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SCIENTIFIC OPINION

Scientific Opinion on the risk posed by pathogens in food of non-animal origin. Part 2 (*Salmonella* in melons)[1]

EFSA Panel on Biological Hazards (BIOHAZ)[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

ABSTRACT

Melons and watermelons are ready-to-eat foods, with an internal pH of 5.1 to 6.7 and can be consumed whole, as fresh-cut products or as fresh juices. Epidemiological data from the EU identified one salmonellosis outbreak associated with consumption of both pre-cut and whole melon between 2007 and 2012. Risk factors for melon and watermelon contamination by *Salmonella* were considered in the context of the whole food chain, together with available estimates of *Salmonella* occurrence and mitigation options relating to prevention of contamination and the relevance of microbiological criteria. It was concluded that each farm environment represents a unique combination of risk factors that can influence occurrence and persistence of *Salmonella* in melon and watermelon production. Appropriate implementation of food safety management systems including Good Agricultural Practices (GAP), Good Hygiene Practices (GHP) and Good Manufacturing Practices (GMP), should be primary objectives of producers. It is currently not possible to assess the suitability of an EU-wide *E. coli* Hygiene Criterion at primary production. The existing Process Hygiene Criterion for *E. coli* in pre-cut melons and watermelons aims to indicate the degree to which GAP, GHP, GMP or Hazard Analysis and Critical Control Points (HACCP) programmes have been implemented. There are Food Safety Criteria for the absence of *Salmonella* in 25g samples placed on the market during their shelf life of ready-to-eat pre-cut melon and watermelon and unpasteurised melon and watermelon juices. A Food Safety Criterion for *Salmonella* in whole melons and watermelons could be considered as a tool to communicate to producers and processors that *Salmonella* should not be present in the product. Since the occurrence of *Salmonella* is likely to be low, testing of whole melons or watermelons for this bacterium could be limited to instances where other factors indicate breaches in GAP, GHP, GMP or HACCP programmes.

KEY WORDS

melons, microbiological criteria, microbiological risk factors, mitigation options, *Salmonella*

1 On request from the European Commission, Question No EFSA-Q-2013-00178, adopted on 11 September 2014.

2 Panel members: Olivier Andreoletti, Dorte Lau Baggesen, Declan Bolton, Patrick Butaye, Paul Cook, Robert Davies, Pablo S. Fernandez Escamez, John Griffin, Tine Hald, Arie Havelaar, Kostas Koutsoumanis, Roland Lindqvist, James McLauchlin, Truls Nesbakken, Miguel Prieto Maradona, Antonia Ricci, Giuseppe Ru, Moez Sanaa, Marion Simmons, John Sofos and John Threlfall. Correspondence: biohaz@efsa.europa.eu

3 Acknowledgement: The Panel wishes to thank the members of the Working Group on risk posed by pathogens in food of non-animal origin Part 2: Ana Allende, Nigel Cook, Paul Cook, James McLauchlin, Christophe Nguyen-The, Birgit Nørrung and Mieke Uyttendaele for the preparatory work on this scientific opinion and EFSA staff: Maria Teresa da Silva Felicio and Ernesto Liebana Criado for the support provided to this scientific opinion.

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SUMMARY

The European Commission asked EFSA's Panel on Biological Hazards (BIOHAZ Panel) to prepare a scientific Opinion on the public health risk posed by pathogens that may contaminate food of non-animal origin (FoNAO). The outcomes of the first and second terms of reference, addressed in a previous Opinion, were discussed between risk assessors and risk managers in order to decide which food/pathogen combinations should be given priority for the other three terms of reference. This is the third Opinion out of five and addresses the risk from *Salmonella* in melons. The terms of reference are to: (i) identify the main risk factors for melons, including agricultural production systems, origin and further processing; (ii) recommend possible specific mitigation options and to assess their effectiveness and efficiency to reduce the risk for humans posed by *Salmonella* in melons and (iii) recommend, if considered relevant, microbiological criteria for *Salmonella* in melons.

The term melon usually refers to members of the plant family *Cucurbitaceae*, which are edible, sweet-fleshed and usually large, multiple-seeded fruit. In botanical terms, melons fall into two plant genera: *Citrullus* to which the watermelon belongs and *Cucumis*, which contains all commonly cultivated types of melon other than watermelons. A wide range of melon and watermelon cultivars are grown, the most common being galia, charentais, cantaloupe, honeydew and piel de sapo, together with seeded and seedless cultivars of watermelon.

The Guidelines on Good Agricultural Practices (GAP) indicate that melons need pre-cooling soon after harvest to reduce field heat. Almost all, if not all of the melons and watermelons, are sensitive to chilling but minimum temperatures at which they can be stored vary between cultivars. For instance, cantaloupe melons can be stored between 2-5 °C while honeydew melons withstand temperatures between 10-14 °C. The majority of watermelons and other cultivated types of melon are typically used whole or as fresh-cut products and they can also be processed into fresh juices. Fresh melon and watermelon juices are not commercially produced except for fresh unpasteurised juices and 'smoothies' (sometimes mixed with other fruit and vegetables) usually for immediate consumption or with very short shelf lives.

