the Ballina area is in place due contamination with OA toxins.

HOW MUCH OKADAIC ACID IS A HARMFUL DOSE?

A dose of about 1 microgram (µg) per kilogram (kg) body weight is thought capable of initiating symptoms of DSP, i.e. around 65µg for a 65kg adult. This equates to 325µg OA per kg flesh in a 200g portion of seafood.

WHAT ARE THE SYMPTOMS?

- Nausea, diarrhoea, vomiting, abdominal pain and headache are the characteristic symptoms.
- Usually resolves by three days following consumption of contaminated shellfish.
- No fatalities have been reported.
- May present a risk of dehydration requiring fluid and electrolyte replenishment, particularly in young children or the elderly.
- *Okadaic acid* is a potent tumour promoter, which raises concerns about the possibility of harmful effects from chronic, low-dose exposure. Such exposures are difficult to measure, so the concerns of public health agencies are currently directed toward concentrations of OA in shellfish that cause acute gastro-intestinal illness.

WHAT CAN BE DONE TO MANAGE DSTS?

- Commercial shellfish production in Australia requires adherence to algal biotoxin management plans to control this hazard. Detection in shellfish product of DSTs that exceed regulatory compliance levels results in mandatory closure of fisheries until toxin concentrations return to safe levels.
- Relaying shellfish to uncontaminated areas may facilitate the elimination of DSTs, but should be confirmed with chemical and/or biological testing.
- Public health authorities may caution or restrict recreational shellfishing when waters are affected by toxic microalgal blooms.
- DSTs are heat-stable, so cooking will not deactivate them.

HOW CAN WE TEST FOR DSTS?

- Monitoring source water samples by microscopy to detect the presence of potentially toxic dinoflagellates.
- Monitoring seafood tissues for DSTs either via antibody-based screening test kits or confirmatory chemical testing conducted by specialist analytical laboratories.

REGULATORY STANDARDS

The Australian Food Standard maximum limit for DST in bivalve molluscs is 200 micrograms OA equivalence per kg, available at http://www.foodstandards.gov.au. State food safety regulators may apply this limit in the case of other seafood products found to be contaminated with DSTs. International regulatory limits for DSTs vary. some countries may not include pectenotoxin, or may also have limits for *Azaspiracid*, *Yessotoxin* and *Gymnodimine* – related algal toxins that do not cause diarrhoea.

International regulatory limits can be found in the Trade & Market Access Database, available at www.frdc.com.au/trade.

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PARALYTIC SHELLFISH POISONS (SAXITOXINS)

Saxitoxins (STXs) are a group of chemically-related neurotoxins produced by a group of marine microalgae known as dinoflagellates. The term "paralytic shellfish poisoning (PSP)" was coined to describe the illness and deaths caused by eating contaminated shellfish. Saxitoxins have also been found in fish, crustaceans, cephalopod molluscs and ascidians, as well as a wide range of filter-feeding, herbivorous and carnivorous gastropods.

WHAT ARE THE CAUSATIVE ORGANISMS?

In Australia the known causative dinoflagellates are from the *Alexandrium genus* (most commonly *A. catenella*, *A. minutum*, *A. ostenfeldii* and *A. tamarense*) and *G ymnodinium catenatum*.

These species grow naturally in marine environments. When they are present in significant levels they may enter the tissues of marine animals, mainly through feeding behaviours. Being water soluble, STXs tend to be found more in filter-feeders and planktivores, but lower-level carnivores may bioaccumulate STXs at levels that can be hazardous to humans. Bivalve shellfish present the greatest risk. STXs have been recorded from Tasmania, Victoria, South Australia and New South Wales.

WHAT OUTBREAKS HAVE OCCURRED?

Toxic blooms and associated seafood product contamination has resulted in considerable economic disruption to affected industries.

Fortunately, Australia's regulatory oversight seems to have been largely effective to date, as there are only a few anecdotal and case reports of relatively mild human illness, all from non-commercial harvests.

In Tasmania in 2011, one male was hospitalised following consumption of mussels.

Several anecdotal cases exist from the consumption of Tasmanian mussels during extensive blooms in 1986 and 1993.

HOW MUCH SAXITOXIN IS A HARMFUL DOSE?

