New Zealand Food Safety
Haumaru Kai Aotearoa

Microbiological risks associated with frozen raw produce used in uncooked food preparations

New Zealand Food Safety Technical Paper No: 2023/14

Prepared by Anne-Marie Perchec (Food Science Risk Assessment) and Christine Esguerra (Food Regulations)

ISBN No: 978-1-991087-16-4 (online)
ISSN No: 2624-022X (online)

July 2023

Te Kāwanatanga o Aotearoa
New Zealand Government

Ministry for Primary Industries
Manatū Ahu Matua

Disclaimer

While every effort has been made to ensure the information in this publication is accurate, the Ministry for Primary Industries does not accept any responsibility or liability for error of fact, omission, interpretation or opinion that may be present, nor for the consequences of any decisions based on this information.

This publication is also available on the Ministry for Primary Industries website at http://www.mpi.govt.nz/news-and-resources/publications/

Contents

Page

1 Executive summary

This report presents the outcomes of a scientific research project undertaken to provide data needed to assess microbiological risks associated with frozen produce used uncooked in blended food preparations (particularly blended beverages, desserts, dips).

Until recently, frozen produce was not considered a high-risk food. However, the occurrence of major outbreaks involving frozen fruits or vegetables in recent years has raised some concerns within New Zealand Food Safety (NZFS) about the safety of frozen produce. Furthermore, changes in consumption trends and the increased popularity of smoothies and similar food preparations in New Zealand have triggered the need for more information on the use and consumption of frozen produce by New Zealand consumers.

While many reports and peer-reviews have studied the microbiological risks associated with fresh produce, there is a lack of information on specific food safety risks associated with frozen produce.

This research reviewed available data on outbreaks associated with the consumption of frozen produce. Three surveys were also commissioned by NZFS in 2020 and 2021. The first two surveys collected data on the uses of frozen raw produce in uncooked blended food preparations by household consumers and food service businesses. The third survey investigated the supply chain for imported and domestic frozen raw produce in New Zealand.

The review of outbreak data shows that frozen berries contaminated with foodborne viruses are the main produce category and pathogens of concern.

Findings from both household and food service surveys confirmed the general trend of increased use of frozen fruits, especially berries, for the preparation and consumption of smoothies and similar blended foods.

The outbreak data and the survey findings with regards to frozen produce, strongly support consideration of strengthened food safety risk management measures for frozen berries to protect the health of the New Zealand public.

Data collected from this research project will help NZFS risk managers understand the microbiological risks associated with frozen produce used uncooked in blended food preparations. These data will be particularly useful for the ongoing review and development of risk management controls for imported frozen berries.

Additional microbiological surveys of other frozen fruit and vegetables are not required.

2 Purpose and scope

This research project was initiated by New Zealand Food Safety (NZFS) to provide data on the microbiological risks associated with frozen raw fruits and vegetables (collectively referred to as frozen raw produce) and support the ongoing review and development of import controls for frozen berries. It focusses on frozen produce that are used uncooked in ready-to-eat food preparations, such as blended beverages, desserts, and similar preparations.

Until recently, frozen produce was not considered a high-risk food. However, the occurrence of major outbreaks involving frozen fruits or vegetables in recent years has raised concerns among NZFS food risk assessors and managers about the safety of frozen produce consumed in New Zealand. In addition, considerations of the changes in food consumption trends and on the increased popularity of smoothies and similar products, have driven the need for this research.

While many reports and peer-reviews have studied microbiological hazards and risks in fresh produce, there is a lack of information on the food safety risks associated with frozen produce. This research project was undertaken to address some of these knowledge gaps, particularly the lack of information on the potential exposure of New Zealand consumers to imported frozen produce used in uncooked food preparations.

This research project was initially planned to be undertaken in two stages. Stage 1 involved the collection of updated information on New Zealand and overseas foodborne outbreaks associated with frozen produce. In addition, in 2020-2021, NZFS commissioned two surveys to collect data on the types and usage of frozen raw produce in uncooked blended food preparations by household consumers and food service businesses. A third survey was also undertaken to investigate the supply chain for imported and domestic frozen raw produce in New Zealand.

Stage 2 was planned for a potential microbiological survey of selected frozen raw produce, the scope of which was to be informed by the outcomes of Stage 1. However, based on the recommendations from this report, NZFS has decided not to proceed with Stage 2 of the project.

This report gives a brief overview of the current knowledge on food safety risks associated with frozen produce. It provides outbreak data and the key findings from the surveys performed in Stage 1 and also includes a brief discussion on the considerations and basis for the recommendation not to proceed with the microbiological survey in Stage 2.

3 Current knowledge on microbial food safety risks associated with frozen fruits and vegetables

3.1 MICROBIAL CONTAMINATION OF FROZEN FRUITS AND VEGETABLES

Fruit and vegetables can be contaminated by a large range of pathogens present in soil, in water and /or in human and animal faeces. Some of these pathogens can also be directly transmitted by symptomatic or asymptomatic handlers during growing, harvesting, and post-harvest processing of produce. The pathogens of most concern include bacteria (e.g. *Salmonella* spp, Shiga-toxin *E. coli* (STEC), *Listeria* spp, *Yersinia* spp.), viruses (e.g. norovirus (NV), hepatitis A virus (HAV)), and parasites (*Cryptosporidium* spp., *Toxoplasma gondii*). The characteristics and prevalence of these pathogens in fresh produce are discussed in King *et al*. (2020).

Most bacterial and viral pathogens that can contaminate fresh produce will survive the freezing process, and therefore may also be present on frozen produce. This may represent a significant risk when frozen produce is consumed directly without any subsequent inactivation steps.

3.2 POST-HARVEST INTERVENTIONS

3.2.1 Effect of pre-freezing steps

Washing and disinfection of fresh produce are common pre-freezing steps. Although these steps can reduce the microbial load on the surface of produce, the effect is typically limited to 1 or 2 log reductions (ICMSF, 2011). The level of microbial reduction is dependent on a number of factors, such as, the type of produce and its characteristics (e.g. surface texture, presence of antimicrobial compounds), the type(s) of microorganism and level of contamination on the produce, whether a biocide is used and the type of biocide (e.g. chlorine, sodium hypochlorite), and the washing conditions (e.g. concentration of biocide, water temperature, duration of contact).

Some fresh produce also undergo preparation steps prior to freezing, such as peeling, cutting and deseeding. These steps involve more manual or mechanical handling and can expose products to further contamination if hygiene and sanitation conditions are not properly controlled.

Many vegetables are blanched before freezing to minimise quality deteriorations, such as discolourations and development of off odours caused by enzymatic reactions triggered by freezing damage to the vegetable's cell structures. Blanching, typically consisting of a short heat treatment over 80°C, destroys the enzymes that cause these organoleptic deteriorations. Blanching also reduces the microbial load on produce, with the level of microbial reduction dependent on the type of produce, the blanching temperature and time, and the type and concentration of microorganisms on the produce. Blanching inactivates vegetative bacterial cells from 1 to 5 log (ICMSF, 2005). For example, it has been demonstrated that blanching will achieve a 5-log reduction in *Listeria monocytogenes* for a large range of vegetables when adequate time and temperatures combinations are applied (EFSA, 2020).

However, blanching can also be considered a risk factor. The modification of the produce structure and characteristics, as a result of heating, combined with the inactivation of the background flora, may favour the growth of pathogens (EFSA, 2020). There is also potential for cross-contamination during cooling of the products if they are not maintained at the right temperature and /or come into contact with other sources of contamination. This may explain the recent outbreaks caused by *Listeria monocytogenes* associated with blanched frozen vegetables in Europe (see section 4).

Blanching or heat treatment is rarely applied to fruits destined for freezing. Some berries may be washed before freezing, but they are not usually blanched or heat-treated unless they are intended for processing into jams and other similar processed products (Palumbo *et al*., 2014).

3.2.2 Effect of freezing

Generally, freezing has little effect on the level of contamination and the viability of most bacterial pathogens and viruses. Freezing of produce can result in a decrease in microbial concentration on the product, but this can be limited and inconsistent as microbial inactivation will depend on the sensitivity of the microorganism to freezing, the type of food matrix, and the freezing and frozen storage parameters (e.g. temperature and time). For example, enteric viruses (HAV and norovirus) and their surrogates can survive for long periods of time in frozen berries with level of reduction generally between 0 and 1 log (Palumbo *et al*., 2014).

Most parasites are killed by freezing temperatures, especially under commercial freezing conditions. However, some parasite eggs such as the eggs of *Ascaris* spp. or *Echinococcus granulosus* may survive freezing temperatures. *Cryptosporidium* oocysts are resistant to freezing unless contaminated produce is stored at -20°C for more than 24 hours, or at -15°C for at least one week (WHO, 2014).

Although outbreaks caused by foodborne parasites are generally associated with fresh produce, there has been one reported *Cyclospora cayetanensis* outbreak linked to home-frozen raspberries. The temperature at which the fruits were frozen is unknown but may not have been low enough to kill *Cyclospora* oocysts (Ho, 2002).

3.3 PREVIOUS NZFS RISK ASSESSMENTS OF FRUITS AND VEGETABLES

3.3.1 Discussion Document: Pathogens in Fresh Fruits and Vegetables in New Zealand (King et al, 2020).

This report is an update of the 2008 discussion document on pathogens in produce. It reports the outcomes of a review of information published since 2008 and reassesses the human health risks in New Zealand associated with foodborne pathogens in fresh, ready-to-eat (RTE) whole and fresh-cut vegetables and fruits (including fresh herbs); raw frozen berries; fresh juices; and sprouted seeds.

There were three New Zealand outbreaks reported from 2008 to 2015 where fresh produce was the most likely vehicle for infection based on epidemiological information. These were outbreaks of salmonellosis linked to watermelon, norovirus infection linked to fresh fruit salad, and yersiniosis, of which the geographic distribution of cases suggested a nationally distributed product such as carrots and/or lettuces.

Four microbiological surveys of fresh produce completed in New Zealand since 2008 reported detections of *Salmonella* spp., *Listeria* spp, norovirus GII in fresh produce, but the prevalence and concentrations were low.

3.3.2 New Zealand Microbiological Risk Ranking of Imported Fruit and Vegetables (Perchec & Esguerra, 2023)

This report presents the outcomes of a scientific review and microbiological risk ranking of imported fruit and vegetables undertaken by NZFS. The scope of the study included fresh, frozen, processed, and preserved fruits and vegetables.

A New Zealand risk ranking model was developed based on two multi-criteria analysis models created separately by the United States Food and Drug Administration and the European Food Safety Authority (BIOHAZ Panel) for similar applications. The New Zealand model is comprised of eight criteria adapted to New Zealand data and circumstances, and produces a general risk ranking of pathogen and produce combinations.

The model was applied to specific produce categories and pathogens, based on the Codex classification of food commodities and other risk ranking publications.

The eight top ranking pathogen-produce combinations were:

- Pathogenic *E. coli* in: lettuce, spinach and "other leafy greens"
- *Salmonella* spp. in: lettuce, "other leafy greens", tomatoes, melons, and "other cucurbitaceae" (e.g. cucumbers, gourds, squashes, pumpkins)

Produce categories were also ranked based on overall risk from various pathogens associated with each produce category. The top ranked produce categories, in decreasing order of rank, were:

- "other leafy greens"
- "pods, legumes and grains"
- herbs
- berries
- tropical fruits
- spinach

The risk ranking lists provide an initial basis or starting point for risk management considerations and prioritisation of resources.