Melons and watermelons are minimally processed and ready-to-eat foods, with an internal pH of 6.13-6.58 for cantaloupe, 5.78-6.00 for casaba, 6.00-6.67 for honeydew, 5.90-6.38 for Persian and 5.18-5.60 for watermelons, 90 % water as well as high amounts of protein (0.8 %) and high amount of sugars which vary depending on the cultivar. These fruit are considered to be highly perishable and a good matrix for bacterial growth, including the growth of *Salmonella*, especially if damage has occurred to the surface of the whole melon or watermelon or during cutting prior to consumption. Despite the large variety of cultivars of melon and watermelon produced, most information on risk factors and mitigation options for *Salmonella* contamination is for cantaloupe melons and there is little or no information for watermelons and other melon cultivars. Melons and watermelons are normally not subjected to physical interventions that will eliminate the occurrence of *Salmonella*.

For the identification of the main risk factors for *Salmonella* in melons, including agricultural production systems, origin and further processing, the BIOHAZ Panel concluded that the risk factors for the contamination of melons and watermelons with *Salmonella* are poorly documented in the literature with limited available data but are likely to include the following, based on what is known for other pathogens or other fresh produce: (1) environmental factors, in particular proximity to animal rearing operations and climatic conditions (e.g. heavy rainfall) that increase the transfer to pathogens from their reservoirs to the melon and watermelon plants; (2) contact with animal reservoirs (domestic or wild life); gaining access to melon and watermelon growing areas; (3) use of untreated or insufficiently treated organic amendments; (4) use of contaminated water either for irrigation or for application of agricultural chemicals such as pesticides, and (5) contamination or cross-contamination by harvesters, food handlers and equipment at harvest or post-harvest.

For *Salmonella*, processes at primary production which wet the external portions of the crop close to harvest represent the highest risk and these include spraying prior to harvest, direct application of

pesticides and other agricultural chemicals and overhead irrigation. Fruit damage during harvest as well as cracking before or during harvest are additional risk factors for *Salmonella* contamination since melon and watermelon flesh has an internal pH of 5.1-6.7 and represents a good substrate for the growth of this bacterium. In addition, growth may be enhanced by co-contamination with some spoilage-causing moulds. Sharp edged or poorly designed storage containers and liners are risk factors that may contribute to melon and watermelon damage. Although cooling melons and watermelons with water during post-harvest handling may reduce microbial loads on their outside surface, this process may also be a source of microbial cross-contamination. Delays in melon and watermelon cooling from ambient temperatures (20-35 °C) to recommended temperatures between 10 to 14 °C, when melon and watermelon rinds are wet from cooling operations or from dew, may permit multiplication of foodborne pathogens on the rind surface of melons and watermelons.

Melting ice water flowing through boxes of melons or watermelons may be a source of foodborne pathogens if already contaminated as well as a risk factor for cross-contamination within and among pallets of this fruit. During processing cross-contamination via equipment, water or food handlers are the main risk factors for contamination of melons and watermelons with *Salmonella*.

Risk factors associated with contamination by *Salmonella* in outbreaks in the US and Canada associated with melon and watermelon consumption were wash water temperature, contaminated hydro-cooler water, damaged rind, rind fungus rot, workers' hands and contaminated conveyor belts and equipment. Edible portions of the melon and watermelon flesh may be contaminated in the cutting or rind removal process because the knife blade may spread microbial contamination on the outside rind of the melon and watermelon to the inner edible portions. *Salmonella* may grow and penetrate into wound tissues in whole cantaloupe melons as well as on cut melon and watermelon and can multiply at temperatures allowing growth, without visual signs of spoilage. Unrefrigerated storage of cut melons and watermelons is likely to be an important risk factor at retail and catering including in domestic and commercial environments.

At distribution, retail and catering and in domestic and commercial environments, cross-contamination, in particular via direct or indirect contact between raw contaminated food and melons and watermelons, is a risk factor for *Salmonella*.

For the recommendation of possible specific mitigation options and the assessment of their effectiveness and efficiency to reduce the risk for humans posed by *Salmonella* in melons, the BIOHAZ Panel concluded that appropriate implementation of food safety management systems including Good Agricultural Practices (GAP), Good Hygiene Practices (GHP) and Good Manufacturing Practices (GMP) should be the primary objective of operators producing melons and watermelons. These food safety management systems should be implemented along the farm to fork continuum and will be applicable to the control of a range of microbiological hazards. Attention should be paid to the selection of the water sources for irrigation, agricultural chemical (e.g. fungicide) application. Production areas should be evaluated for hazards that may compromise hygiene and food safety, particularly to identify potential sources of faecal contamination. If the evaluation concludes that contamination in a specific area is at levels that may compromise the safety of crops, in the event of heavy rainfall and flooding for example, intervention strategies should be applied to restrict growers from harvesting or using this land for melon and watermelon production production until the hazards have been addressed. Each farm environment (including open field or greenhouse production) should be evaluated independently for hazards as it represents a unique combination of numerous characteristics that can influence the occurrence and persistence of foodborne pathogens in or near melon and watermelon growing areas.