A dose of about 1.5 micrograms of STX equivalents per kilogram body weight is thought capable of initiating symptoms of saxitoxin poisoning, i.e. around 100 micrograms for a 65 kg adult. This equates to 500 micrograms STX equivalents per kg seafood in a 200g portion.

Note that this dose is a topic of some controversy amongst expert groups. It is calculated from published reports of mild symptoms of STX poisoning in individuals who may be particularly sensitive to the toxin/s, and is lower than the concentration of saxitoxins currently mandated as the safety level in Australia and most other countries. The current regulatory level has been in operation for many decades, with a long history of protecting public health from STXs in commercial shellfish.

WHAT ARE THE SYMPTOMS?

- STXs block nerve conduction, manifesting as respiratory distress due to partial paralysis of the muscles necessary for breathing.
- Mild neurological symptoms encompass tingling or numbness around the lips or in fingers and toes (paraesthesias), sensations of floating or weightlessness (dysaesthesias), or gastrointestinal upset (nausea, vomiting, diarrhoea, gut pains).
- More severe poisoning may present with functional weakness (impaired grip strength, staggering gait), difficulty breathing and signs of acute respiratory insufficiency, e.g. cyanosis of the lips or fingernails.
- Severe STX intoxication can cause catastrophic acute respiratory failure and death by asphyxiation.

WHAT CAN BE DONE TO MANAGE SAXITOXINS IN SEAFOOD?

Shellfish production in Australia requires adherence to algal biotoxin management plans to control this hazard. Each state monitors commercial shellfish areas for toxic algae in the water and/or toxins in the shellfish. Detection of either factor above compliance levels results in mandatory closure of fisheries until toxin concentrations return to safe levels.

Relaying shellfish to uncontaminated areas may facilitate the elimination of STXs, but should be confirmed with chemical and/or biological testing.

Avoid consumption of crustacean tomalley ("mustard") during bloom events as crustaceans are known to concentrate STXs in the hepatopancreas.

Public health authorities may caution or restrict some commercial and recreational fishing activities when waters are affected by toxic microalgal blooms.

HOW CAN WE TEST FOR SAXITOXINS?

- Monitoring source water samples by microscopy to detect the presence of potentially toxic dinoflagellates.
- Monitoring seafood tissues for STX either via antibody-based screening test kits or confirmatory chemical testing conducted by specialist analytical laboratories.

REGULATORY STANDARDS

The Australian regulatory limit for STX in bivalve molluscs is 800 micrograms STX equivalents per kg, available at http://www.foodstandards.gov.au. State food safety regulators usually apply this limit in the case of other seafood products found to be contaminated with STXs.

International regulatory limits can be found in the Trade & Market Access Database available at www.frdc.com.au/trade.

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SALMONELLA

Salmonella are facultative anaerobic, non-sporulating, Gram negative bacteria. The genus *Salmonella* consists of the two species *Salmonella* enterica and *Salmonella bongori*. *S. enterica* has six subspecies and 1,500 serotypes. *S. enterica* is a frequently reported cause of foodborne illness, occurring in both food poisoning-triggered epidemics and in isolated cases.

HOW IS *SALMONELLA* TRANSMITTED?

Salmonella are widely distributed in nature and can enter the aquatic environment, food and water through animals, domestic stock, poor sanitation and inappropriate disposal of human and animal wastes.

Salmonella-related gastroenteritis has been frequently linked with the consumption of contaminated fresh produce, raw meats, poultry, eggs and dairy products.

A small number of outbreaks have been associated with seafood. The presence of *Salmonella* in seafood may derive from contamination occurring in the natural aquatic environment, in aquaculture or during processing and storage.

WHAT OUTBREAKS HAVE OCCURRED?

In Australia, only five outbreaks including 60 cases have been reported in relation to the consumption of seafood.

Salmonella have been identified as a cause of seafood related outbreaks in the European Union, the United Stated and in other countries. The US FDA has demonstrated the presence of *Salmonella* in a variety of fish and shellfish, including ready- to-eat seafood products, seafood products requiring minimal cooking and shellfish eaten raw.

HOW MUCH IS A HARMFUL DOSE?

The infectious dose of *Salmonella* varies with both serotype and the contaminated food matrix.

Human trials suggest approximately 105 colony forming units are required to infect healthy adults.

WHAT ARE THE SYMPTOMS?