The two NZFS studies discussed in this section do not adequately address the food safety risks specifically associated with frozen produce. This current research project on frozen raw produce was undertaken to fill in this knowledge gap.

3.4 CURRENT ISSUES ASSOCIATED WITH FROZEN FRUIT AND VEGETABLES

As discussed in the previous sections, current understanding of the microbial risks associated with fruit and vegetables remains relatively general and does not address specifically the risks associated with frozen produce.

The issues and observations detailed below have raised some questions within NZFS and triggered the need for more data to inform the microbiological food safety risk assessment of frozen fruit and vegetables consumed raw in New Zealand.

a) Strong epidemiological evidence linking frozen raw produce to foodborne outbreaks

Traditionally, frozen food products have not been considered as high-risk products because pathogens of food safety concern cannot grow in these products, although they may survive, and frozen foods in general have a good safety record. However, in recent years, many international outbreaks have been attributed to the consumption of frozen raw produce and some outbreaks have also occurred in New Zealand (see Section 4).

b) The increasing popularity and consumption in New Zealand of uncooked blended beverages and desserts containing raw produce

Consumption of fruit and vegetables has increased worldwide due to recommendations for healthier diets. In New Zealand, Ministry of Health guidelines recommend New Zealand adults to eat five servings of vegetables and two servings of fruits a day (Ministry of Health, 2020).

Consequently, smoothies and similar blended beverages have become very popular and are consumed either at home or at other venues, as they are considered as a convenient way to get the recommended intake of fruit and vegetables per day. There has been a visible increase in the number of smoothie and juice bars serving customised blended beverages. The variety of pre-prepared smoothies available in supermarkets, as well as the volume and variety of frozen raw fruits available in supermarkets intended for home preparation of smoothies and other uncooked blended beverages (e.g. shakes, lassi) and desserts (e.g. ice cream, sorbet, puddings) have also increased.

c) Change in consumer behaviour and use of frozen vegetables

Recent years have also seen the development of new diet trends including an increased consumption of raw foods. Some frozen vegetables that are traditionally cooked before consumption (e.g. kale, spinach, peas) are now being used raw in uncooked blended beverages and other food preparations, such as dips.

d) A significant proportion of frozen fruits available for sale in New Zealand is imported

Ensuring a constant and diverse supply of fresh fruit and vegetables for the consumer is challenging, especially for remote countries like New Zealand. Freezing of fruit and vegetables enables long-term preservation of produce while maintaining their quality and extending their use beyond the production cycle. This ensures a consistent market supply of fruit and vegetables year-round and provides consumers access to a variety of produce in a convenient form.

Imported frozen raw fruits, including frozen berries and frozen tropical fruits, constitute a significant proportion of the frozen fruits sold in New Zealand. Imports of frozen berries from 2019 to 2021 were approximately 10,000 tonnes per year. Frozen berries and tropical fruits are imported from various countries, and NZFS has little knowledge about the production and processing controls applied in these countries, from growing and harvest, to processing.

Good agricultural practices (GAP) and Hazard Analysis Critical and Control Point (HACCP) based food safety systems should be followed by growers and processors of frozen produce. However, it is currently difficult to get such assurances for frozen berries imported into New Zealand. The effectiveness of current import controls for frozen berries is questionable and is under review.

4 Foodborne outbreaks associated with frozen produce

4.1 NEW ZEALAND OUTBREAKS

Between 2000 and 2022, three outbreaks associated with the consumption of frozen produce[1] were reported in New Zealand.

[1] One hepatitis A outbreak was associated with New Zealand blueberries, but the blueberries were consumed fresh and not frozen.

- In 2014, there was a norovirus outbreak involving 10 confirmed and 44 probable cases, with the suspected food identified as berry trifle (consisting of frozen raspberries, custard, sponge) (Horn *et al*., 2015).
- In 2015, there was a hepatitis A outbreak linked to the consumption of frozen berries imported from China. This outbreak involved seven cases, including five hospitalisations (Lopez *et al*., 2016).
- In June 2022, another hepatitis A outbreak was associated with the consumption of frozen berries imported from Serbia. At the time of writing this report (June 2023), there are 39 cases, of which 19 required hospitalisations, but this outbreak has not yet been declared over. All the cases have an HAV sequence profile closely related to an HAV strain that caused an outbreak in Sweden in 2020-2021 and which had been linked to frozen berries imported from Serbia.

4.2 OVERSEAS OUTBREAKS

Using literature search engines and official reports from several countries, a total of 115 overseas outbreaks[2] were found to be associated with frozen produce between 2000 and 2021 (Table 1 in Appendix A).

A significant proportion of these 115 outbreaks were due to norovirus (68%) and HAV (25%), and only a small proportion (6%) was caused by other pathogens (Figure 1).

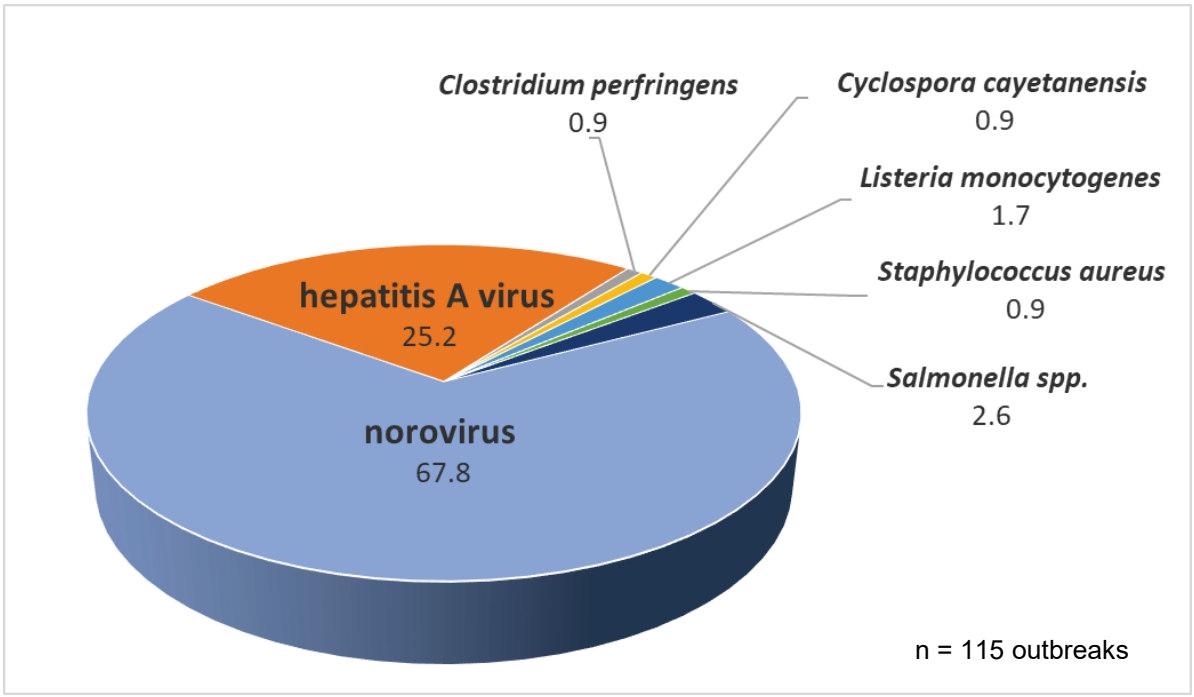

Figure **1**: Percentages of overseas foodborne outbreaks associated with frozen produce between 2000 and 2021.

It is unclear why there is a significant difference between norovirus and HAV outbreak prevalence. One probable explanation is that the immunity gained post-infection or post- Hep A vaccination lasts longer for HAV than for norovirus. Furthermore, the longer incubation period for HAV compared to norovirus makes investigations of hepatitis A cases more challenging (Nasheri *et al*., 2019).

[2] Overall data on outbreaks associated with fresh produce can be found in King *et al.* (2020) and Perchec & Esguerra (2023) .

Of the 115 outbreaks associated with frozen produce, 104 (90%) were linked to the consumption of frozen berries (Figure 2), with raspberries being the most common berry type linked to outbreaks (Table 1). The apparent higher contamination of raspberries with viruses may be related to their greater fragility (meaning they have to be manually handled) and/or to their specific texture. Similar findings were reported by Nasheri *et al.* (2019). As a point of comparison, for the same period, only about 13 outbreaks were associated with fresh berries and none with dried berries.

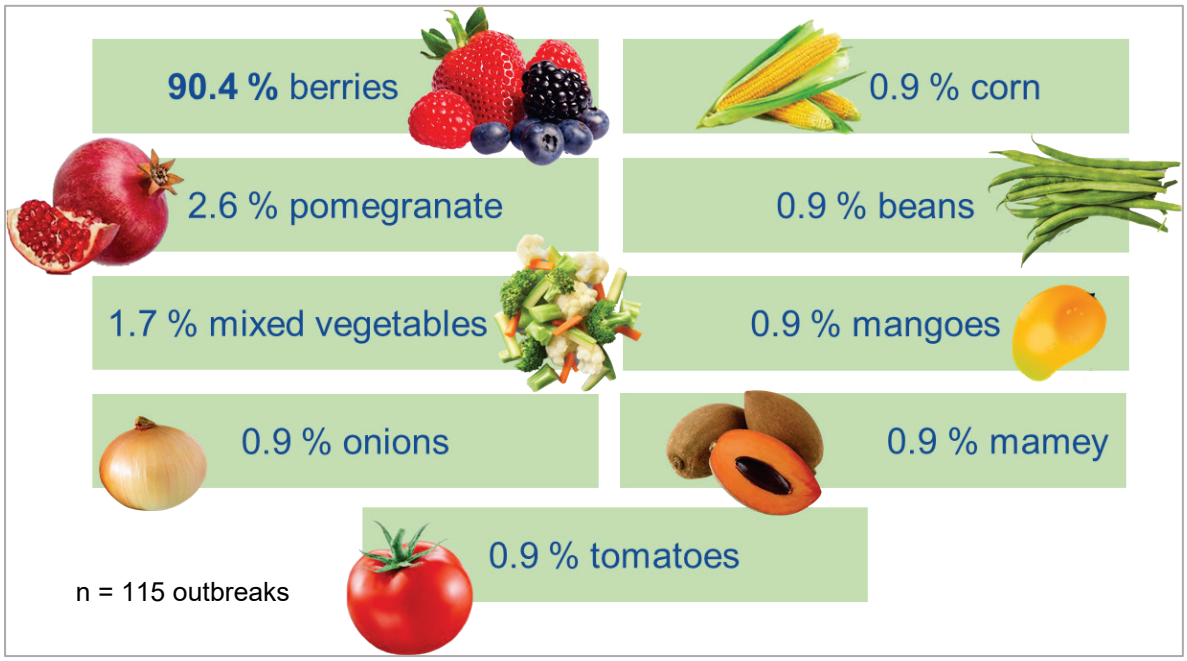

Figure **2**: Proportions of foodborne outbreaks associated with different types of frozen produce.