Among the potential interventions, both water treatment and efficient drainage systems that take up excess overflows are needed to prevent the additional dissemination of contaminated water. Since *E. coli* is an indicator micro-organism for faecal contamination in irrigation water, growers should arrange for periodic testing to be carried out to inform preventive measures. At primary production, assessment of risks for *Salmonella* contamination from the environment could inform the measures to reduce risks from previous cultivation or adjacent land use (particularly when associated with domestic animal production) as well as attractants and harbourage of wild animals and pests. Attention should be directed towards water quality since *Salmonella* can survive in water, including water used for irrigation and for dilution and application of agricultural chemicals. Attention should also be paid to appropriate treatment, storage and application of organic amendments if used.

Care should also be taken to prevent the use of equipment contaminated with *Salmonella*, particularly segregation from equipment that has come into contact with animals or their excreta. Persons handling food during harvesting or minimal processing are potential sources of *Salmonella* contamination, and adequate toilet and hand-washing facilities must be provided at production areas together with the exclusion of persons with symptoms of gastroenteritis. Scrupulous compliance with hand hygiene practices such as effective washing is an absolute necessity for all food supply chain employees, and should be emphasised in local codes of practice and training manuals. During minimal processing, cooling and washing, all the necessary steps to prevent contamination by *Salmonella* should be carried out, however these processes, at best, are aimed at preventing contamination or subsequent growth. Where contamination has occurred at primary production, even with adequately operated and monitored washing procedures, at best, only a 1 to 2 log unit reduction of *Salmonella* can be achieved in the final product. For *Salmonella*, the risk of cross-contamination during washing or hydro-cooling is reduced if the microbial quality of the water is maintained using disinfectant agents. Processing waters should be monitored to ensure that, if used, the disinfectant is present at sufficient concentrations to achieve its intended purpose. During distribution, retail, catering and handling in domestic environments, all reasonable steps should be taken to prevent cross-contamination of *Salmonella* from other foods, as well as from food handlers. Refrigerated storage of cut melons and watermelons is an important mitigation at retail and catering including in domestic and commercial environments.

For the recommendation, if considered relevant, of microbiological criteria for *Salmonella* in melons throughout the production chain, the BIOHAZ Panel concluded that epidemiological data from both the EU and North America have identified salmonellosis outbreaks associated with both pre-cut and whole melons and watermelon consumption. There is no routine or regular monitoring of melons and watermelons for the presence of *Salmonella* in EU Member States and there is limited data on the occurrence of *Salmonella* in/on melons and watermelons in EU although some studies of surveys in non EU countries are present in the peer reviewed world literature. There are difficulties in both making meaningful comparisons between individual studies as well as assessing the representativeness of these data to estimate the overall levels of contamination.

The current legal framework does not include microbiological criteria applicable at the primary production stage. There are limited studies available on the presence and levels of enteric bacteria such as *E. coli* on melons and watermelons and therefore it is currently not possible to assess the suitability of an EU-wide *E. coli* Hygiene Criterion at primary production. Using *E. coli* as an indicator of recent human or animal faecal contamination is likely to be useful for verification of GAP and GHP at individual production sites (e.g. to assess the cleanliness of the water used for irrigation and other water uses such as for the application of pesticides and fertilizers).

The existing Process Hygiene Criterion for *E. coli* in pre-cut melons and watermelons aims to indicate the degree to which GAP, GHP, GMP or HACCP programmes have been implemented. There is insufficient information available on the occurrence and levels of *E. coli* in pre-cut, melons and watermelons and therefore the suitability of this criterion cannot be assessed. Using *E. coli* as an indicator for verification of GMP and food safety management systems (including HACCP) might be useful for melons and watermelons in individual processing premises e.g. during food safety management audits, where epidemiological studies indicated a higher risk of infection or at the discretion of the food business operator.

There are Food Safety Criteria for the absence of *Salmonella* in 25 g samples of ready-to-eat pre-cut fruit and vegetables which is applicable to cut melon and watermelon placed on the market during their shelf life (Regulation (EC) No 2073/2005). This regulation is also applicable to unpasteurised melon and watermelon juices placed on the market during their shelf life. A Food Safety Criterion for *Salmonella* in whole melons and watermelons could be considered as a tool to communicate to producers and processors that *Salmonella* should not be present in the product. Since the occurrence of *Salmonella* is likely to be low, testing of whole melons or watermelons for this bacterium could be limited to instances where other factors indicate breaches in GAP, GHP, GMP or HACCP programmes.

The BIOHAZ Panel also recommended that: (1) more detailed categorization of food of non-animal origin should be introduced to allow disaggregation of the currently reported data collected via EFSA's zoonoses database on occurrence and enumeration of foodborne pathogens; (2) risk assessment studies should be performed to inform the level of hazard control that should be achieved at different stages of melon and watermelon production and minimal processing. Such studies should be supported by targeted surveys on the occurrence of *Salmonella* in melons and watermelons at specific steps in the food chain to identify the level of hazard control and efficacy of application of food safety management systems, including GAP, GHP, GMP and HACCP, that has been achieved at different stages of production systems. (3) there should be implementation and evaluation of procedures such as sanitary surveys, training, observational audits and other methods to verify agricultural and hygiene practices for melon and watermelon at primary production, and (4) further data should be collected to evaluate the suitability of *E. coli* criteria at both primary production and during minimal processing of melons and watermelons.