S. enterica predominantly causes two distinct diseases:

- Gastroenteritis or "food poisoning" caused by non-typhoidal *Salmonella* serotypes. It is characterised by sudden nausea, vomiting, abdominal cramps, diarrhoea, headache, chills and fever. The symptoms can be mild to severe and may last between 5-7 days.
- Typhoid fever is caused by *S. enterica* Typhi and Paratyphi, which only occurs in humans. If untreated, the fever can last for weeks; however, with antimicrobial treatment patients recover within 10-14 days. Effective vaccination against typhoid fever is possible.

WHAT CAN BE DONE TO INACTIVATE OR ELIMINATE *SALMONELLA*?

Salmonella can be killed by exposure to :

- ≥60°C for 4-6 minutes,
- ≥30% NaCl (salt) concentration,
- Water activity of below 0.94,
- pH of less than 3.8, although this is dependent on the type of acid used,
- A high concentration of chlorine. It has been found thatthis can achieve a 1 – 2.5 log10 reduction in colony units per gram of food, and;
- Irradiation, although effectiveness is dependent on food product and the level of pathogen contamination.

WHAT CAN BE DONE TO MANAGE *SALMONELLA* IN SEAFOOD?

- Good manufacturing practice.
- Good hygiene practice.

HOW CAN WE TEST FOR *SALMONELLA*?

There are several testing methods for *Salmonella* in foods. The recommended methods are based on the International Standard (ISO 6579) and Australian Standard (AS 5013.10-2009).

REGULATORY STANDARDS

The Australian regulatory limit for salmonella can be found at Food Standard 1.6.1 (http://www.foodstandards.gov.au/).

International regulatory limits can be found in the Trade & Market Access Database available at www.frdc.com.au/trade.

MORE INFORMATION

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STAPHYLOCOCCUS AUREUS

Staphylococcus spp are ubiquitous in the environment and can be found in food due to environmental, human and animal contamination.

S. aureus is a Gram-positive, non-motile, spherical (cocci) shaped, non-spore forming bacterium that is responsible for almost all staphylococcal food poisoning. *S. aureus* can grow under aerobic and anaerobic conditions, but is a poor competitor and is often outcompeted by other microorganisms. *S. aureus* is a versatile human pathogen capable of producing highly heat-stable enterotoxins that can cause gastroenteritis.

WHAT FOODS ARE MOST AT RISK?

Foods that require extensive handling during preparation and are kept above refrigeration temperature (4°C) for extended periods after preparation have an increased risk.

WHAT OUTBREAKS HAVE OCCURRED?

Since 2001, there has been only one reported outbreak involving three cases of staphylococcal food poisoning that was linked to seafood consumption. This outbreak occurred in 2006 and was associated with the consumption of sushi rolls.

HOW MUCH *S. AUREUS* IS A HARMFUL DOSE?

Staphylococcal enterotoxins are produced during the exponential growth phase of *S. aureus*. The intoxication dose of the enterotoxins is less than 1.0 microgram. This toxin level is typically reached when *S. aureus* populations exceed 105-108 colony forming units per gram of food. However, in susceptible individuals (young children, the elderly and severely debilitated) ingestion of 0.1-0.2 micrograms of enterotoxins is sufficient to cause symptoms.

WHAT ARE THE SYMPTOMS?

The onset of staphylococcal symptoms are usually rapid (1-7 hours after ingestion) and in many cases acute. Symptoms commonly include:

- Nausea, abdominal cramping, vomiting and diarrhoea.
- In more severe cases, dehydration, headache, muscle cramping, and transient changes in blood pressure and pulse rate may occur.
- The duration of illness usually lasts from only a few hours to one day; however in some instances, hospitalisation may be required.
- Fatalities from staphylococcal food poisoning are rare in the general population but have been reported from other countries.

WHAT CAN BE DONE TO MANAGE *S. AUREUS*?

- Prevention of contamination during processing by good manufacturing practice (e.g. wearing gloves and proper personal protection), good personal hygiene and proper sanitisation of food contact surfaces and utensils.
- Avoid time and temperature abuse of food products, especially those that require considerable handling during preparation.

HOW CAN WE TEST FOR *S. AUREUS*?