Table **1**: Distribution of worldwide outbreaks for berries and pathogens between 2000 and 2021.

Berry type	Number of outbreaks	Outbreaks/Pathogens
Mixed berries	18	3 NV
		15 HAV
Raspberries	73	71 NV
		1 HAV
		1 Cyclospora
Strawberries	12	3 NV
		9 HAV
Blackberries	1	NV
Total	104	

A review by Bozkurt *et al*. (2021) showed that the proportion of HAV and norovirus-related outbreaks is generally higher for frozen berries than fresh berries, except for strawberries. Between 1983 and 2018, frozen berries were implicated in 77% of HAV and 68% of norovirus-related outbreaks associated with berries. However, similar to the present report, the information presented in Bozkurt *et al*. (2021) is rather limited in terms of geographic coverage as most of the available data and publications are sourced from the United States, Canada, and from some European countries. For

example, publicly available records or investigations of outbreaks associated with frozen fruits or vegetables were not located for countries such as China and Russia.

Data availability could also be limited because investigations of outbreaks associated with frozen produce are particularly complex. Frozen products have long shelf-lives (over one year) and consequently, the distribution of cases who have consumed a particular frozen produce can span several months or years, as demonstrated by the outbreak caused by *Listeria monocytogenes* in frozen vegetables over the period 2015-2018 in Europe (EFSA, 2020). Tracing the source and distribution of affected frozen produce can also be challenging because fruit and vegetables can be grown, processed, and distributed in a multitude of different countries.

Of the 115 reported outbreaks associated with frozen produce, only 5.3% have been associated with frozen vegetables. Frozen vegetables are typically blanched or heated prior to freezing, which could likely explain the low number of outbreaks associated with these products. Frozen vegetables are also more often cooked before consumption compared to frozen fruits. However, this practice seems to be changing with more consumers now adding frozen vegetables directly in ready-to-eat food preparations, such as salads, shakes and dips, without a pre-cooking step. This could have food safety consequences, as demonstrated by the *Listeria monocytogenes* outbreak associated with frozen corn that occurred in Europe between 2015 and 2018 and caused 53 cases and 10 deaths (EFSA, 2020). Therefore, frozen raw vegetables used in uncooked food preparations should not be overlooked as a source of potential foodborne outbreaks.

The rare outbreaks associated with frozen vegetables have all been attributed to pathogenic bacteria (*Listeria monocytogenes*, *Staphylococcus aureus* and *Clostridium perfringens*). As foodborne viruses are mostly spread via direct contact from food handlers, frozen vegetables appear less often contaminated with these pathogens because vegetables are more likely to be mechanically harvested than soft fruits such as berries. Furthermore, compared to frozen fruit, the processing of frozen vegetables generally includes more steps, such as peeling, cutting, washing, and blanching, which provide more opportunities for bacterial contaminations from the processing environment. For example, *Listeria* spp. and *Salmonella* spp. are known to form biofilms and persist for long periods in the manufacturing environment, leading to potential recontamination of the vegetables after the heating step. Although foodborne viruses such as HAV and norovirus can also persist in the environment, they are unable to multiply.

Only one outbreak caused by parasites has been associated with frozen produce, which is as expected since most parasites are inactivated under commercial freezing conditions. This outbreak involved *Cyclospora cayetanensis* in frozen raspberries. The berries had been home-frozen before being used directly in a cake, and in this particular situation, the home-freezing conditions and parameters may have been insufficient to kill the parasites.

5 Use of frozen raw produce in uncooked food preparations

5.1 BACKGROUND

As shown in Table 1 of Appendix A, the food vehicles identified in the outbreaks are mostly smoothies, cold desserts, and cakes. Therefore, the research has focused specifically on these products.

To assess the potential exposure of New Zealand consumers to food safety risks from frozen raw produce, NZFS risk assessors and managers need to understand what types of raw produce are commonly used in uncooked food preparations, such as blended beverages, desserts, and dips, and the way they are used by household consumers and food service businesses. To fill in these data gaps, NZFS commissioned Colmar Brunton in 2020 to undertake two separate surveys of household

and food service users of frozen raw produce in uncooked food preparations. A third survey was also commissioned to look at the the supply chain for frozen raw produce in New Zealand.

The surveys focused on commercially produced frozen raw fruits and vegetables (some may have been blanched prior to freezing), including imported and New Zealand produced products.

The types of frozen raw produce considered in the study included: berries, citrus fruits, stone fruits (peach, plum), tropical fruits (mango, avocado, lychee, pineapple, pomegranate, papaya, kiwifruit, melons), coconut, herbs, leafy vegetables (spinach, kale), root vegetables (carrots), legumes (peas), and stem and flower vegetables (celery, broccoli).

For the two user surveys, "uncooked blended beverages and desserts" was defined as blended beverages and desserts that are not heat treated or preserved before consumption and are usually served and consumed cold. They mostly refer to smoothies, slushies, shakes, lassi, yoghurt-based beverages, ice creams, sorbets, fruit mousse, and cold puddings. Other similar preparations, such as dips and baby food, were also included. The use of uncooked frozen raw produce as added ingredients in other ready-to-eat foods, such as salads, garnishes, and breakfast cereals, was not considered because it is more difficult to obtain reliable data. It would have increased the duration of the interviews and would have complicated the analysis of the results. Very often, people do not know or remember the exact ingredients of complex dishes, where the ingredient of interest is present in only small amounts.

Sections 5.2 to 5.4 of this report briefly describe the findings of the three surveys. The full report for the two user surveys is available at https://www.mpi.govt.nz/dmsdocument/57901. The third survey (supply chain) remains confidential and will not be published as it contains sensitive commercial information.

5.2 SURVEY 1 - HOUSEHOLD USERS

Survey 1 involved an online survey of 1004 household consumers who prepare uncooked blended beverages and desserts using frozen raw produce. Its objectives were to establish the profiles of these household users, and to collect information on the types of frozen raw produce they use, what they are used for, and how they are used.

The key findings of the study are listed below. Further details are shown in Table 2 in Appendix B. and in the full report *(*https://www.mpi.govt.nz/dmsdocument/57901*)*.

- Of the different types of frozen raw produce, berries are the most used by household users. Ninety percent of users use frozen berries uncooked, while 60% also use other frozen fruits (non-berries). The types of frozen berries most used are blueberries, raspberries, strawberries, and mixed berries. The non-berry fruit that is most used by household users is frozen mango.

- Compared to frozen berries and other frozen fruits, frozen vegetables and herbs are used by fewer people (when consumed uncooked). Twenty-five percent of household users use frozen vegetables, while 8% use frozen herbs. The frozen vegetables that are most used without further cooking are carrots and spinach.

- Smoothies, shakes, and lassi are the food preparations that are most likely to be made with frozen raw produce. Ninety percent of household users make these items, with 51% making them at least once a week. Berries are the frozen ingredient most commonly used in uncooked blended beverages and desserts, while frozen vegetables come out on top for dips and baby food.

- Most household users purchase their frozen produce from the supermarket. The brands of frozen berries that users are most likely to purchase contain imported frozen berries.

- There is uncertainty amongst users of frozen berries and other fruits as to where their produce comes from, with 30% and 32%, respectively, saying that they don't know. Users of frozen vegetables and frozen herbs are more confident that their product is New Zealand grown, with 55% and 61%, respectively, indicating this.

These findings are similar to those obtained in a consumer survey conducted in Ireland in 2020 which included interviews of a total of 815 participants (Food Safety Authority of Ireland, 2022). This study found that frozen vegetables, frozen fruits, and frozen herbs were consumed, respectively, by 80%, 40% and 13% of the participants. About 32% of the participants said they consume one or more types of frozen vegetables, fruits, or herbs without cooking them. Strawberries, blueberries, raspberries, and mixed berries were the frozen fruits most likely to be eaten uncooked in a dessert or in a smoothie. A smaller number of consumers said they would regularly eat uncooked non-ready-to-eat frozen vegetables such as sweetcorn, carrots, peas, peppers, and spinach in a salad or as a garnish.

5.3 SURVEY 2: FOOD SERVICE BUSINESSES

Survey 2 involved phone interviews of 256 food service businesses that prepare and sell uncooked blended beverages and desserts to the public.

The key findings of the study are listed below. More details can be found in Table 3 in Appendix B and in the full report *(*https://www.mpi.govt.nz/dmsdocument/57901*)*.

- Frozen raw produce in uncooked beverages and desserts are mostly prepared and sold by cafés (64%) and restaurants (24%) located in large towns and cities throughout the country.

- Frozen berries are the frozen produce category most likely to be used uncooked by food service businesses. Ninety-four percent did so, while 41% used other frozen fruits (non-berries) uncooked. The most widely used berries are blueberries, mixed berries, raspberries, and strawberries. Mangoes are the most widely used non-berry fruit. These are all in line with the household user findings.

- Compared to berries and other fruits, frozen vegetables and herbs are used infrequently in uncooked beverages and desserts by food service businesses. Only 11% of food service businesses use frozen vegetables uncooked, while 1% use frozen herbs. For those businesses who use frozen vegetables uncooked, peas and avocados are the most common vegetables they use.

- Most frozen fruits are almost exclusively used in smoothies. For example, 97% of food service businesses that use frozen bananas use them in smoothies.

- Food service businesses typically purchase their frozen produce from wholesalers, and they tend to buy brands that are exclusively sold by wholesalers. All brands of frozen fruit purchased appear to contain imported fruit produce.

- Smoothies are commonly purchased by the general public from cafés, while cocktails are purchased from bars, pubs, or clubs. Forty-seven percent of ice creams and 48% of yoghurt / yoghurt drinks are purchased from 'another type of business' – this potentially would include sites such as 'Real Fruit Ice Cream' stores.

5.4 SURVEY 3: SUPPLY CHAIN

The third survey focused on the specific categories of frozen produce which were identified in the first two surveys as the most used in blended food preparations by household users and food businesses. This survey investigated the supply chain for imported and domestically produced frozen raw produce from sourcing of the frozen produce to their sale to final users in New Zealand. It was undertaken to collect information on the types and sources of frozen produce, the key business sectors involved in the supply and distribution of frozen produce and the types of activities they are involved in.

Ten businesses were interviewed for the survey. These 10 businesses represent most of the key players in the industry and manage the majority of the key brands used by household and food service users identified in surveys and 1 and 2. One major frozen produce importer declined to participate in the survey, but this is not likely to have a significant impact on the general findings of the survey.

The key findings of the survey are as follows:

- Most importers of the key brands of frozen fruits in the New Zealand market are involved in multiple sectors in the supply chain, with individual businesses involved in importation, manufacturing, wholesale, and retail sale. Manufacturing is generally limited to mixing of frozen fruits and repacking.

- The main categories of frozen produce imported into New Zealand are frozen berries (blueberries, raspberries, strawberries, mixed berries), frozen tropical fruits (banana, pineapple, mango), frozen mixed fruits and frozen vegetables (spinach, and mixed vegetables).

- Imports of frozen fruits by the businesses interviewed largely consist of frozen berries, which include bulk packed and retail-ready frozen berries.

- For frozen berries, the main countries of export identified in the survey are consistent with NZFS imports data shown in Table 2.