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BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

In May 2011 a major outbreak of Shiga toxin-producing *Escherichia coli* (STEC[4]) O104:H4 occurred in Germany. About 4,000 people were reported ill with symptoms and the outbreak resulted in the death of more than 56 people. Other countries reported a certain number of people becoming ill by the same strain, most of whom had recently visited the region of northern Germany where the outbreak occurred. At the end of June 2011, there was a second cluster in Bordeaux, France, which was caused by the same *Escherichia coli* strain. In both cases, investigations pointed to the direction of sprouted seeds.

According to the 2009 Zoonoses Report[5], the majority of verified outbreaks in the EU were associated with foodstuffs of animal origin. Fruit and vegetables were implicated in 43 (4.4 %) verified outbreaks. These outbreaks were primarily caused by frozen raspberries contaminated with Norovirus.

According to the US Centre for Disease Control and Prevention (CDC) 2008 report on surveillance for food borne disease outbreaks[6], the two main commodities associated with most of the outbreak-related illnesses originating from food of plant origin were fruits-nuts and vine-stalk vegetables. One of the main pathogen-commodity pair responsible for most of the outbreaks was Norovirus in leafy vegetables. The pathogen-commodity pairs responsible for most of the outbreak-related illnesses were *Salmonella* spp. in vine-stalk vegetables and *Salmonella* spp. in fruits-nuts. In addition, as recently as September 2011, a multistate outbreak of listeriosis linked to cantaloupe melons caused 29 deaths in the US.

Regulation (EC) No 852/2004 on the hygiene of foodstuffs[7] lays down general hygiene requirements to be respected by food businesses at all stages of the food chain. All food business operators have to comply with requirements for good hygiene practice in accordance with this Regulation, thus preventing the contamination of food of animal and of plant origin. Establishments other than primary producers and associated activities must implement procedures based on the Hazard Analysis and Critical Control Points (HACCP) principles to monitor effectively the risks.

In addition to the general hygiene rules, several microbiological criteria have been laid down in Regulation (EC) No 2073/2005[8] for food of non-animal origin.

Following the STEC O104:H4 outbreak in Germany and France, the Commission already has asked EFSA for a rapid Opinion on seeds and sprouted seeds. EFSA adopted a scientific Opinion on the risk posed by STEC and other pathogenic bacteria in seeds and sprouted seeds on 20 October 2011. The current mandate intends to supplement the adopted Opinion.

In view of the above, there is a need to evaluate the need for specific control measures for certain food of non-animal origin, supplementing the general hygiene rules.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

EFSA is asked to issue scientific Opinions on the public health risk posed by pathogens that may contaminate food of non-animal origin such as fruit, vegetables, juices, seeds, nuts, cereals, mushrooms, algae, herbs and spices and, in particular:

4 Also known as Verocytotoxin-producing *Escherichia coli* (VTEC).
5 EFSA Journal 2011;9(3):2090
6 www.cdc.gov/mmwr/preview/mmwrhtml/mm6035a3.htm?s_cid=mm6035a3_w
7 Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs. OJ L 139, 30.4.2004, p. 1-54.
8 Commission Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs. OJ L 338, 22.12.2005, p. 1-26.

1. To compare the incidence of foodborne human cases linked to food of non-animal origin and foodborne cases linked to food of animal origin. This ToR should provide an indication of the proportionality between these two groups as regard humans cases and, if possible, human burden.

2. To identify and rank specific food/pathogen combinations most often linked to foodborne human cases originating from food of non-animal origin in the EU.

3. To identify the main risk factors for the specific food/pathogen combinations identified under ToR 2, including agricultural production systems, origin and further processing.

4. To recommend possible specific mitigation options and to assess their effectiveness and efficiency to reduce the risk for humans posed by food/pathogen combinations identified under ToR 2.

5. To recommend, if considered relevant, microbiological criteria for the identified specific food/pathogen combinations throughout the production chain.

The Commission would like an Opinion on the first and second terms of reference by the end of December 2012. The outcome of the first and second terms of reference should be discussed between risk assessors and risk managers in order to decide which food/pathogen combinations should be given priority for the other terms of reference. The Commission would like an Opinion on the other terms of reference by the end of 2013.

Clarifications of the Terms of Reference 3 to 5 of the request on the risk posed by pathogens in food of non-animal origin

Background as provided by the European Commission

On 23 January 2012, a request was provided to the European Food Safety Authority (EFSA) to issue scientific Opinions on the public health risk posed by pathogens that may contaminate food of non-animal origin (FoNAO).

The BIOHAZ Panel of EFSA adopted during its meeting on 6 December 2012 an Opinion on the first and second terms of reference, focussing on

- the comparison of the incidence of foodborne human cases linked to FoNAO and foodborne cases linked to food of animal origin;

- identifying and ranking specific food/pathogen combinations most often linked to foodborne human cases originating from FoNAO in the EU.

