FOOD STANDARDS Australia New Zealand
Te Mana Kounga Kai – Ahitereiria me Aotearoa

Imported food risk statement

Melon (whole) and *Salmonella* spp.

Scope: Whole melons (including, but not limited to, rockmelon (cantaloupe), watermelon, honeydew melon)

Recommendation and rationale

Do *Salmonella* spp. in imported whole melons present a potential medium or high risk to public health:

☑ *Yes*

☐ *No*

Rationale:

- *Salmonella* spp. can be very infectious and cause incapacitating but not usually life threatening illness. Sequelae can occur but are rare.
- There is strong evidence that *Salmonella* spp. have caused foodborne illness associated with consumption of melons sold whole.
- The method of production and processing can introduce contamination, and there is also the potential for post-processing contamination to occur. Whole melons do not undergo a pathogen elimination step prior to consumption.
- Growth of *Salmonella* spp. can occur on both smooth and netted melon rind , i.e. on the outside of whole melon, but growth is not supported at refrigeration temperatures.
- Current evidence supports a higher risk from *Salmonella* spp. to be associated with whole melons specifically with a netted and/or rough surface, or from melons grown on the ground regardless of surface type. However, all melons are susceptible to *Salmonella* contamination during primary production and processing and can support the growth of *Salmonella* both on the rind and in the flesh above refrigeration temperatures.

General description

Nature of the microorganism:

Salmonella spp. are facultative anaerobic Gram-negative, non-spore forming rod-shaped bacteria belonging to the *Enterobacteriaceae* family. The genus *Salmonella* is divided into two species: *S. enterica* (comprising six subspecies) and *S. bongori,* with over 99% of infections in humans caused by *S. enterica* subsp. *enterica* (Bell and Kyriakides 2002; Crum-Cianflone 2008). Over 2,500 serotypes of *Salmonella* spp. have been identified, which differ in their reservoir, host, growth characteristics and the severity of disease they cause. Some serotypes are host-specific, some are host-adapted, while others, such as *S.* Typhimurium, have a broad host range (Jay et al. 2003; Wallis 2006). *Salmonella* spp. colonise the intestinal tract of warm and cold-blooded vertebrates including livestock, wildlife and humans and also live in the surrounding environment (FSANZ 2013). *Salmonella* spp. are transmitted by the faecal-oral route, through consumption of contaminated food and water or from direct contact with infected people and animals (Jay et al. 2003).

Growth of *Salmonella* spp. can occur at temperatures ranging between 5.2–46.2°C, pH of 3.8–9.5 and a minimum water activity of 0.93 when other conditions are near optimum. The minimum pH for growth is dependent on temperature, presence of salt, nitrite and the type of acid present. *Salmonella* spp. can survive for months or even years in foods with a low water activity (ICMSF 1996; Podolak et al. 2010).

Adverse health effects:

Salmonella spp. cause incapacitating but rarely life threatening illness of moderate duration. Sequelae can occur but are rare. People of all ages are susceptible to salmonellosis, however, the elderly, infants and immunocompromised individuals are at a greater risk of infection and generally have more severe symptoms (FSANZ 2013).

Salmonellosis symptoms include abdominal cramps, nausea, diarrhea, mild fever, vomiting, dehydration, headache and/or prostration. Onset of illness is typically 24–48 hours after exposure to an infectious dose (range of 8–72 hours) and usually lasts for 2–7 days. Severe disease such as septicemia sometimes develops, predominantly in immunocompromised individuals. A small number of individuals develop sequelae such as reactive arthritis, appendicitis, meningitis or pneumonia as a consequence of infection. The fatality rate for salmonellosis is generally less than 1% (FDA 2012; FSANZ 2013).

The particular food matrix and strain of *Salmonella* spp*.* influence the level of *Salmonella* spp. required to cause illness. As few as one to 100 cells has been reported to cause illness. However, in most cases, significantly more cells are required for illness to occur (FDA 2012; ICMSF 1996).

Consumption patterns:

2.8% of children (2-5 years),   1.7% of children (aged 6–16 years), 2.3% of adults (aged 17–69 years) and 3.5% of people aged 70 and above reported consumption of fresh rockmelon from all sources (peeled, raw, and in mixed foods).

Further, the mean amount of rockmelon consumed by both age groups of children is significantly higher than for the other age classes (6.8/3.2 compared to 1.6/1.5 g/kg bw/day respectively for single and mixed foods).