Table **2**: NZFS imports data for frozen berries from 2019 to 2022.

Type of frozen berries	Volume (tonnes)*				Country of export (% of volume)
	2019	2020	2021	2022	
Blueberries	2,530	3,630	3,280	3,110	Chile (41%), Canada (40%), United States (8%), China (5%)
Raspberries	1,730	1,960	1,990	1,820	Chile (38%), China (18%), Belgium (14%), Poland (9%), Montenegro (8.7%)
Strawberries	1,610	1,400	1,670	1,520	China (56%), Chile (21%), Egypt (14%)
Mixed berries	1,590	2,720	2,460	2,630	Chile (44%), Belgium (21%), China (20%)
Blackberries	340	200	270	280	Chile (46%), China (46%), Poland (4%)
Currants	10	40	70	180	Poland (61%), United Kingdom (13%), Canada (8%)
Other berries	480	720	610	560	China (25%), Chile (25%), Canada (15%), Vietnam (14%), United States (8%)
TOTAL	**8,290**	**10,670**	**10,350**	**10,100**	

* Note that the proportions of the above volumes that are for ready-to-eat use (e.g. smoothies) versus that for further processing (e.g. preserves, juices and concentrates) is unknown.

- Estimates of total import volumes in the survey cannot be compared to NZFS imports data because some participants declined to provide information, some gave rough estimates, and some gave estimated values ($) rather than quantity (kg).

- Businesses interviewed indicated that frozen peas, corn, and mixed vegetables available in the market consist largely of New Zealand grown produce but are sometimes supplemented with imported produce when there are local shortages.

- A general overview of the supply chain for imported frozen produce is shown in Figure 3.

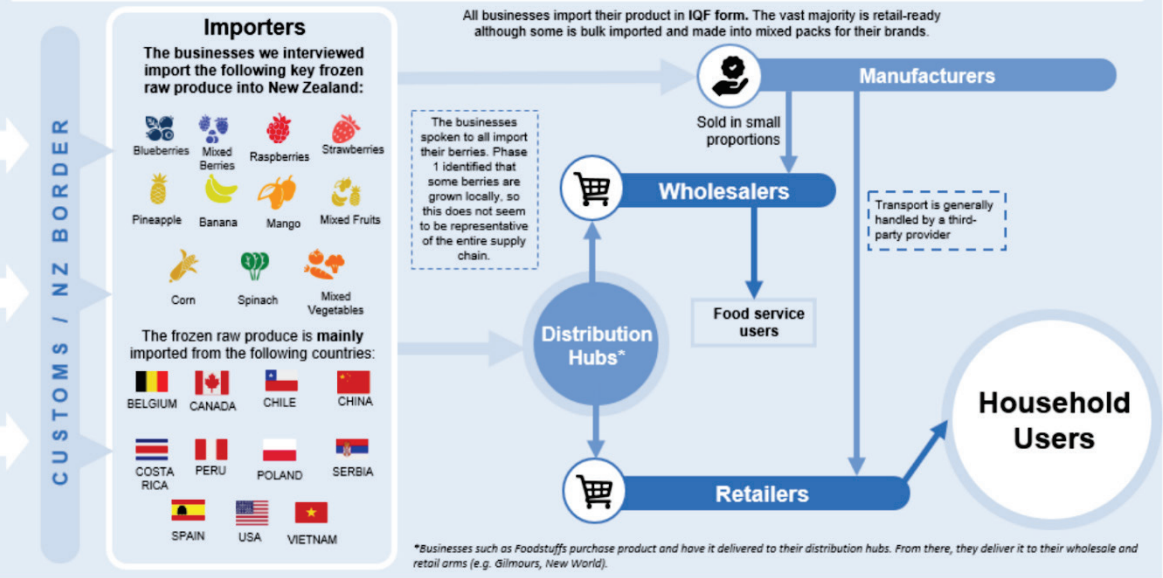

Figure **3**: Supply chain for imported produce into New Zealand

- Importers' requirements for their overseas suppliers vary considerably. Some processors or growers are required to have a HACCP-based food safety programme or third-party certification against a private standard (e.g. British Retail Consortium (BRC), Global GAP), and/or to perform microbiological and chemical testing of produce and to provide certificates of analysis. Some importers visit and audit the overseas farms and processing facilities themselves (pre-Covid) and some rely on audits by overseas third-party accredited auditors.

The supply chain survey is less informative than the two user surveys. The collection of more comprehensive information about the supply chain and the controls applied by importers was limited by the lack of response and participation from some key frozen produce importers, and the difficulties in identifying the right people from various big businesses (who could provide the information needed). There were also confidentiality issues, with some importers declining to share operational or trade information.

6 Conclusions from Stage 1

The review of outbreak data shows that frozen berries contaminated with foodborne viruses are by far the main produce category and pathogens of food safety concern.

Both household user and food service user surveys provide good baseline data on the usage of frozen raw produce in uncooked blended food preparations in New Zealand.

The results of the surveys confirm the general trend of increased use of frozen fruits, especially berries, for the preparation and consumption of smoothies and similar blended foods.

The outbreak data and the survey findings with regards to frozen produce, strongly support consideration of strengthened food safety risk management measures for frozen berries to protect the health of the New Zealand public.

Data collected from Stage 1 of this research project will help NZFS risk managers understand the microbiological risks associated with frozen produce used uncooked in blended food preparations. These data will be particularly useful for the ongoing review and development of risk management controls for imported frozen berries.

7 Recommendations for a microbiological survey in Stage 2

Data on the prevalence of hazards in foods are a major input in food risk assessments and are generally obtained from microbiological surveys.

Stage 2 of this research project was planned for a potential microbiological survey of selected frozen raw produce, the scope of which was to be informed by the outcomes of Stage 1.

This section discusses the different factors to be considered when weighing the pros and cons of undertaking a microbiological survey.

7.1 SCOPE OF A POTENTIAL MICROBIOLOGICAL SURVEY

The results from the user and supply chain surveys discussed in section 5 clearly show that, in New Zealand, frozen berries are the frozen raw produce that are most purchased and used in uncooked blended beverages and desserts, followed by two other fruits, mangoes and bananas.

Available epidemiological data show that outbreaks and adverse events are mostly associated with frozen berries and are caused predominantly by HAV and norovirus. Other frozen fruits of interest have rarely (only few outbreaks with pomegranate arils, mangoes, and mamey) or never (bananas) been associated with outbreaks. Frozen vegetables are also rarely associated with outbreaks.

While outbreaks associated with frozen non-berry fruit seem relatively rare, various pathogens have caused outbreaks in fresh fruit. For example, while there has been only one reported outbreak associated with frozen mangoes (caused by HAV), *Salmonella* spp. has caused recent outbreaks in fresh mangoes, and consequently, this pathogen may also represent a microbial risk for frozen mangoes. It would be valuable to examine this issue further and to collect more information to assess this potential risk.

Fresh or frozen bananas have never been directly implicated in any foodborne outbreak. Similarly, there have been no outbreaks associated with frozen spinach and carrots. The recent outbreaks caused by *Listeria monocytogenes* in frozen vegetables (although corn, not spinach or carrot, was involved) could be of concern. However, in New Zealand, this potential risk seems to be limited based on the consumption patterns and habits revealed by the household and food service user surveys in Stage 1.

These data suggest that a potential microbiological survey of frozen produce in Stage 2 of the current project should focus on HAV and norovirus in imported frozen berries.

7.2 SURVEY OF HAV AND NOROVIRUS IN FROZEN BERRIES

A survey of HAV and norovirus in frozen berries would give prevalence data which may be used to answer the following questions:

- Are frozen berries imported into New Zealand contaminated with HAV and/or norovirus, and at what level? Can we provide a baseline prevalence with the levels of contamination?
- When foodborne viruses are detected in imported frozen berries using molecular methods, are they infectious or not?

The following factors were considered in determining the merits and limitations of undertaking a survey of HAV and norovirus in frozen berries.

a) **Sample size**

As levels of foodborne viruses on produce are very low, their distribution on the surface of fruits is very heterogenous, and their occurrence is sporadic, the sampling plan for a microbiological survey of HAV and norovirus in frozen berries will require the collection of a very large number of samples to be able to detect positive and contaminated batches of frozen berries and give an accurate estimation of the prevalence.

b) Detection method

Viruses are not able to grow outside a cell environment, and they do not multiply in a food matrix. Therefore, enrichment methods developed for bacteria, where food suspensions are incubated at a suitable temperature to enable the multiplication of bacteria and thus increase the probability of detection, cannot be used for the detection of viruses in food products. Instead, detection methods for viruses need to include a concentration step and/or a filtration step, which have their own limitations.

Until recently, it was not possible to replicate norovirus in cell lines like other common viruses, but few years ago, a new cell culture-based method using stem cells from intestinal tissue was developed. However, this method is not yet standardised and is still restricted to specialised research laboratories, meaning it is not suitable for investigation and monitoring purposes. Similarly, cultivation of HAV is only possible for some specific strains, and wild viruses, like those found on produce, are more difficult to cultivate.

Thus, current detection methods used in food microbiology for foodborne viruses are based on Polymerase Chain Reaction (PCR) methodologies, in particular Real-Time quantitative Polymerase Chain Reaction (RT-qPCR). Viruses need to be concentrated and purified before the acid nucleic extraction, which means that only a small proportion of the initial sample is used as the input material for analysis. For example, for a sample of 25 g of fruit, only 5 to 10% will be really analysed, decreasing the likelihood of detecting the virus.

Depending on the characteristics of the food matrix, the presence of natural inhibitors and compounds can hinder virus recovery using RT-qPCR methodology. For example, the recovery rate for HAV in food is usually around 20 to 40%. This means that even if a sample is contaminated with HAV, the virus will be detected in only 20 to 40% of cases.

Furthermore, the use of PCR methodology does not assess the viability and infectiousness of the virus. This is an important issue, as RT-qPCR can detect the presence of small pieces of nucleic acid in any type of sample, even without the presence of intact viruses that are able to infect the cells of a host. Currently, various overseas research laboratories are developing specific RT-

qPCR protocols to discriminate between infectious and non-infectious viruses, but these new methods are not yet validated and standardised.

c) Costs

Detection methods for viruses are more complex than those used for bacteria (e.g. *Salmonella* or STEC), therefore, testing for viruses is far more expensive.

Based on all these considerations, performing a microbiological survey of viruses in frozen berries will deliver results with limited usefulness for the evaluation of risks and their management. The obtainment of negative results will not guarantee that the samples are free of foodborne viral contamination. In addition, the significance of positive results obtained with RT-qPCR will be difficult to assess in terms of public health risk.

The limitations described above are supported by various surveys conducted overseas on fresh or frozen produce, which reported very low rates of detection of HAV and norovirus.