It was agreed in the original request that the outcome of the first and second terms of reference should be discussed between risk assessors and risk managers in order to decide which food/pathogen combinations should be given priority for the other terms of reference addressing risk factors, mitigation options and possible microbiological criteria.

The first Opinion of EFSA under this request identifies more than 20 food/pathogen combinations in its five top ranking groups. The Opinion also contains a preliminary assessment of risk factors linked to certain examples of FoNAO (e.g. tomatoes, watermelons and lettuce), representing specific production methods for several FoNAO. Several risk factors and mitigation options may be common for several food/pathogen combinations due to similar production methods. It seems therefore opportune to combine the risk assessment of such food/pathogen combinations. When risk factors and mitigation options are identified as more specific to the individual food/pathogen combination, then these should be considered to supplement this approach and added where possible within the

Opinions. Alternatively, it is worth mentioning that a reference could be made if such specific risks have already been addressed in previous Opinions.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

EFSA is asked, in accordance with article 29 of Regulation (EC) No 178/2002[9], to provide scientific Opinions on the public health risk posed by pathogens on food of non-animal origin as regards risk factors, mitigation options and possible microbiological criteria. When considered more appropriate e.g. because of low prevalence of the pathogen or in view of a broader process control, indicators may be proposed as Process Hygiene Criteria. When addressing mitigation options at primary production, attention should be paid to Article 5(3) of Regulation (EC) No 852/2004[10], which laid down that the application of hazard analysis and critical control points (HACCP) principles shall only be applied to food business operators after primary production and associated activities[11]. This provision does, however, not exclude proposing microbiological criteria in accordance with terms of reference 5 when considered relevant.

EFSA is requested to provide Opinions in line with the agreed terms of Reference 3 to 5 (EFSA-Q-2012-00237) for the following food/pathogen combinations with a similar production system:

(1) The risk from *Salmonella* and Norovirus in leafy greens eaten raw as salads.
Cutting and mixing before placing on the market should be included as potential risk factor and specific mitigation options proposed if relevant.

(2) The risk from *Salmonella*, *Yersinia*, *Shigella* and Norovirus in bulb and stem vegetables, and carrots.

(3) The risk from *Salmonella* and Norovirus in tomatoes.

(4) The risk from *Salmonella* in melons.

(5) The risk from *Salmonella* and Norovirus in berries.

[9] OJ L 31, 1.2.2002, p.1.

[10] Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs.

[11] See guidance at: http://ec.europa.eu/food/food/biosafety/hygienelegislation/guidance_doc_852-2004_en.pdf

ASSESSMENT

1. Introduction

Melon and watermelon are food commodities sold either raw or minimally processed and are ready-to-eat foods which are widely consumed and generally free from noxious substances such as poisonous chemicals, toxins and pathogenic organisms. However, the previous EFSA Opinion (EFSA Panel on Biological Hazards (BIOHAZ), 2013), risk ranked the combination of this food product together with *Salmonella* spp., as the second most often linked to human cases of infection originating from food of non-animal origin in the EU. The main types of melons consumed in the EU are cultivars of *Cucumis melo* L. (e.g. cantaloupe, galia etc) and *Citrullus lanatus* (Thunb.) Matsum. & Nakai (watermelon) and differences between these two species will be considered in the subsequent text.

The main risk factors, together with their mitigation options, are applicable to many points in the food chain for melons and watermelons. However, since melons and watermelons do not include any processing steps or control points which will ensure removal or inactivation of biological hazards, it is particularly important to consider risk factors (and consequentially mitigation options) at the point of production. This property is in common with other foods of non-animal origin (FoNAO) which are minimally processed and ready-to-eat, as well as with some foods of animal origin (e.g. unpasteurised dairy products, shellfish and meats which are eaten raw).

The approaches used in this Opinion are:

1. To provide a descriptive analysis of the whole production process for a representative range of melon and watermelon cultivars which considers their agricultural production, growing, harvesting, processing, distribution, retail, catering and domestic use. Risk factors for contamination by *Salmonella* spp. are considered in the context of the agricultural, processing, distribution and retail/catering/domestic environments. In discussions with the EU Commission it was agreed that for all the FoNAO considered in this and related Opinions, only raw and minimally processed products are considered (which includes cutting, washing, peeling, shredding, freezing, mashing and juiced without pasteurisation). Products undergoing thermal treatments (including blanching as well as shelf stable juices) are not considered in the scope of these Opinions.

2. General mitigation options are assessed together with a separate Section relating to *Salmonella* spp. contamination of melons and watermelons. The assessment of the mitigation options is performed in a qualitative manner similar to that performed for the Scientific Opinion on the risk posed by Shiga toxin-producing *Escherichia coli* (STEC) and other pathogenic bacteria in seeds and sprouted seeds (EFSA Panel on Biological Hazards (BIOHAZ), 2011) and include consideration of generic mitigation options previously identified for leafy greens (EFSA BIOHAZ Panel, 2014b) and berries (EFSA BIOHAZ Panel, 2014a) as well as those specific for melons and watermelons.