Enumeration of *S. aureus* by enrichment isolation, or selective enrichment isolation, may be achieved by using either:

- The Australian Standard direct plate count (AS 5013.12.1- 2004). The direct plating method is suitable when *S. aureus* is expected to be greater than 100 colony forming units per gram of food.
- The Australian Standard most probable number (AS 5013.12.3-2004). The most probable number procedure is recommended for surveillance of products expected to have a small population of *S. aureus* and a large population of competing organisms.

REGULATORY STANDARDS

Australian regulatory limit for *S. aureus* can be found in Section 1.6.1 of the Australia New Zealand Food Standards Code, available at http://www.foodstandards.gov.au.

International regulatory limits can be found in the Trade & Market Access Database, available at www.frdc.com.au/trade.

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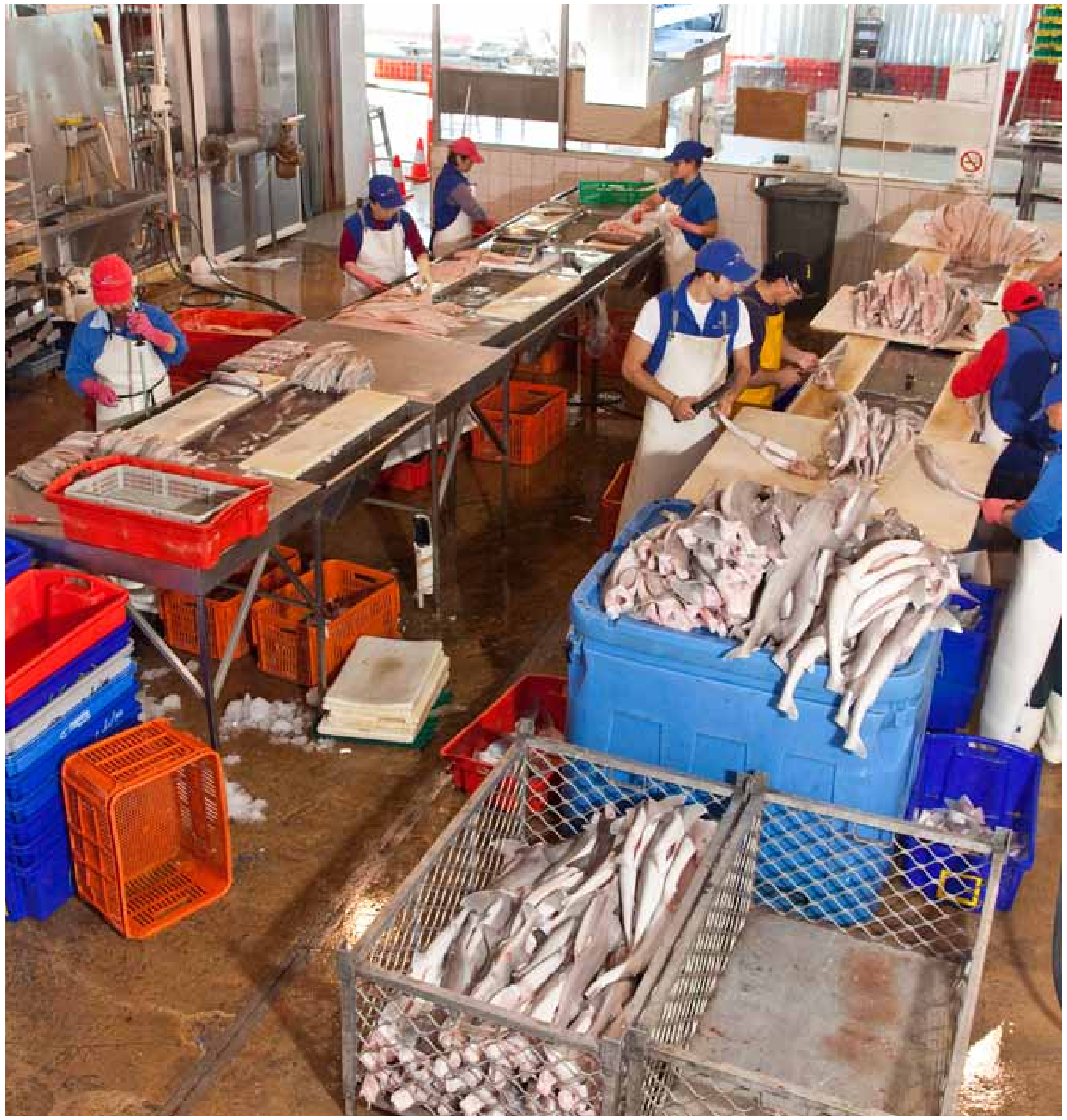

TOXIC METALS

WHAT IS ARSENIC?