For example, the Canadian Food Inspection Agency (CFIA) conduct regular targeted surveys to focus its surveillance activities on areas of highest health risk[3]. Between April 2014 and March 2016, they conducted a targeted survey for foodborne viruses in fresh berries and frozen fruits and analysed by RT-qPCR, a total of 1,061 samples of frozen fruits (656 frozen berries and 405 other frozen fruits) from retail locations across 11 Canadian cities. They did not detect HAV and norovirus GI, however, norovirus GII was detected in two samples of frozen berries (blueberry, strawberry) and in one sample of other frozen fruit (peach) representing, respectively, 0.3 and 0.2% of the total samples tested. The fruits that had been analysed were from imported and domestic origins, but no details are given on the origins of the fruits with positive results. This study was followed by a similar one between April 2016 and March 2021 (Steele *et al*., 2022). A total of 3,292 samples of frozen fruit were collected, including 3,100 samples of frozen berries and 192 samples of frozen pomegranate arils. Norovirus was detected in 12 samples of frozen berries (detection rate of 0.4%) and one sample of pomegranate arils (detection rate of 0.5%) (three norovirus GI and 10 norovirus GII) while HAV was not detected at all, representing a rate of detection of 0.4%.

Similarly, the United States Food and Drug Administration (US FDA) is currently conducting a survey of frozen berries (strawberries, raspberries, and blackberries) from domestic and imported origins[4]. They are aiming to analyse a total of 2,000 samples for HAV and norovirus for a period of two years. As of July 2022, respectively 431 and 689 samples of domestic and imported frozen berries have been analysed for HAV and norovirus by RT-qPCR. The rates of detection are 0.4% for HAV (three detections from domestic berries and two detections from imported berries), and 1.1% for norovirus (six detections from domestic berries and six from imported berries).

A recent publication from Italy reported similar detection rates (Pavoni *et al*., 2021). With the study spanning a period of six years, a total of 2749 samples of fresh and frozen berries yielded only five detections (0.18%), with two positive results for HAV and three for norovirus.

A 2012 New Zealand survey of pre-packaged ready-to-eat leafy vegetable salads reported a norovirus detection rate of 1% (3 positive samples out of 305 samples analysed) (Hewitt & Rivas, 2015). Norovirus GII was detected at a concentration of less than 50 genome copies per 25g.

[3] https://inspection.canada.ca/food-safety-for-industry/food-chemistry-and-microbiology/food-safety-testing-bulletin-and-reports/viruses-in-fresh-berries-and-frozen-fruits/eng/1506954705347/1506954705706
[4] https://www.fda.gov/food/sampling-protect-food-supply/microbiological-surveillance-sampling-fy-19-20-frozen-berries-strawberries-raspberries-and

The limitations of foodborne virus surveys in produce are noted by some authors (Macori *et al.*, 2018), however, other researchers advise that even with a low rate of virus detections, monitoring programmes are still useful to inform risk assessment activities (Li *et al.*, 2018).

7.3 RECOMMENDATIONS

In conclusion, the authors do not recommend proceeding with a microbiological survey in Stage 2 of the project. A microbiological survey for HAV and norovirus in imported frozen berries will require a very large number of samples and yield very limited meaningful results for the reasons discussed in section 7.2. Undertaking such a survey will not add anything significant to NZFS's current understanding of the microbiological risks associated with frozen raw berries.

At present, microbiological surveys of other frozen fruit and vegetables do not appear relevant either. This may be reconsidered, if there are specific questions that need to be addressed focusing on specific microorganisms in specific frozen fruit or vegetables.

8 Overall conclusions

The outbreak data and the survey findings with regards to frozen produce, strongly support consideration of strengthened food safety risk management measures for frozen berries to protect the health of the New Zealand public.

Additional microbiological surveys of other frozen fruit and vegetables are not required.

9 References

Bernard, H., Faber, M., Wilking, H., Haller, S., Höhle, M., Schielke, A., Ducomble, T., Siffczyk, C., Merbecks, S.S., Fricke, G., Hamouda, O., Stark, K., & Werber, D. (2014). Large multistate outbreak of norovirus gastroenteritis associated with frozen strawberries, Germany, 2012. Eurosurveillance, 19(8), 20719.

Bozkurt, H., Phan-Thien, K. Y., van Ogtrop, F., Bell, T., & McConchie, R. (2021). Outbreaks, occurrence, and control of norovirus and hepatitis A virus contamination in berries: A review. Critical Reviews in Food Science and Nutrition, 61(1), 116-138.

Center for Disease Control and Prevention (CDC) (2016a). 2016 - Multistate outbreak of hepatitis A linked to frozen strawberries (Final Update). https://www.cdc.gov/hepatitis/outbreaks/2016/hav-strawberries.htm

Center for Disease Control and Prevention (CDC) (2016b) Multistate Outbreak of Listeriosis Linked to Frozen Vegetables (Final Update). https://www.cdc.gov/listeria/outbreaks/frozen-vegetables-05-16/index.html.

Collier, M. G., Khudyakov, Y. E., Selvage, D., Adams-Cameron, M., Epson, E., Cronquist, A., Jervis, R. H., Lamba, K., Kimura, A.C., Sowadsky, R., Hassan, R., Park, S.Y., Garza, E., Elliott, A.J., Rotstein, D.S., Beal, J., Kuntz, T., Lance, S.E., Dreisch, R., …& Xu, F. (2014). Outbreak of hepatitis A in the USA associated with frozen pomegranate arils imported from Turkey: An epidemiological case study. The Lancet Infectious Diseases, 14(10), 976-981.

Cotterelle, B., Drougard, C., Rolland, J., Becamel, M., Boudon, M., Pinede, S., Traoré, O., Balay, K., Pothier, P., & Espié, E. (2005). Outbreak of norovirus infection associated with the consumption of frozen raspberries, France, March 2005. Weekly releases (1997–2007), 10(17), 2690.

EFSA Panel on Biological Hazards (BIOHAZ). (2013). Scientific Opinion on the risk posed by pathogens in food of non-animal origin. Part 1 (outbreak data analysis and risk ranking of food/pathogen combinations). EFSA Journal, 11(1), 3025.

EFSA (2018). Listeria monocytogenes: update on foodborne outbreak. https://www.efsa.europa.eu/en/press/news/180703

EFSA Panel on Biological Hazards (BIOHAZ), Koutsoumanis, K., Alvarez-Ordóñez, A., Bolton, D., Bover-Cid, S., Chemaly, M., ... & Allende, A. (2020). The public health risk posed by *Listeria monocytogenes* in frozen fruit and vegetables including herbs, blanched during processing. EFSA Journal, 18(4), e06092.

Enkirch, T., Eriksson, R., Persson, S., Schmid, D., Aberle, S. W., Löf, E., Wittesjö[7], B., Holmgren, B.,Johnzon, C., Gustafsson, E.X., Svensson, L.M., Lisa Labbé Sandelin, L., Richter, L., Lindblad, M., Brytting, M., Maritschnik, S., Tallo, T., Malm, T., Sundqvist[1], L.,& Ederth, J. L. (2018). Hepatitis A outbreak linked to imported frozen strawberries by sequencing, Sweden and Austria, June to September 2018. Eurosurveillance, 23(41), 1800528.

Einöder-Moreno, M., Lange, H., Grepp, M., Osborg, E., Vainio, K., & Vold, L. (2016). Non-heat-treated frozen raspberries the most likely vehicle of a norovirus outbreak in Oslo, Norway, November 2013. Epidemiology & Infection, 144(13), 2765-2772.

Falkenhorst, G., Krusell, L., Lisby, M., Madsen, S. B., Böttiger, B. E., & Mølbak, K. (2005). Imported frozen raspberries cause a series of norovirus outbreaks in Denmark, 2005. Weekly releases (1997–2007), 10(38), 2795.

Fell, G., Boyens, M., & Baumgarte, S. (2007). Tiefkühlfrüchte als Risikofaktor für Gastroenteritis-Ausbrüche durch Noroviren. Bundesgesundheitsblatt-Gesundheitsforschung-Gesundheitsschutz, 2(50), 230-236.

Fiset, M., Ramsay, D., & Gaulin, C. (2018). Éclosions de norovirus liées aux petits fruits. In Flash Vigie—Bulletin québécois de vigie de surveillance et d'intervention en protection de la santé publique (Vol. 13). Gouvernement du Quebec

Fitzgerald, M., Thornton, L., O'gorman, J., O'Connor, L., Garvey, P., Boland, M., ... & O'Flanagan, D. (2014). Outbreak of hepatitis A infection associated with the consumption of frozen berries, Ireland, 2013-linked to an international outbreak. Eurosurveillance, 19(43), 20942.

Food Safety Authority of Ireland. (2022). National Microbiological Survey and Consumer Habits in Relation to Frozen Vegetables, Fruits and Herbs. Monitoring & surveillance series – Microbiology

Franklin, N., Camphor, H., Wright, R., Stafford, R., Glasgow, K., & Sheppeard, V. (2019). Outbreak of hepatitis A genotype IB in Australia associated with imported frozen pomegranate arils. Epidemiology & Infection, 147.

Fresh Produce Safety Centre (2017). AU: Frozen berries Hepatitis A Virus outbreak fact sheet (2017). https://fpsc-anz.com/2017/06/03/au-frozen-berries-hepatitis-a-virus-outbreak-fact-sheet-2017/

Gillesberg - Lassen, S., Soborg, B., Midgley, S. E., Steens, A., Vold, L., Stene-Johansen, K., Rimhanen-Finne, R., Kontio, M., Löfdahl, M., Sundqvist, L., Edelstein, M., Jensen, T., Vestergaard, H.T., Fischer, T.K., Mølbak, K., & Ethelberg, S. (2013). Ongoing multi-strain food-borne hepatitis A outbreak with frozen berries as suspected vehicle: four Nordic countries affected, October 2012 to April 2013. Eurosurveillance, 18(17), 20467.

Guzman-Herrador, B. R., Panning, M., Stene-Johansen, K., Borgen, K., Einöder-Moreno, M., Huzly, D., Jensvoll, L., Lange, H., Maassen, S., Myking, S., Myrmel, M., Neumann-Haefelin, C., Nygård, K., Wenzel, J.J., Øye, A.K., & Vold, L. (2015). Importance of molecular typing in confirmation of the source of a national hepatitis A virus outbreak in Norway and the detection of a related cluster in Germany. Archives of virology, 160, 2823-2826.

Hjertqvist, M., Johansson, A., Svensson, N., Abom, P. E., Magnusson, C., Olsson, M., Hedlund, O., & Andersson, Y. (2006). Four outbreaks of norovirus gastroenteritis after consuming raspberries, Sweden, June-August 2006. Weekly releases (1997–2007), 11(36), 3038.

Hewitt, J. & Rivas, L. (2015). Microbiological Survey of Pre-Packaged Leafy Salads Available at Retail in New Zealand. MPI Technical Paper No: 2015/18. https://www.mpi.govt.nz/dmsdocument/12933-Microbiological-survey-of-pre-packaged-leafy-salads-available-at-retail-in-New-Zealand, accessed 17/03/2023

Ho, A. Y., Lopez, A. S., Eberhart, M. G., Levenson, R., Finkel, B. S., da Silva, A. J., ... & Herwaldt, B. L. (2002). Outbreak of cyclosporiasis associated with imported raspberries, Philadelphia, Pennsylvania, 2000. Emerging Infectious Diseases, 8(8), 783.

Horn, B., Lopez, L., Cressey, P. and Roos, R. (2015). Annual Report Concerning Foodborne Disease in New Zealand 2014. ESR Client Report FW15016, Christchurch, New Zealand

International Commission on Microbiological Specifications for Foods (ICMSF) (2005) Vegetables and vegetable products. In: ICMSF, Microorganisms in foods 6: microbial ecology of food commodities, 2nd edn. Kluwer Academic/Plenum Publishers..