6.8% of children (2-5 years), 4.3% of older children (6-16 years), 2.7% of adults (aged 17–69 years) and 1.9% of people aged 70 above reported consumption of fresh watermelon (peeled and raw as a single item). Watermelon was less frequently consumed as a mixed food with <2% reported consumption across all age groups. Overall, 8.2% of children (2-5 years), 6.0% of older children (6-16 years), 4.3% of adults (aged 17–69 years) and 3.4% of people aged 70 above reported consumption of fresh watermelon.

Further, the mean amount of watermelon consumed by both age groups of children is significantly higher than for the other age classes (5.4/4.7 compared to 1.8/1.4 g/kg bw/day respectively for single and mixed foods).

Honeydew melon was the least consumed of the specified melons with <1% of children (2-5 years), <1% of older children (6-16 years), 1.2% of adults (aged 17–69 years) and 1.5% of people aged 70 above reporting consumption (peeled and raw as a single item or as part of a mixed food item). No significant difference was noted in the amount consumed (g/kg bw/day), however this may be due to lower number of people reporting consumption of honeydew melon.

Data is from the 2011–12 Australian National Nutrition and Physical Activity Survey (ABS 2014). The reported percentages are based on a single day of consumption information from the above survey, and do not indicate the frequency of consumption of fresh melon.

Risk factors and risk mitigation:

The safety of all melon varieties relies on a consistent and well managed through-chain, multi-hurdle approach to minimise risk (FSANZ 2021). There are multiple sources and routes of melon contamination in the supply chain from primary production to the point of sale. To minimise contamination of melons with *Salmonella* spp., effective control measures are necessary during primary production and processing. This involves the application of Good Agricultural Practices (GAP) on-farm, Good Hygienic Practices (GHP) throughout the supply chain, and Good Manufacturing Practices (GMP) as well as controlling inputs through-chain (Bowen et al. 2006; Codex 2017; FSANZ 2021; Singh 2019).

Key factors that contribute to contamination are the proximity of melons to soil during production and their netted rough skin. Melon ring ground spots have been demonstrated to have significantly greater microbial population than other areas of the rind, and may therefore be more susceptible to microbial contamination (Codex 2017). Melons which are grown on the ground are therefore at a higher risk for *Salmonella* contamination than those grown suspended above the ground.

Other risk factors during primary production of all melons including the quality of water used for irrigation and application of water-soluble agricultural chemicals; use of untreated, inadequately treated or re-contaminated manure as fertiliser; animal intrusion; and environmental factors, such as site location and extreme weather events (e.g. dust storms and heavy rainfall). Risk can be managed by application of GAP, including the use of water of suitable quality (e.g. clean or potable water for application of agricultural chemicals and direct contact irrigation water); minimising contact of melons with soil, soil amendments[1] and irrigation water (i.e. use of sub-surface or drip irrigation rather than overhead irrigation); proper management of fertiliser storage and treatment facilities; knowledge of previous land use; minimising wildlife access to the growing field; and the use of windbreaks to provide a buffer between wind and crops (Codex 2017; FSANZ 2021; Singh 2019).

When melons are harvested, a stem scar is left on the fruit and this may provide a route for the entry of foodborne pathogens. Svoboda et al. (2016) and others have noted that the watermelon rind, although considered smooth, can suffer damage to the waxy coating during production and harvesting, allowing ingress of surface contaminants to the pulp where growth can occur. Post-harvest handling practices should therefore be implemented to minimise stem scar and rind infiltration of foodborne pathogens into the edible portions of melon flesh, such as during washing operations (Codex 2017).

[1] Physical, chemical and biological materials added to the soil to improve the health, nutrition and crop productivity of the soil, e.g. inorganic fertilisers, manure and compost Singh (2019).

During the washing procedure there is the risk of internalisation of pathogens, with greater temperature differences between the fruit and wash water more likely to result in the fruit absorbing water from the surrounding environment. Ideally melons should be pre-cooled prior to washing and sanitising to reduce the temperature differential (Bowen et al. 2006; FSANZ 2021; Singh 2019). Potable water containing a sanitiser (e.g. chlorine) should be used to wash the melons, and the sanitiser must be effective and at an appropriate concentration. Melons may have smooth or netted rind surfaces; microbial pathogens more easily adhere to the latter, survive and become more difficult to eliminate during post-harvest practices (Codex 2017). Pathogens may then transfer from rind to the pulp or flesh of melons during handling (Vadlamudi et al. 2012). Whole netted or rough surfaced melons are more often associated with *Salmonella* outbreaks than smooth rind melons. Several different chemical sanitisers have been shown to be effective against foodborne pathogens including *Salmonella* (Svoboda et al. 2016). Potable water should also be used for fungicide treatment (Singh 2019). Post-harvest, melons can also be contaminated by *Salmonella* spp. present in niche sites such as processing equipment during processing, packing and storage (Huang et al. 2015). Melons should be cooled following processing, and the cool chain maintained throughout distribution, to reduce the potential for internalisation during washing and sanitising, and prevent or slow the growth of pathogens on the flesh or on the rind of melons (FSANZ 2021; Singh 2019). Also, adequate sanitation and handwashing facilities should be available for staff harvesting melons in the field, and for staff handling melons in packing facilities. A well-designed environmental monitoring program can reduce the risk of pathogens colonising the processing environment and subsequently contaminating produce (Singh 2019).