Arsenic is present in seafood mostly as an organic form, which is much less toxic than inorganic. Arsenic is a recognised human carcinogen.

WHAT IS CADMIUM?

Cadmium is widely distributed in the environment, and can be found in many food items, including some seafood products. Cadmium is a carcinogen and is toxic to the kidneys.

WHAT IS MERCURY?

Mercury in organic form, particularly methylmercury, is of greatest concern to public health. Methylmercury is fat-soluble, and therefore tends to be found in higher concentrations in large carnivorous fish such as shark, swordfish and some tuna. Methylmercury has harmful effects on the development of brain, so pregnant women and children are the main focus of seafood safety interventions.

WHAT IS LEAD?

Lead causes harmful effects on the kidneys and nervous system. Children are particularly sensitive to the neurotoxic effects of inorganic lead because the blood-brain barrier is underdeveloped. Dietary exposure to lead occurs through a wide range of foods and beverages; some seafood products can contribute to lead intake.

WHAT OUTBREAKS HAVE OCCURRED?

Toxic metals are rarely found in seafood at concentrations likely to cause outbreaks of acute illness. Adverse human health effects arise from repeated, cumulative low-dose exposures from a wide range of dietary and non-dietary sources, of which seafood consumption may in some cases be a significant contributor.

HOW MUCH TOXIC METAL IS A HARMFUL DOSE?

Doses of toxic metals from seafood consumption alone are unlikely to cause acute illness. Harmful concentrations of specific metals in particular food items are assessed by food safety authorities based on information relating to typical consumption patterns and the known chronic health effects of exposure from dietary and other sources.

WHAT ARE THE SYMPTOMS?

Overt signs and symptoms of acute metal poisoning are unlikely to be attributable to consumption of seafood alone. Foetal and childhood exposure to methylmercury and/or lead may manifest as subtle but measureable dose-related cognitive impairment.

Long-term excess exposure to particular toxic metals, from all sources (dietary and non-dietary), can cause:

- Chronic renal failure, cancers of the breast, prostate and uterus, and bone disease – osteoporosis, osteomalacia and spontaneous fractures – associated with chronic cadmium poisoning; and
- Cancers of the skin, lungs, bladder and kidney, and chronic skin diseases – hyperkeratosis and dyspigmentation – associated with chronic arsenic poisoning.

WHAT CAN BE DONE TO MANAGE TOXIC METALS IN SEAFOOD?

- Metals in seafood tissues cannot be destroyed by cooking or processing.
- Fish meal is the principal source of toxic metals in farmed fish; alternative fish feeds produced from vegetable sources can considerably reduce fillet loads of arsenic and mercury.
- Toxic metals accumulate preferentially in crustacean hepatopancreas, so processes and/or advisories to eliminate or reduce consumption of crab, lobster or prawn "mustard" may be considered.
- Toxic metals may be present at high levels in some estuarine, coastal and marine waters and food webs from both natural and human-associated sources. Public health authorities may place controls or advisories around the collection of seafood, particularly shellfish and bottom dwelling fish, from these areas.

HOW CAN WE TEST FOR TOXIC METALS?

Modern chemical methods can accurately detect and quantify a range of toxic metals in seafood and water; several analytical laboratories offer these services. Inductively coupled plasma-mass spectrometry is one of the more widely adopted methods.

REGULATORY STANDARDS

National and international food safety agencies monitor and regulate specific seafood products for toxic metal levels. Maximum allowable levels in Australia vary for different seafoods and can be found at http://www.foodstandards.gov.au.

International regulatory limits can be found in the Trade & Market Access Database, available at http://www.frdc.com.au/ trade.

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VIBRIO

Vibrio are naturally occurring marine bacteria that is found in most aquatic environments. Some species of this bacterial group are known to cause human illness.

WHICH SPECIES ARE HARMFUL TO HUMANS?