International Commission on Microbiological Specifications for Foods (ICMSF) (2011). *Microorganisms in foods 8: use of data for assessing process control and product acceptance*. Springer.

Kääriäinen, S., Obach, D., Paspaliari, D. K., Tofferi, M., Nieminen, A., Pihlajasaari, A., ... & Rimhanen-Finne, R. (2022). *Salmonella* Typhimurium outbreak associated with frozen tomato cubes at a restaurant in western Finland, January to February 2021. Eurosurveillance, 27(41), 2200316.

King, N., Hewitt, J., Cressey, P., Perchec-Merien, A.M., & D'Sa, E. (2020). Discussion document update: pathogens in fresh fruit and vegetables in New Zealand. New Zealand Food Safety Technical report No: 2020/18. https://www.mpi.govt.nz/dmsdocument/40956/direct.

Korsager, B., Hede, S., Bøggild, H., Böttiger, B. E., & Mølbak, K. (2005). Two outbreaks of norovirus infections associated with the consumption of imported frozen raspberries, Denmark, May-June 2005. Weekly releases (1997–2007), 10(25), 2729.

Le Guyader, F. S., Mittelholzer, C., Haugarreau, L., Hedlund, K. O., Alsterlund, R., Pommepuy, M., & Svensson, L. (2004). Detection of noroviruses in raspberries associated with a gastroenteritis outbreak. International journal of food microbiology, 97(2), 179-186.

Li, D., Butot, S., Zuber, S., & Uyttendaele, M. (2018). Monitoring of foodborne viruses in berries and considerations on the use of RT-PCR methods in surveillance. Food Control, 89, 235-240.

Loharikar, A., Newton, A., Rowley, P., Wheeler, C., Bruno, T., Barillas, H., Pruckler, J., Theobald, L., Lance, S., Brown, J.M., Barzilay, E.J., Arvelo, W., Mints, E., & Fagan, R. (2012). Typhoid fever outbreak associated with frozen mamey pulp imported from Guatemala to the western United States, 2010. Clinical infectious diseases, 55(1), 61-66.

Lopez, L. D., Roos, R., Cressey, P. J., Horn, B., & Lee, J. (2016). Foodborne disease in New Zealand 2015. Ministry for Primary Industries.

Macori, G., Gilardi, G., Bellio, A., Bianchi, D. M., Gallina, S., Vitale, N., Gullino, M.L., & Decastelli, L. (2018). Microbiological parameters in the primary production of berries: a pilot study. Foods, 7(7), 105.

Mäde, D., Trübner, K., Neubert, E., Höhne, M., & Johne, R. (2013). Detection and typing of norovirus from frozen strawberries involved in a large-scale gastroenteritis outbreak in Germany. Food and environmental virology, 5, 162-168.

Maunula, L., Roivainen, M., Keränen, M., Mäkelä, S., Söderberg, K., Summa, M., ... & Niskanen, T. (2009). Detection of human norovirus from frozen raspberries in a cluster of gastroenteritis outbreaks. Eurosurveillance, 14(49), 19435.

McLauchlin, J., Aird, H., Amar, C., Barker, C., Dallman, T., Lai, S., ... & Willis, C. (2021). An outbreak of human listeriosis associated with frozen sweet corn consumption: Investigations in the UK. International Journal of Food Microbiology, 338, 108994.

Ministry of Health. 2020. Eating and Activity Guidelines for New Zealand Adults: Updated 2020. Wellington: Ministry of Health.

Mollers, M., Boxman, I. L., Vennema, H., Slegers-Fitz-James, I. A., Brandwagt, D., Friesema, I. H., ... & Te Wierik, M. J. (2018). Successful use of advertisement pictures to assist recall in a food-borne hepatitis A outbreak in the Netherlands, 2017. Food and Environmental Virology, 10(3), 272-277.

Müller, L., Schultz, A. C., Fonager, J., Jensen, T., Lisby, M., Hindsdal, K., Krusell, L., Eshøj, A., Møller, L.T., Porsbo, L.J., Böttiger, B.E., Kuhn, K., Engberg, J., & Ethelberg, S. (2015). Separate norovirus outbreaks linked to one source of imported frozen raspberries by molecular analysis, Denmark, 2010–2011. Epidemiology & Infection, 143(11), 2299-2307.

Nasheri, N., Vester, A., & Petronella, N. (2019). Foodborne viral outbreaks associated with frozen produce. Epidemiology & Infection, 147.

Nordic outbreak investigation team. (2013). Joint analysis by the Nordic countries of a hepatitis A outbreak, October 2012 to June 2013: Frozen strawberries suspected. Eurosurveillance, 18(27).

Palumbo, M., Harris, L. J., & Danyluk, M. D. (2014). Survival of Foodborne Pathogens on Berries: FSHN13-12/FS236, 11/2013. EDIS, 2014(7).
Pavoni, E., Bertasi, B., Galuppini, E., Mangeri, L., Meletti, F., Tilola, M., ... & Losio, M. N. (2021). Detection of Hepatitis A Virus and Norovirus in Different Food Categories: A 6-Year Survey in Italy. Food and Environmental Virology, 1-8.

Perchec, A.M. & Esguerra, C. New Zealand microbiological risk ranking of imported fruit and vegetables. New Zealand Food Safety Technical Paper N0: 2023/11.
https://www.mpi.govt.nz/dmsdocument/56587/direct

Public Health Agency of Canada (2021a). Public Health Notice: Outbreak of Hepatitis A infections; consumers advised not to eat Nature's Touch Organic Berry Cherry Blend frozen fruit. Public Health Notices. https://www.canada.ca/en/public-health/services/public-health-notices/2016/public-health-

notice-outbreak-hepatitis-a-infections-consumers-advised-nature-s-touch-organic-berry-cherry-blend-frozen-fruit.html

Public Health Agency of Canada (2021b). Public Health Notice: Outbreak of hepatitis A infections linked to frozen mangoes. Public Health Notices. https://www.canada.ca/en/public-health/services/public-health-notices/2021/outbreak-hepatitis-a-infections-frozen-mangoes.html

Public Health Agency of Canada (2021c). Public Health Notice: Outbreak of Salmonella infections linked to frozen whole kernel corn. Public Health Notices. https://www.canada.ca/en/public-health/services/public-health-notices/2021/outbreak-salmonella-infections.html

Rispens, J. R., Freeland, A., Wittry, B., Kramer, A., Barclay, L., Vinjé, J., ... & Houston, K. (2020). Notes from the Field: Multiple Cruise Ship Outbreaks of Norovirus Associated with Frozen Fruits and Berries—United States, 2019. Morbidity and Mortality Weekly Report, 69(16), 501.

Ruscher, C., Faber, M., Werber, D., Stark, K., Bitzegeio, J., Michaelis, K., ... & Enkelmann, J. (2020). Resurgence of an international hepatitis A outbreak linked to imported frozen strawberries, Germany, 2018 to 2020. Eurosurveillance, 25(37), 1900670.

Sarvikivi, E., Roivainen, M., Maunula, L., Niskanen, T., Korhonen, T., Lappalainen, M., & Kuusi, M. (2012). Multiple norovirus outbreaks linked to imported frozen raspberries. Epidemiology & Infection, 140(2), 260-267.

Saupe, A. A., Rounds, J., Sorenson, A., Hedeen, N., Bagstad, E., Reinberg, R., ... & Smith, K. (2020). Outbreak of norovirus gastroenteritis associated with ice cream contaminated by frozen raspberries from China; Minnesota, USA, 2016. Clinical Infectious Diseases, 2021 ;73(11) : e3701–7

Scavia, G., Alfonsi, V., Taffon, S., Escher, M., Bruni, R., De Medici, D., … & Rizzo, C. (2017). A large, prolonged outbreak of hepatitis A associated with consumption of frozen berries, Italy, 2013–14. Journal of Medical Microbiology, 66(3), 342-349.

Severi, E., Verhoef, L., Thornton, L., Guzman-Herrador, B. R., Faber, M., Sundqvist, L., Rimhanen-Finne, R., Roque-Afonso, A.M., Ngui, S.L., Allerberger, F., Baumann-Popczyk, A., Muller, L., Parmakove, K., Alfonsi, V., Tavoshi, L., Vennema, H., Fitzgerald, M., Myrmel, M., Gertler, M., Ederth, J., … & Rizzo, C. (2015). Large and prolonged food-borne multistate hepatitis A outbreak in Europe associated with consumption of frozen berries, 2013 to 2014. Eurosurveillance, 20(29), 21192.

Steele, M., Lambert, D., Bissonnette, R., Yamamoto, E., Hardie, K., & Locas, A. (2022). Norovirus GI and GII and hepatitis A virus in berries and pomegranate arils in Canada. International Journal of Food Microbiology, 379, 109840.

Swinkels, H. M., Kuo, M., Embree, G., Andonov, A., Henry, B., & Buxton, J. A. (2014). Hepatitis A outbreak in British Columbia, Canada: The roles of established surveillance, consumer loyalty cards and collaboration, February to May 2012. Eurosurveillance, 19(18), 20792.

Tavoschi, L., Severi, E., Niskanen, T., Boelaert, F., Rizzi, V., Liebana, E., ... & Coulombier, D. (2015). Food-borne diseases associated with frozen berries consumption: a historical perspective, European Union, 1983 to 2013. Eurosurveillance, 20(29), 21193.

Terio, V., Bottaro, M., Di Pinto, A., Catella, C., Chironna, M., Bozzo, G., ... & Martella, V. (2015). Outbreak of hepatitis A in Italy associated with frozen redcurrants imported from Poland: A case study. Food and Environmental Virology, 7(3), 305-308.

Wadamori, Y., Gooneratne, R., & Hussain, M. A. (2017). Outbreaks and factors influencing microbiological contamination of fresh produce. Journal of the Science of Food and Agriculture, 97(5), 1396-1403.

World Health Organization. 2014. Multicriteria-based ranking for risk management of food-borne parasites: Microbiological risk assessment series 2014. No. 23. World Health Organization, Rome, Italy, 302 pp.

Appendix A

Table 1: Outbreaks associated with frozen produce (2000-2021) from New Zealand and overseas.