Melons have been demonstrated to support the growth of *Salmonella* spp., both on the rind and in the flesh above refrigeration temperatures (FSANZ 2021, Feng et al. 2017). For instance, experimental studies have shown that at temperatures of 19-37°C, *Salmonella* spp. can grow on the rind of netted melons and also the smooth waxy surface of canary melons at temperatures ≥15°C (Annous et al. 2004; Beuchat and Scouten 2004; Scolforo et al 2017). If the rind of whole melons are damaged, the flesh has been demonstrated to support the growth of *Salmonella* spp. at similar rates for both rockmelon and watermelon (Golden et al. 1993; Li et al. 2013; Penteado and Leitão 2004). However at refrigeration temperatures, although *Salmonella* spp. can survive on melon rind and the flesh, growth of *Salmonella* spp. is not supported (Annous et al. 2004; Beuchat and Scouten 2004; FSANZ 2021, Feng et al. 2017). Due to the physical similarities between different types of melons, it is likely that *Salmonella* spp. may be able to survive and grow on the rind and within the pulp of other types of melons.

Melons are generally consumed without further processing treatment that would eliminate or inactivate pathogens if present (Codex 2017).

Public information for vulnerable populations to avoid consumption of foods that supports the growth of *Salmonella* is available on various government websites including the FSANZ website.

Surveillance information:

Infection with *Salmonella* spp. is a notifiable disease in all Australian states and territories. In 2021 the reported incidence rate was 41.7 cases per 100,000 population (10,731 cases), this includes both foodborne and non-foodborne cases[2]. The foodborne rate is estimated to be 72% (90% Crl 53-86%) for domestically acquired *Salmonella*, non-typhoid cases in Australia (Kirk et al. 2014). The previous five year mean reported incidence rate was 60.1 cases per 100,000 population per year (ranging from 46.9–73.8 cases per 100,000 population per year)[2]. It is anticipated that the global coronavirus disease pandemic would have contributed to the decrease in reported cases in 2021, due to very limited overseas travel (i.e. minimal cases of salmonellosis acquired overseas) and potentially less people seeking medical care.

The most common *Salmonella* serovar identified in Australia in 2016 was *S*. Typhimurium (38% of cases) with a large range of other serovars accounting for the remaining cases (OzFoodNet 2021).

Illness associated with consumption of melon sold whole contaminated with *Salmonella* spp.

A search of the scientific literature from January 2000 to October 2022 via EBSCO; the US CDC National Outbreak Reporting System; and other publications identified four salmonellosis outbreaks associated with contamination whole melons and an additional number of outbreaks in which it was not reported if the melons were sold whole or cut. Examples of the outbreaks are listed below:

- Australia (2016) – 144 *S. enterica* serovar Hvittingfoss cases linked to consumption of rockmelons across multiple Australian states. A case control study determined that consumption of rockmelons was significantly associated with illness (odds ratio of 6.4). The outbreak strain was isolated from retail samples of rockmelon from the implicated grower. Inadequate sanitation of the product was a contributing factor to the outbreak. FSANZ coordinated a trade recall of whole rockmelons from the implicated grower (FSANZ 2016; NSW OzFoodNet 2017; OzFoodNet 2021).

[2] Data on the number of salmonellosis cases provided by the National Interoperable Notifiable Disease Surveillance System with population data from the Australian Bureau of Statistics (accessed 25 March 2022)