3. Sampling and analytical methods for the detection of *Salmonella* spp. (together with the use of *Escherichia coli* as an indicator organism) in melons and watermelons are considered in an identical manner as those identified for leafy greens (EFSA BIOHAZ Panel, 2014b) and berries (EFSA BIOHAZ Panel, 2014a). A summary of data on estimates of occurrence for *Salmonella* and *E. coli* in melons and watermelons is presented. The relevance of microbiological criteria applicable to production, processing and at retail/catering were considered.

2. Production of melons

2.1. Definition of melons

The term melon usually refers to members of the plant family *Cucurbitaceae*, which are edible, sweet-fleshed and usually large, multiple-seeded fruit. Melons were defined in a previous Opinion (EFSA Panel on Biological Hazards (BIOHAZ), 2013) and include: bitter melon, horned melon, muskmelon (cantaloupe, wintermelon, galia) and watermelon. In botanical terms, melons fall into two plant genera: *Citrullus* to which the watermelon belongs and *Cucumis*, which contains all commonly cultivated types of melon other than watermelon (Pilgrim and Petersen, 2011).

Watermelon cultivars are most usually divided in two main categories of seeded or seedless cultivars which can have red or yellow flesh. Sterile hybrids producing seedless cultivars occur (Maynard, 1996). The edible watermelon is produced on trailing vines that may reach 4.6 m or more in length. This fruit varies in shape from spherical to ovoid. The colour of the hairless skin varies with cultivars from shades of green to pale yellowish to almost black and may be solid, striped, or marbled appearance. Fruit have a thin, firm outer rind, inside of which is a layer of white-fleshed inner rind that may be up to about 2.5 cm thick, and an interior edible pulp containing seeds unless the cultivar is triploid (USDA, 2004). Pulp colour of most commercial cultivars is of shades of yellow or red (Sackett, 1974).

Many botanical cultivars of *Cucumis* melons are commonly produced in Europe, such as ananas, baskavas, branco, Western shipper, yellow Easter shipper, green Eastern shipper, canary, yellow charentais, green charentais, galia, honeydew, kirkagac, ogen, piel de sapo, rochet, and tendral. Depending on the cultivar, the shape varies from spherical to ovoid, the rind from green to white, and the flesh from white to greenish. A melon contains an abundance of seeds wrapped in a viscous layer. When unripe, its flavour is reminiscent of cucumber, but when mature, its flavour and aroma are refreshing and sweet. Sizes and maturity indices vary between cultivars. Maturity indices of melons and watermelons can be based on different characteristics such as stem separation and/or background rind colour. For instance, honeydew melons are ready-to-eat when the peel turns pale green to cream coloured and the surface feels waxy. The majority of honeydew melons have green-flesh, but specialty fruit can have gold, orange, or pink-flesh. Canary melons are ready-to-eat when the peel, which is generally smooth but sometimes furrowed, is bright canary-yellow and the ovoid shaped fruit is springy at the blossom-end. The flesh should be crisp, flavourful, and white with a hint of pink around the seed cavity (USDA, 2004).

Despite the large variety of cultivars of melon and watermelon produced, most information on risk factors and mitigation options for *Salmonella* contamination is for cantaloupe melons, and there is limited or no information for watermelons and other melon cultivars.

The majority of watermelons and other cultivated types of melon are typically used whole or as fresh-cut products and they can also be processed into fresh juices. However, fresh melon and watermelon juices are not commercially produced except for fresh unpasteurised juices and 'smoothies' (sometimes mixed with other fruit and vegetables) usually for immediate consumption or with very short shelf lives (see Section 6). Melons and watermelons for human consumption may be subject to other processing (pasteurised juicing and seed drying) but these are also outside the scope of this Opinion.

2.1.1. Seed and seedling production

Melons, including watermelons, may be planted by direct seeding or by transplantation. The process to obtain melon seeds is similar to that previously described for leafy greens (EFSA BIOHAZ Panel, 2014b). Direct seeding in raised beds covered with black plastic mulch is recommended. Melons and watermelons are warm-season crops that should only be planted after the danger of frost has passed. Soil temperatures should be above 15 °C, and the optimum temperature range for germination is between 21 and 35 °C. Seeding will require 1 to 2 kg of seed per acre, unless a precision-type seeder is being used. In the case of cantaloupe and related melons, it is recommended to sow seeds at a depth of 1.5-2.5 cm (Kemble, 1996). The use of transplanted seedlings can reduce seed cost compared to direct seeding and results in earlier production. When seedlings are used for watermelons, they are usually field-ready in three to five weeks, after being grown in greenhouses (Hochmuth and Elmstrom, 1992). For both, melons and watermelons, seeds should be sown and raised in seedling trays containing a non-soil potting mix such as a peat moss to avoid soil borne plant diseases. Seeds take 2-5 days to germinate (Pilgrim and Petersen, 2011).

Melons, including watermelons, generally require full sun and well-drained soil. Where soil is poorly drained, melons and watermelons are often planted in raised beds. The best soils are deep fertile sandy loams but these fruit can also be grown on somewhat heavier soils if the fields are designed to drain well. Production on heavy clay soils is not recommended due to water retention problems (Pilgrim and Petersen, 2011).