Year	Reporting country	Pathogen	Frozen produce	Country of origin	Number of cases	Setting	Food vehicle	Reference
2001	Sweden	Norovirus	Raspberries	NR[5]	30	retail (bakery)	cake with cream topping	Le Guyader *et al*. (2004)
2003	Sweden	Norovirus	Raspberries	Serbia, Montenegro	51	NR	ND[6]	Tavoschi *et al.* (2015)
2005	Denmark	Norovirus	Raspberries	Poland	450	hospital	ND	Falkenhorst *et al*. (2005), Korsager *et al*. (2005)
2005	Denmark	Norovirus	Raspberries	Poland	70	nursing home	ND	Falkenhorst *et al*. (2005), Korsager *et al*. (2005)
2005	Denmark	Norovirus	Raspberries	Poland	400	catering	ND	Falkenhorst *et al*. (2005), Korsager *et al*. (2005)
2005	Denmark	Norovirus	Raspberries	Poland	40	restaurant	ND	Falkenhorst *et al*. (2005), Korsager *et al*. (2005)
2005	Denmark	Norovirus	Raspberries	Poland	50	nursing home	ND	Falkenhorst *et al*. (2005), Korsager *et al*. (2005)
2005	Denmark	Norovirus	Raspberries	Poland	33	company	cold dessert (buttermilk, fresh cheese, and berries)	Falkenhorst *et al*. (2005), Korsager *et al*. (2005)
2005	France	Norovirus	Raspberries	NR	75	school	cold dessert (fresh cheese and berries)	Cotterelle *et al*. (2005)
2005	Germany	Norovirus	Blackberries	Poland?	241	canteen	yoghurt	Fell *et al*. (2007)
2006	Denmark	Norovirus	Raspberries	Serbia, Montenegro	25	NR	ND	Tavoschi *et al*. (2015)
2006	Sweden	Norovirus	Raspberries	China	12	private function	cake	Hjertqvist *et al*. (2006)
2006	Sweden	Norovirus	Raspberries	China	10	family	cheesecake	Hjertqvist *et al*. (2007)
2006	Sweden	Norovirus	Raspberries	China	12	school	drinks	Hjertqvist *et al*. (2008)

[5] NR = Not Reported

[6] ND= No Data

Year	Reporting country	Pathogen	Frozen produce	Country of origin	Number of cases	Setting	Food vehicle	Reference
2006	Sweden	Norovirus	Raspberries	China	9	catering	dessert	Hjertqvist *et al*. (2009)
2006	The Netherlands	Norovirus	Raspberries	chile	45	NR	ND	Tavoschi *et al*. (2015)
2007	Denmark	Norovirus	Raspberries	NR	9	NR	ND	Tavoschi *et al*. (2015)
2009	Belgium	*Staphylococcus aureus*	Beans	NR	14	NR	ND	EFSA (2013)
2009	Finland	Norovirus	Raspberries	Poland	501	school	dessert	Sarvikivi *et al*. (2012)
2009	Finland	Norovirus	Raspberries	Poland	5	catering	ND	Sarvikivi *et al*. (2012)
2009	Finland	Norovirus	Raspberries	Poland	50	catering	ND	Sarvikivi *et al*. (2012)
2009	Finland	Norovirus	Raspberries	Poland	65	restaurant	ND	Sarvikivi *et al*. (2012)
2009	Finland	Norovirus	Raspberries	Poland	22	catering	ND	Sarvikivi *et al*. (2012)
2009	Finland	Norovirus	Raspberries	Poland	30	catering	ND	Sarvikivi *et al.* (2012)
2009	Finland	Norovirus	Raspberries	Poland	11	school	ND	Sarvikivi et al. (2012)
2009	Finland	Norovirus	Raspberries	Poland	10	catering	ND	Sarvikivi *et al.* (2012)
2009	Finland	Norovirus	Raspberries	Poland	32	restaurant	ND	Sarvikivi *et al*. (2012)
2009	Finland	Norovirus	Raspberries	Poland	12	restaurant	ND	Sarvikivi *et al.* (2012)
2009	Finland	Norovirus	Raspberries	Poland	11	hotel	ND	Sarvikivi *et al.* (2012)
2009	Finland	Norovirus	Raspberries	Poland	128	restaurant	ND	Sarvikivi *et al.* (2012
2009	Finland	Norovirus	Raspberries	Poland	13	catering	ND	Sarvikivi *et al.* (2012)
2009	Finland	Norovirus	Raspberries	Poland	15	restaurant	ND	Maunula *et al*. (2009)
2009	Finland	Norovirus	Raspberries	Poland	46	daycare centre	berry dessert	Maunula *et al*. (2009)
2009	Finland	Norovirus	Raspberries	Poland	15	cafeteria	ND	Maunula *et al*. (2009)
2009	Sweden	Norovirus	Raspberries	NR	130	school, kindergarten	ND	EFSA (2013), Nasheri *et al*. (2019)
2010	Denmark	Norovirus	Raspberries	Serbia	30	company canteen	cake	EFSA (2013), Müller *et al*. (2015)
2010	Denmark	Norovirus	Raspberries	Serbia	60	conference centre	smoothie	Müller *et al*. (2015), EFSA (2013)
2010	Denmark	Norovirus	Raspberries	NR	5	NR	ND	EFSA (2013)
2010	Finland	Norovirus	Raspberries	NR	43	workplace, school	ND	EFSA (2013), Tavoschi *et al*. (2015)

Year	Reporting country	Pathogen	Frozen produce	Country of origin	Number of cases	Setting	Food vehicle	Reference
2010	Finland	Norovirus	Raspberries	NR	90			EFSA (2013), Tavoschi *et al*. (2015)
2010	Sweden	Norovirus	Raspberries	NR	8	retail	ND	EFSA (2013), Nascheri *et al*. (2019)
2010	Sweden	Norovirus	Raspberries	NR	21	NR	ND	EFSA (2013)
2010	Sweden	Norovirus	Strawberries	NR	7	school	ND	EFSA (2013), Nascheri *et al*. (2019)
2010	Sweden	Norovirus	Raspberries	Poland	2	NR	ND	Tavoschi *et al*. (2015)
2010	United States	*Salmonella* Typhi	Mamey pulp	Guatemala	12	retail, market, restaurant	fruit drink	Loharikar *et al*. (2012)
2011	Denmark	Norovirus	Raspberries	Serbia	15	NR	layer cake	EFSA (2013), Nascheri *et al*. (2019)
2011	Denmark	Norovirus	Raspberries	China	8	private function	cake	EFSA (2013), Nascheri *et al*. (2019)
2011	Denmark	Norovirus	Raspberries	Serbia	12	private function	cake	EFSA (2013), Tavoschi *et al*. (2015)
2011	Denmark	Norovirus	Raspberries	Serbia	25	NR	cake	EFSA (2013), Tavoschi *et al*. (2015)
2011	Denmark	Norovirus	Raspberries	Serbia	2	canteen	ND	EFSA (2013), Müller *et al*. (2015)
2011	Denmark	Norovirus	Raspberries	Serbia	30	canteen	mousse	EFSA (2013), Müller *et al*. (2015)
2011	Denmark	Norovirus	Raspberries	Serbia	5	café	smoothie	EFSA (2013), Müller *et al*. (2015)
2011	Denmark	Norovirus	Raspberries	Serbia	5	home	smoothies	EFSA (2013), Tavoschi *et al*. (2015)
2011	Denmark	Norovirus	Raspberries	Serbia	113	hospital	ND	EFSA (2013), Tavoschi *et al*. (2015)
2011	Denmark	Norovirus	Raspberries	Serbia	6	NR	ND	EFSA (2013), Tavoschi *et al*. (2015)
2011	Finland	Norovirus	Raspberries	NR	19	farm?	ND	EFSA (2013), Nasheri *et al*.- (2019)
2011	Finland	Norovirus	Raspberries	NR	41	hospital	ND	EFSA (2013), Nascheri *et al*. (2019)

Year	Reporting country	Pathogen	Frozen produce	Country of origin	Number of cases	Setting	Food vehicle	Reference
2011	Finland	Norovirus	Berries[7]	NR	9	hospital	ND	EFSA (2013), Nascheri *et al*. (2019)
2011	Germany	Norovirus	Raspberries	Germany?	18	hospital	dessert (with buttermilk)	Tavoschi *et al*. (2015), Nascheri *et al*. (2019)
2011	Sweden	Norovirus	Raspberries	NR	24	restaurant	ND	EFSA (2013), Nascheri *et al*. (2019)
2011	Sweden	Norovirus	Raspberries	NR	82	restaurant	sauce	Nasheri *et al*. (2019)
2012	Canada	HAV	Pomegranate arils	Egypt	6	retail	ND	Swinkels *et al*. (2014)
2012	Germany	Norovirus	Raspberries	China	10950	catering	dessert	Mäde *et al*. (2013), Bernard *et al*. (2014)
2013	Norway	Norovirus	Raspberries	NR	74	private function	raspberry mousse	Einöder-Moreno *et al*. (2016)
2013	Finland	Norovirus	Raspberries	Poland	29	workplace, school	ND	Tavoschi *et al*. (2015), Nascheri *et al*. (2019)
2013	Denmark	Norovirus	Raspberries	Poland, Serbia	13	NR	ND	Tavoschi *et al*. (2015)
2013	United States	HAV	Pomegranate arils	Turkey	165	retail	ND	Collier *et al*. (2014)
2012	Denmark	HAV	Strawberries	North Africa	66	retail	smoothie	Gillesberg-Lassen *et al*. (2013), Nordic Outbreak Investigation Team (2013)
2012	Finland	HAV	Strawberries	North Africa	13	retail	ND	
2012	Norway	HAV	Strawberries	North Africa	7	retail	ND	
2012	Sweden	HAV	Strawberries	North Africa	17	retail	ND	
2013	Austria	HAV	Mixed berries	several countries	1	retail	often smoothies, cakes	Severi *et al*. (2015)
2013	Bulgaria	HAV	Mixed berries	several countries	1	multiple settings		Severi *et al*. (2015)
2013	Denmark	HAV	Mixed berries	several countries	1	multiple settings		Severi *et al*. (2015)
2013	Finland	HAV	Mixed berries	several countries	12	multiple settings		Severi *et al*.(2015)
2013	France	HAV	Mixed berries	several countries	5	multiple settings		Severi *et al*. (2015)

[7] For this entry (and the following) mentioning only "berries", the references do not indicate the type of specific berries or if there are a mix of different berries.