- USA (2012) – 261 cases of salmonellosis (228 cases of *S.* Typhimurium and 33 cases of *S.* Newport infection), including 3 deaths, across 24 US states were linked to consumption of rockmelon. The *S*. Typhimurium outbreak strain was isolated from rockmelons sampled at retail and from the growing field of the implicated farm. The *S*. Newport outbreak strain was also isolated from rockmelon collected from the growing field of the same farm. The contamination of fresh whole rockmelon is likely to have occurred in the growing field, with contamination spreading and proliferating in the packing house, during storage and transport. Multiple defects in GAP and GHP in production, processing and distribution were identified (CDC 2012; FDA 2013).
- EU (2011-2012) – 63 confirmed cases across 6 countries in the EU were traced back to *Salmonella* Newport and consumption of ready-to-eat pre-sliced or whole watermelon imported from Brazil. Cases were predominately female (45/63) and ranged in age from 6 months to 95 years, with the greatest number (15/63) in children aged 5 years or less. Investigations of confirmed cases indicate that the watermelons were contaminated but the contamination did not occur during processing, demonstrating an unidentified point of contamination between growing and distribution (Byrne et al. 2014).
- US (1973-2011) – a review of outbreaks associated with cantaloupe, watermelon and honeydew in the US between 1973-2011 revealed 34 outbreaks each caused by a single melon type, resulted in 3602 illness, 322 hospitalisations, 46 deaths and 3 fetal losses. Of them, Cantaloupe accounted for 19 outbreaks (56%), followed by watermelon (13, 38%) and honeydew (2, 6%). *Salmonella* spp. were the most common reported cause (19, 56%) followed by norovirus (5, 15%)(Walsh et al. 2014).
- Australia (2006) – 115 cases of *S.* Saintpaul linked to consumption of rockmelons across six Australian states. The outbreak strain was isolated from the skin of both whole and half (cut) rockmelons obtained from a single point of sale identified by a case. Food safety issues were identified that may have contributed to produce contamination, including the use of untreated or inadequately treated water and incorrect use of chemical disinfectants (Munnoch et al. 2009).

Data on the prevalence of *Salmonella* spp. in whole melon

A search of the scientific literature from January 2000 to October 22 via EBSCO and other publications identified a number of surveys for *Salmonella* spp. contamination on whole melons. Examples of survey findings include:

- German (2014-2015): *Salmonella* spp. were isolated from 1.4% of rind and 0.7% of pulp samples from 147 imported peeled muskmelons (Esteban-Cuesta et al. 2018).
- USA (2015): *Salmonella* spp. were isolated from 56.3% of rinse samples from whole rockmelons (n=16) collected from two vendors at farmer's markets (Li et al. 2017). Note that this was a very small study.
- USA (2009-2014): *Salmonella* spp. were isolated from 0.19% of peel samples from whole rockmelons (n=1075) collected at retail (Zhang et al. 2018).
- USA (2000-2004): *Salmonella* spp. were not detected on whole rockmelon sampled in the field (n=1957) (Suslow 2004).
- USA and Mexico (2000): *Salmonella* spp. were detected in surface swabs of 0.8% of whole rockmelons (n=250) sampled in the cooler on US farms and were not detected in surface swabs of packed whole rockmelons (n=75) on Mexican farms (Castillo et al. 2004)
- Canada (2009-2013): *Salmonella* spp. were isolated from 0.08% of samples taken from the outside of whole rockmelons (n=2,400) collected at retail (CFIA Personal communication; Denis et al. 2016).

Nine surveys identified from Europe, Mexico, Canada and the USA showed a prevalence of *Salmonella* spp. ranging from 0–56% of samples of whole melons. An overall estimated prevalence of 0.3% (95% CI 0.0–3.5%) was determined using a random effects meta-analysis.

There is limited data available on prevalence of *Salmonella* on the rind of melons other than rockmelon (cantaloupe) and muskmelons which is a limitation and creates uncertainty of the risk posed. However, given the known risk factors associated with netted/rough rind melon grown directly on the ground or soil there is the potential for contamination of the fruit during growth. Similarly, any melons grown on ground or soil could be contaminated by *Salmonella* including smooth skinned melons. Further, due to the surface features of this group of melons, anti-microbial washes may not be as effective as for smooth rind melons. The bulk of the evidence is for rockmelon and watermelon as these are the most frequently consumed.

Standards or guidelines

- Codex general principles of food hygiene *CXC 1 – 1969* provides a framework of general principles for producing safe and suitable food for consumption by outlining necessary hygiene and food safety controls to be implemented through the food chain from primary production through to final consumption (Codex 2020).
- Codex code of hygienic practice for fresh fruit and vegetables *CXC 53-2003* addresses GAP and GHP that help control microbial, chemical and physical hazards associated with all stages of the production of fresh fruits and vegetables, from primary production to consumption (Codex 2017).