2.2. Description of production systems

Production of melons and watermelons, is optimal at warm temperatures (optimal air temperatures: 15-32 °C for melons and 18-35 °C for watermelon) and abundant sunlight. Melons grow and fruit best in the drier periods of the year. Wet climates and humid conditions tend to promote an increased incidence of foliage and root diseases as well as a reduction in sweetness and flavour (Pilgrim and Petersen, 2011). Production cycles from planting to harvest will be dependent on temperature and sunlight but there are also varietal differences. Production cycles of 70 to 90 days for watermelons and 90 to 110 days for other types of melons have been reported.

Melons and watermelons are mainly produced in open fields although they can be also produced as a protected crop.

Domestic production for local consumption occurs particularly in Eastern and Southern European Countries (particularly for watermelons) and this is outside the scope of this Opinion.

2.2.1. Open field production

Cultivation occurs in open fields, raised beds or hills, and this system improves soil drainage and allows access to the crop without causing soil compaction. Raised beds are typically 1 m to 2 m wide and 30 m long. The width is determined by the type of equipment used and by the crop (Delahaut and Newenhouse, 1998).

In Europe, melons, mostly cantaloupe and galia melons grown in open field are primarily grown on plastic mulch. The use of black plastic polyethylene mulch provides many positive advantages for growers, such as an increase of the soil temperature earlier in the growing season, moisture conservation, and reduces several common problems: soil compaction and crusting, ground rot of fruit, fertilizer leaching, drowning of crops, evaporation, and competition from weeds. For cantaloupe melons, black plastic mulch promotes increased yields, earlier maturing crops of higher quality, as well as enhanced insect management and weed control (Kemble, 1996). Cantaloupe melons are generally ready to be harvested 30 to 35 days following pollination (Kemble, 1996).

2.2.2. Greenhouse production

Melons, including watermelons, as with many other warm-season (frost-sensitive) vegetable crops can also be grown in greenhouses. However, this type of production system makes a minor contribution to total melon production in Europe. Melons such as Charentais-type cultivars, Doublon and Vedrantais grown under greenhouse conditions with optimum density and cultivation practices can result in higher yields of fruit than field-grown crops (Wacquant, 1974).

Various methods and techniques developed for growing plants without soil are collectively called soil-less systems. These methods include a great diversity of systems, from the purely hydroponic, which are based on the supply of water and nutrients only (e.g. nutrient film technique, or NFT), to those based on artificial mixes that contain various proportions of different substrates. In between these extremes lie a great number of soil-less or minimal soil methods that make use of some sort of growth medium, which is either inert (e.g. rockwool slabs, polyurethane chunks, and perlite) or non-inert (e.g. gravel culture, sand culture, and peat bags) (Papadopoulos, 1991). Soil-less culture and vertical plant growth (trellising) have been reported to be good systems to improve available light interception, air movement, and microclimates of the plants, as well as promoting the efficient use of water and nutrients through precise irrigation and recycling methods (Rodriguez et al., 2007).

Shaw et al. (2001) reported that Galia muskmelons grown in a passively ventilated greenhouse using perlite soil-less culture can produce 9 to 15 fruit/m^2 at a plant density of 3.0 plants/m^2. Individual plant yields ranged from 3 to 5 fruit/plant with a mean fruit weight of 1.2 kg/fruit (≈ 14.0 kg/m^2). Consequently, yields were greater than those produced by plants grown in either walk-in tunnels (Waldo et al., 1997) or by field cultivation (Hochmuth et al., 1998).

Reports from countries where melons are commercially produced indicate that yields of 4.3 to 5.9 kg/m^2 are generally achieved under protected structures (e.g. tunnels and greenhouses) using soil. These yields are common in Israel (Arava Desert) at a planting density of 1.3 plants/m^2 (Hecht, 1998; Rodriguez et al., 2007). As a comparison, Galia produced in Spain at a plant density of 2.0 plants/m^2 using coconut coir and rockwool as soil-less media yielded 12.7 kg/m^2 (Torres and Miguel, 2003).

2.2.3. Water Sources and irrigation systems

Melons, and particularly watermelons, can withstand moderate drought conditions when well established. However increased yields can be obtained with irrigation (Pilgrim and Petersen, 2011). When grown without irrigation, crops use moisture accumulated during the winter for germination and growth (Ban et al., 2006).

Irrigation water can originate from diverse sources (e.g. collected rainfall, subsurface, surface, or reclaimed water). Sources of irrigation water can be generally ranked by risk of microbial contamination (Leifert et al., 2008): in order of increasing risk these are potable water, rain water, groundwater from deep wells, groundwater from shallow wells, surface water, and finally raw or inadequately treated wastewater. In Europe, the main water sources used for irrigation of melons and watermelons are surface waters (river, lake) and reservoirs supplied by well water. Rainwater, well water and potable-quality water are used in the case of hydroponic production (Appendix B, Freshfel, 2013).

All types of irrigation (overhead, drip) can be used in melon and watermelon production. The most efficient method is to supply water using a drip irrigation system. Such a system will provide an adequate supply of water without wetting the foliage which promotes the development of plant diseases (Pilgrim and Petersen, 2011). However, sprinkler irrigation is also used. When using plastic mulch, drip irrigation is the recommended method (Sanders, 1988).