Year	Reporting country	Pathogen	Frozen produce	Country of origin	Number of cases	Setting	Food vehicle	Reference
2013	Germany	HAV	Mixed berries	several countries	34	multiple settings		Severi *et al*.(2015)
2013	Italy	HAV	Mixed berries	several countries	1438	home, commercial settings		Scavia *et al*. (2017), Severi *et al*. (2015), Terio *et al.* (2015)
2013	Norway	HAV	Mixed berries	several countries	33	multiple settings	berry-mix cake	Guzman-Herrador *et al*. (2015), Severi-2015)
2013	Poland	HAV	Mixed berries	several countries	6	multiple settings	often smoothies, cakes	Severi *et al*. (2015)
2013	Sweden	HAV	Mixed berries	several countries	11	multiple settings		Severi *et al*. (2015)
2013	The Netherlands	HAV	Mixed berries	several countries	15	multiple settings		Severi *et al*. (2015)
2013	England	HAV	Mixed berries	several countries	5	multiple settings		Severi *et al*. (2015)
2013	Ireland	HAV	Mixed berries	several countries	27	multiple settings		Severi *et al*. (2015), Fitzgerald *et al.* (2014)
2014	New Zealand	Norovirus	Raspberries	NR	10	restaurant, café, bakery	cake (trifle berry)	Horn *et al*. (2015)
2014	Sweden	Norovirus	Raspberries	Serbia	23	school, kindergarten	ND	Nascheri *et al*. (2019)
2014	Denmark	Norovirus	Raspberries	Serbia	9	retail	ND	Nascheri *et al*. (2019)
2014	Denmark	Norovirus	Strawberries	NR	11	school	dessert	Nascheri *et al*. (2019)
2014	Germany	Norovirus	Berries[2]	NR	240	schools, nurseries	fruit jelly	Nascheri *et al*. (2019)
2015	Sweden	Norovirus	Raspberries	Serbia	65	institution	ND	Nascheri *et al*. (2019)
2015	Germany	Norovirus	Raspberries	NR	73	school, kindergarten	panna cotta	Nascheri *et al*. (2019)
2015	Australia	HAV	Strawberries	China	35	retail	ND	Wadamori *et al*. (2016)
2015	New Zealand	HAV	Mixed berries	China	7	retail	ND	Lopez *et al.* (2016)
2015	Germany	*Clostridium perfringens*	Onions	NR	3	canteen or workplace catering	ND	EFSA (2020)
2015	United States	Norovirus	Strawberries	NR	123	NR	sauce	Bozkurt *et al*. (2021)

Year	Reporting country	Pathogen	Frozen produce	Country of origin	Number of cases	Setting	Food vehicle	Reference
2016	Canada	HAV	Berries	NR	25	retail		Public Health Agency of Canada (2021a)
2016	United States	Norovirus	Raspberries	China	15	retail	ice-cream	Saupe *et al*. (2020)
2016	United States	HAV	Strawberries	Egypt	143	café	smoothie	CDC (2016a)
2016	United States	Norovirus	Mixed berries	NR	19	private function	dessert	Bozkurt *et al*. (2021)
2016	United States	*Listeria monocytogenes*	Vegetables (corn, peas, onions)	United States	9	retail	ND	CDC (2016b)
2017	Canada	Norovirus	Raspberries	China	345	retirement homes	desserts, coulis, yoghurts, veloutés	Fiset *et al.* (2018)
2017	Canada	Norovirus	Raspberries	China	187	hotel (conference)		Fiset *et al.* (2018)
2017	Canada	Norovirus	Raspberries	China	30	childcare centre		Fiset *et al.* (2018)
2017	Canada	Norovirus	Raspberries	China	7	childcare centre		Fiset *et al.* (2018)
2017	Canada	Norovirus	Raspberries	China	46	retirement home		Fiset *et al.* (2018)
2017	Canada	Norovirus	Raspberries	China	109	retirement home		Fiset *et al.* (2018)
2017	Australia	HAV	Mixed berries	Canada and China	4	retail	ND	Fresh Produce Safety Centre (2017)
2017	The Netherlands	HAV	Raspberries	Bulgaria	14	retail	ND	Mollers *et al*. (2018)
2018	Australia	HAV	Pomegranate arils	Egypt	30	retail, restaurant	salad	Franklin *et al*. (2019)
2018	Austria	HAV	Strawberries	Poland	14	restaurant	ice cream	Enkirch *et al*. (2018)
2018	European Countries	*Listeria monocytogenes*	Mixed vegetables	Hungary	47	retail	ND	EFSA (2018), McLauchlin *et al.* (2021)
2018	Sweden	HAV	Strawberries	Poland	20	juice bars, restaurants, school	smoothies, desserts,	Enkirch *et al*.(2018)
2019	United States	Norovirus	Raspberries	China	188	cruise	smoothie	Rispens et al. (2020)

Year	Reporting country	Pathogen	Frozen produce	Country of origin	Number of cases	Setting	Food vehicle	Reference
2021	Canada	HAV	Mangoes	Mexico	3	retail	ND	Public Health Agency of Canada (2021b)
2018-2020	Germany	HAV	Strawberries	Egypt	65	retail	dessert	Ruscher *et al*. (2020)
2021	Canada	*Salmonella* spp.	Corn	NR	118	retail	ND	Public Health Agency of Canada (2021c)
2021	Finland	*Salmonella* spp.	Tomato	NR	49	restaurant	salad	Kääriäinen *et al*. (2022)

Appendix B

Table 2: Key findings from household user survey

Questions	Results										
Information on user											
• basic demographic information (e.g. age, gender, ethnicity, residence, income, household composition) • who typically buys the produce, who prepares the food at home and who consumes them	Demographics consistent with national profile (except age and ethnicity)										
	Age			**Gender**	**Ethnicity**		**Residence**		**Household consumers**		
	31% 30-44 y old			54% women	69% Eu, 18% Asian		36% Auckland		62% respondent (with 69% 18-29 y, 66% women) 66% other adult		
Information on produce used											
• the types of frozen raw produce they buy and use • the proportions or volumes of each type of produce bought over a defined period *(last 6 months)* • origin of the frozen raw produce: imported or New Zealand produced; do they have a preference • where they source the frozen raw produce from (e.g. supermarket, specialty shop, green grocers)		**Berries** 90% NETT (use at least one type)				**Other fruits** 60% NETT (use at least one type)			**Vegetables** 25% NETT (use at least one type)			**Herbs** 8% NETT
		Blueberry	Raspberry	Strawberry	Mixed berries	Mango	Banana	Mixed fruits	Spinach	Carrot	Mixed Veg	
	Proportions bought	72%	66%	62%	68%	37%	24%	27%	10%	10%	12%	-
	Volumes used	1,782T	1,410T	1,601T	7,038T	1,535T	1,221T	2,171T	251T	217T	1,285T	438T
Purchase	**Supermarket**	96%				93%			94%			76%
	Dairy	3%				4%			4%			10%
	Asian/Indian store	3%				4%			5%			15%
	Brands	Pams	54%			Pams	32%		Watties	65%		*NA*
		Fruzio	42%			Orchard Gold	23%		McCain	56%		
		Orchard Gold	40%			Fruzio	17%		Pams	47%		
		Woolworths	33%			Oob	14%		Birds Eye	26%		
	imported produce	>99 %				98%			99%			*NA*
	only NZ-grown	15% NETT				16% NETT			42% NETT			
	Impact	53% said country of origin has important or moderate impact on what they buy										

Information on final food products

- the types of foods the frozen raw produce are used in
- how they handle the frozen produce and prepare the food (e.g. thawed before using, blanched before using, blended using a blender/pureed or used whole, combined with other ingredients, used immediately after preparation or prepared in large amounts and stored)
- how frequent is the food prepared and consumed at home
- when/how is the food consumed (e.g. breakfast, meal replacer as part of a diet plan, snack)
- aside from the home, where else do they consume uncooked blended beverages and desserts

		Food made with frozen produce									Treatment		
		Smoothies	Slushies	Puddings	Ice-cream	Yoghurts	Sorbets	Mousses	Dips	Baby food	Added straight	Defrosted	Blanched
Berries		81%	40%	38%	33%	26%	23%	16%	3%	8%	84%	30%	3%
Other fruits		50%	26%	16%	23%	16%	16%	9%	5%	7%	77%	32%	4%
Vegetables		14%	5%	5%	3%	4%	4%	4%	13%	13%	57%	44%	12%
Herbs		3%	3%	2%	2%	2%	2%	2%	6%	3%	47%	52%	17%
Consumption ≥ once a week		51%	16%	9%	9%	15%	8%	6%	6%	8%			
Storage	none	90%	79%	44%	31%	33%	50%	40%	39%	36%			
	chiller	10%	15%	60%	12%	65%	33%	52%	57%	44%			
	freezer	4%	14%	12%	73%	14%	33%	17%	18%	42%			
	RT	1%	2%	1%	1%	4%	1%	3%	3%	4%			

Table **3**. Key findings from food service user survey

Questions	Results										
Information on user											
• nature of the business, their targeted market, geographical location	**Type**				**Location**			21% part of franchise			
	Café 64%, Restaurant 24%, Take-away 13%, Catering 12%				Auckland 18%, Canterbury 16%, Otago 14%, Wellington 12%			28% qualified for the survey			
Information on produce used											
• the types of frozen raw produce they buy and use • proportions or volumes of each type of produce used over a defined period • origin of the frozen raw produce: imported or New Zealand produced • where they source the frozen raw produce from (e.g. retail outlet, wholesaler, importer); if possible, name of business and brand of product		**Berries**				**Other fruits**			**Vegetables**			
		Blueberry	Raspberry	Strawberry	Mixed berries	Mango	Banana	Pineapple	Pea	Avocado	Carrots	Spinach
	Proportions bought	56%	40%	38%	46%	80%	30%	17%	27%	26%	17%	17%
	Volumes used	301T	97T	159T	170T	298T	486T	244T	6T	52T	6T	2T
	Purchase **Wholesalers**	**89%**				(Bidfood 70%, Gilmours 21%)						
	Supermarkets	**15%**				(Countdown 44% PaknSave 40% New World 24%)						
	Importers	**4%**				(Bidfood 50%)						
	Brands	Smart Choice 24% Sujon 24%				Smart Choice 25% Sujon 22%			Watties 45% Smart Choice 14%			
		Gilmours 12% Fruzio 10%				Fruzio 13%			Talleys (NZ grown only) 15%			
	Origin	100% purchase brands with imported produce										

Information on final food products

- how they handle the frozen produce and prepare the food (e.g. thawed before using, blanched before using, blended using a blender/pureed or used whole, combined with other ingredients, used immediately after preparation or prepared in large amounts and stored)
- size per serving
- number of servings sold per specified time period
- general profile of people who buy the uncooked blended beverage or dessert (e.g. age, gender, etc)
- any consumer information provided by the business (e.g. list of ingredients in different beverages)

		Food made with frozen produce									Treatment			Storage			
		Smoothies	Shakes & slushies	Cocktails	Yoghurts (drinks & frozen)	Ice-creams	Sorbets	Mousses	Puddings	Dips, sauces	Added straight	Defrosted	Blanched	None	Chiller	Freezer	RT
Berries	Blueberry	85%	7%	4%	12%	13%	2%	2%	20%	4%	82%	15%	1%	74%	12%	13%	1%
	Boysenberry	74%	13%	3%	18%	18%	3%	3%	24%	5%							
	Raspberry	76%	6%	6%	14%	10%	4%	4%	24%	5%							
	Strawberry	84%	9%	5%	13%	13%	3%	1%	20%	6%							
	Mixed berries	82%	7%	11%	16%	11%	4%	1%	18%	5%							
Frui	Bananas	97%	3%	0%	6%	6%	0%	0%	5%	0%	88%	8%	3%	77%	10%	14%	0%
	Mangoes	89%	4%	2%	8%	4%	3%	0%	7%	0%							
Vegetables		?	?	?	?	?	?	?	?	?	39%	50%	8%	41%	52%	4%	3%
Consumers	Demographics	Age				Gender				Ethnicity				Location			
	All types	Equal, in line with general profile				49% men, 51% women				78% EU, 16% Asian				ACK 35%, Canterbury 23%, WG 11%			
	Smoothies	higher for 30-44 y				54% women				68% EU, 24% Asian				ACK 39%, Canterbury 10%, WG 11%			
	Frequency NETT last month	32%	23% - 12%	19%	45% – 16%	67%	22%	17%	31%	?							
Place of purchase	Restaurant	4%	17-5%	31%	3%	11%	16%	22%	26%	?							
	Café	42%	26-11%	7%	13%	10%	15%	15%	22%	?							
	Juice/smoothie bar	27%	15-18%	4%	11-20%	4%	11%	8%	4%	?							
	Other	14%	35-47%	9%	58-46%	47-20%	47%	38%	29-9%	?							