- Annex IV (Melons) of the code of hygienic practice for fresh fruit and vegetables *CXC 53-2003* provides specific guidance on how to minimise microbiological hazards during primary production through packing and transport of fresh melons, including fresh melons processed for the pre-cut market and consumer use (Codex 2017).
- Annex I (Ready-to-eat, fresh, pre-cut fruits and vegetables) of the code of hygienic practice for fresh fruit and vegetables *CXC 53-2003* recommends the application of GHP for all stages involved in the production of ready-to-eat, fresh, pre-cut fruits and vegetables, from the receipt of raw materials to the distribution and consumption of finished products (Codex 2017).
- In Australia, FSANZ has developed a new standard for the primary production and processing of melons, including watermelon, rockmelon, honeydew and piel de sapo.[3] Standard 4.2.9 – "Primary Production and Processing Standard for Melons" was included in the Australia New Zealand Food Standards Code (the Code) on 12 August 2022, with a 30 month commencement period. It therefore takes effect from 12 February 2025. It covers primary production and primary processing activities, having requirements for managing inputs (such as water, fertilizer, soil amendments), animals and pests, temperature of harvested melons, actions following weather events, washing and sanitizing of melons and health and hygiene of personnel and visitors, as well as compliance with the required food safety management statement set out by Standard 4.1.1.
- There are industry developed schemes to manage food safety in horticulture. These are audited by a third party against specific requirements. The main food safety schemes currently in use are the Harmonised Australian Retailers Produce Scheme (HARPS)[4] and four schemes internationally benchmarked to the Global Food Safety Initiative (GFSI)[5] (FSANZ 2020). Further, Chapter 3 Standards (Food Safety Standards) of the Australia New Zealand Food Standards Code apply to food businesses that further process, handle or sell horticultural produce (this could include processing of rockmelons, i.e. cutting and/or freezing rockmelons). Some requirements in these Standards (depending upon the local jurisdiction) can apply to activities such as transport and pack house activities (providing they are not considered to be "primary food production"). Some elements of traceability are also provided through food receipt and recall provisions of Standard 3.2.2, and labelling requirements under Standard 1.2.2.
- There are also non-regulatory guidelines for rockmelon safety in Australia. Melon Food Safety: A Best Practice Guide for Rockmelons and Speciality Melons (Singh 2019) is such a guide. These control measures would also be applicable for use with all melons during processing. Specific *Salmonella* control measures recommended by this guide include:
    - do not use raw animal manures or untreated composts containing animal manures or poultry litter
    - implement measures to prevent livestock and wildlife entering production fields and processing areas
    - train staff to spot animal incursions in the field and to report them to farm management
    - regularly test the microbiological quality of the water used for irrigation, chemical sprays and postharvest washing
    - develop an environmental monitoring program to validate cleaning and sanitising protocols in packing houses
    - regularly clean work surfaces, floors, equipment, doors and handles
    - make sure anything brought into the processing area (e.g. new or repaired equipment) is thoroughly cleaned beforehand.
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Management approaches used by overseas countries

- European Union: *Salmonella* must be absent in 25 grams of ready-to-eat pre-cut fruit and vegetables; this applies to pre-cut rockmelons (European Commission 2019).
- Canada: Imported fresh fruit or vegetables must meet Canadian requirements as set out in the *Safe Food for Canadian Regulations* as well as the *Food and Drug Regulations*. Under Section 8 of the *Safe Food for Canadian Regulations* food that is imported, exported or inter-provincially traded must not be contaminated; must be edible; must not consist in whole or in part of any filthy, putrid, disgusting, rotten, decomposed or diseased animal or vegetable substance; and must have been manufactured, prepared, stored, packaged and labelled under sanitary conditions (CFIA 2020).
- United States: The Produce Safety Rule of the *Food Safety Modernization Act* established science-based minimum standards for the safe growing, harvesting, packing, and holding of fruits and vegetables grown for human consumption. This includes requirements for water quality; biological soil amendments; sprouts; domesticated and wild animals; worker training and health and hygiene; and equipment, tools and buildings (FDA 2019b). The USDA has aligned the harmonized Good Agricultural Practices Audit Program (USDA H-GAP) with the requirements of the FDA Food Safety Modernization Act's Produce Safety Rule. While the requirements of both programs are not identical, the relevant technical components in the FDA Produce Safety Rule are covered in the USDA H-GAP Audit

[3] Proposal P1052 – PPP Requirements for Horticulture (Berries, Leafy Vegetables and Melons) www.foodstandards.gov.au/code/proposals/Pages/P1052.aspx
[4] HARPS: https://harpsonline.com.au/
[5] GFSI: https://mygfsi.com/

Program. However, the USDA audits are not regarded as a substitute for FDA or state regulatory inspections (FDA 2019a). In the US industry guidelines have been available for a number of years aimed to minimise *Salmonella* contamination on rockmelons, for example the National Commodity-Specific Food Safety Guidelines for Cantaloupes and Netted Melons[6] developed in 2013.

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