Although the majority of *Vibrio* species are considered non-pathogenic to humans, some have been associated with human illness. The three species widely regarded to be associated with human illness are: *Vibrio parahaemolyticus*, *V. vulnificus* and *V. cholera*. Several other species have also been associated with illness, either at a lower frequency or with less conclusive evidence:

- *V. alginolyticus,*
- *V. carchariae,*
- *V. cincinnatiensis,*
- *V. damsel,*
- *V. fluvialis,*
- *V. furnissii,*
- *V. hollisae,*
- *V. metschnikovii* and
- *V. mimicus*.

WHAT TYPES OF ILLNESS CAN OCCUR?

There are three distinct syndromes that can occur from *Vibrio* infections: gastrointestinal illness, septicaemic infection and wound infections. The latter is not associated with consumption of seafood.

WHAT OUTBREAKS HAVE OCCURRED?

Illnesses associated with *Vibrio* contaminated seafood are rare in Australia. A total of 5 cases associated with bivalve shellfish have occurred between 1992 and 2013. One of these cases resulted in a mortality from *V. parahaemolyticus*. The remaining four cases were associated with *V. vulnificus* and two of these patients died.

Two large outbreaks of *V. parahaemolyticus* (1990 and 1992) were associated with imported prawns.

HOW MUCH IS A HARMFUL DOSE?

- Approximately 106 cells of *V. cholera* in healthy adults.
- Approximately 2 x 105 - 3 x 107 cells of *V. parahaemolyticus* in healthy adults.
- The dose of *V. vulnificus* for healthy people is unknown, but in at risk groups (see susceptible individuals below) it may be less than 100 cells.

WHAT ARE THE SYMPTOMS OF *V. PARAHAEMOLYTICUS* ASSOCIATED WITH THE CONSUMPTION OF SEAFOOD?

- Severe gastrointestinal illness including diarrhoea, which can sometimes be bloody, abdominal pains, nausea and vomiting.
- Occasional septicaemic infection, only rarely associated with mortality.

WHAT ARE THE SYMPTOMS OF *V. VULNIFICUS* ASSOCIATED WITH THE CONSUMPTION OF SEAFOOD?

- Primary septicaemia with symptoms of fever chills and nausea may occur in susceptible individuals e.g. immuno-compromised and can result in mortality.
- Gastroenteritis, which presents as vomiting, diarrhoea and abdominal pains.

WHAT ARE THE SYMPTOMS OF *V. CHOLERA* (NON O1/O139) ASSOCIATED WITH THE CONSUMPTION OF SEAFOOD?

- Diarrhoea (bloody) and abdominal cramps.
- Fever, and although rarer in occurrence, septicaemia can also develop in compromised individuals.

WHICH SEAFOOD CAN BE CONSIDERED VECTORS?

- Bivalve shellfish (*V. parahaemolyticus* and *V. vulnificus*).
- Prawns/shrimp (*V. cholerae*).
- Finfish (*V. parahaemolyticus*).

WHAT INCREASES THE RISK?

- Post-harvest temperature abuse throughout the supply chain can allow the growth of these pathogens in the seafood to levels associated with illness.
- Susceptible individuals (the immuno-compromised, those who suffer from liver disease and/or have excess levels of iron in the blood serum) are at a greatly increased risk of septicaemia.
- Harvesting of seafood from areas of lower salinity can present a higher risk.
- In Australia, the prevalence of *Vibrio* species is not well understood, and the relationship between temperature and salinity has not been explored.

WHAT DECREASES THE RISK?

- The Australian Shellfish Quality Assurance Program Operations Manual sets maximum storage temperatures for live bivalves post-harvest to control the growth of indigenous pathogens. Shell stock must be placed under ambient refrigeration at 10°C or less within 24 hours of harvest or depuration. Under the NSW Shellfish Industry Operations Manual, Sydney Rock Oysters must be stored at 25°C or less within 24 hours of harvest and at 21°C or less within 72 hours of harvest.
- *Vibrios* are highly susceptible to heat. Heating to greater than 65°C will inactivate pathogenic strains.
- Appropriate adherence to regulatory temperature controls is the best preventative measure.
- Depuration is not effective in removing *Vibrio* from bivalve shellfish.

HOW CAN WE TEST FOR *VIBRIO*?

- Microbiological analysis using selective media.
- Identification of isolates by biochemical phenotype or Polymerase Chain Reaction (PCR).
- PCR detection direct from enrichment cultures.

REGULATORY STANDARDS

There is no standard set for *Vibrio* in the Australia New Zealand food standards code. limits are set by several countries including (but not limited to) Canada, China, India, Japan, Thailand the United States of America.

International regulatory limits can be found in the Trade & Market Access Database, available at www.frdc.com.au/trade.

MORE INFORMATION

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WAX ESTERS

Wax esters are fatty acid components of certain types of fish. Wax esters are indigestible by humans and cause a condition known as steatorrhoea or, more specifically, keriorrhoea, in which anal leakage of an oily residue occurs, sometimes accompanied by abdominal cramping, nausea and vomiting.

WHAT FISH SPECIES ARE WAX ESTERS FOUND IN?

Wax esters are found in the fats of certain types of fish, and in particular Escolar (*Lepidocybium flavobrunneum*) and Oilfish (*Ruvettus pretiosus*). These two species contain very high proportions of indigestible wax esters.

Fish mislabelling and misidentification has led to instances where Escolar or Oilfish have been incorrectly or fraudulently sold in Australia under different names, such as Butterfish and Rudderfish. Escolar has been sold in other countries under names such as Sea Bass, Cod, White Tuna and Hawaiian Butterfish.

WHAT OUTBREAKS HAVE OCCURRED?

Reported outbreaks from consumption of wax esters are infrequent in Australia. One outbreak was reported from New South Wales in 2001, where delegates at a conference consumed mislabelled Escolar for lunch. Of the 44 delegates interviewed by public health officers, 20 reported symptoms. Other cases and outbreaks have been reported from Victoria and South Australia.

HOW MUCH WAX ESTER IS A HARMFUL DOSE?

A single meal of Escolar or Oilfish is sufficient to cause gastro-intestinal symptoms.

WHAT ARE THE SYMPTOMS?

- Oily diarrhoea is caused by accumulation of indigestible fish oils in the rectum before being expelled, often involuntarily.
- Symptoms are not life-threatening, and the diarrhoea caused by wax ester consumption does not result in dehydration or electrolyte imbalance.
- Severity ranges from a painless discharge of oily yellow, orange or green liquid to more intense diarrhoea, nausea, vomiting and abdominal cramping.
- Symptom onset ranges from hours to days following a single exposure.

WHAT CAN BE DONE TO MANAGE WAX ESTERS IN SEAFOOD?

- Cooking does not destroy or degrade wax esters. Some agencies recommend grilling in order to separate oils from the flesh, but others dispute such advice, suggesting that water loss from grilling or baking can concentrate the oil content.
- Addressing the issue of fish mislabelling, misidentification and substitution is an important management intervention.

HOW CAN WE TEST FOR WAX ESTERS?

- A rapid and inexpensive chemical test for detecting wax esters in fish has been developed overseas and could be adopted by Australian laboratories.
- DNA barcoding can confirm the identity of fish species in cases where the provenance is uncertain or disputed.

REGULATORY STANDARDS

There is no regulation against the sale of Escolar or Oilfish in Australia. Some state authorities, e.g. Queensland, recommend a health warning about the risks of consuming these fish is displayed at the point of sale.

Regulatory intervention is highly variable internationally. Escolar and Oilfish are prohibited for import and sale in Japan, Italy and South Korea. Other countries do not regulate these fish.

Requirements for veracity and integrity in product labelling represent more widely-adopted regulatory practices that can impact on the sale of Escolar or Oilfish.

International regulatory limits can be found in the Trade & Market Access Database, available at www.frdc.com.au/trade.

MORE INFORMATION

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CONSIDERING THE BENEFITS AND RISKS OF SEAFOOD CONSUMPTION

Eating seafood confers many benefits: it provides top-quality protein, and is an excellent source of important nutrients like iodine, selenium, vitamins A and D, and long-chain polyunsaturated omega-3 fatty acids. However like all foods, some seafood products may contain substances that are harmful to health.

Illness from seafood is rare, so the benefits of seafood consumption must be weighed against the risks. For most people, following the recommended national dietary guidelines is the best means of balancing risks and benefits. For some groups such as pregnant women and children, specific advisories on healthy and safe seafood choices should apply.

For more information, please see: http://www.nap.edu/catalog/11762/seafood-choices-balancing-benefits-and-risks and http://www.foodstandards.gov.au/

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