It is recommended that only fungicides that are authorized for use on melons and/or watermelons by the prevailing regulatory authorities in both the country of origin and destination markets shall be used. Fungicides and all other pesticides shall be used according to the manufacturer's instructions.

Water is used when preparing water-based chemical treatments, such as pesticides and fungicides. Special attention should be given to the microbiological quality of the water to avoid the risk of contamination.

2.2.4. Different types of fertilisation, organic/manure/compost

To optimise crop quality and productivity it is considered advisable to fertilize plants prior to transplanting, although this may depend on the crop and soil type. Optimal delivery is to apply the fertilizers between the rows which secures full availability for the plants, increases utilization and avoids chemical burning of leaves from contact with fertilizer (Enza Zaden, 2013). Fertilization can be done with chemical and/or organic fertilizers. Chemical fertilizers are easy to transport, are used efficiently for growth of the plants and provide high yields, but it has been observed that with succeeding harvests, the quantity of chemical fertilizers has to be increased because of declining soil fertility. Organic fertilizers are available in different forms such as liquid, powder, granular and pelleted from various sources of organic materials. Treated animal manure and compost from wastes and vegetable residues are also sometimes used. Where necessary (e.g. due to heavy rain), fertilization can be given via the irrigation system, which is known as fertigation, and is the combined use of fertilizers with irrigation water. The main difference from normal crop fertilization is that fertilizers are added in soluble forms, in low amounts but at high frequencies of delivery (Lucena, 1995).

Moderate amounts of fertilizer are required to achieve adequate yields in melon and watermelon production. Plants respond better when applications of nitrogen and potassium are split, but fertilizer application methods vary according to the production and irrigation system. For example, when using drip irrigation, growers incorporate micronutrients into the bed prior to planting and add the remaining nitrogen and potassium through the drip irrigation (Hochmuth, 1992; Hochmuth and Elmstrom, 1992).

2.2.5. Harvesting

Watermelons are harvested after attaining an acceptable level of sweetness while still remaining internally crisp as a result of high moisture content in the intact cells of the flesh. Once cells begin to separate and over-ripen, air spaces form and the fruit loses its crispness. When watermelons are harvested, they may be firm but will not develop an adequate level of sweetness. This is because watermelons are considered non-climacteric fruit.

Climacteric fruit are defined as fruit that enter 'climacteric phase' after harvest i.e. they continue to ripen. Therefore, there are melons that continue to ripen after harvest while other melons do not. Cantaloupe melons have a typical climacteric behaviour with ethylene playing a major role in the regulation of the ripening process and affecting the ripening rate. However, other melon cultivars are non-climacteric. When crossing a cantaloupe charentais melon with a non-climacteric melon, the climacteric character is generally genetically dominant. However, other experiments made by crossing two non-climacteric melons have generated climacteric fruit, indicating that different and complex genetic regulation exists for the climacteric character (Pech et al., 2008).

Melons, and particularly cantaloupes, are harvested based on the stage of maturity in relation to a variety of traits and market preferences. A cantaloupe's maturity stage is usually judged by the formation of an abscission zone between the vine and the cantaloupe. This characteristic of cantaloupe maturity is commonly called 'slip' and most cantaloupes are harvested between three quarters and full slip (PMA, 2013). However, this can be different for other types of melons.

During harvest, melons and watermelons should be protected from sunburn by maintaining them in shade until shipment, packing or processing. Watermelons harvested early in the morning are more likely to experience bruising and splitting than those harvested later in the day (Mossler et al., 2013). This is due to their large size and vulnerability to splitting or cracking under stress, and it is in the early morning when they hold the most water. Also, it is not recommended to pick wet fruit, as the dirt on the watermelon surface will spread to other fruit during handling. Melon and watermelon harvest will depend on the climate and the cultivar but it is most likely to occur in Europe between mid-June to mid-October.

Damage sustained during harvesting and handling may produce cracking which leads to microbial deterioration and a reduction of quality and appearance of the fruit. Melons and watermelons should be carefully laid in rows and loaded into field trucks (sometimes padded) to be off-loaded to road trucks or taken to on site packing facilities (Mossler et al., 2013). Most melons, including watermelons, are shipped in bulk. Pallet bins are becoming increasingly popular since they can be moved directly into supermarkets (Sargent, 1992; Hochmuth et al., 1997).

Melons and watermelons should not be shipped in closed trucks or stored with other fruit (bananas, peaches) and vegetables (tomatoes) that emit ethylene gas, which acts as the natural aging or ripening plant hormone. When exposed to ethylene, watermelons breakdown internally and the flesh takes on a water-soaked appearance. This leads to flesh softening and flavour loss (Boyhan et al., 1999).

At a collection point, melons and watermelons are off-loaded by hand from the field trucks, sized and graded, and then re-loaded into road trucks or into fiberboard pallet bins. Melons can also be sorted, sized, and loaded directly into fiberboard bins in the field. Bulk shipments usually entail handling of melons at least five times from harvest until reaching the retail store. Minimization of handling throughout the process is desirable to reduce bruising and improve overall quality (Sargent, 1992; Hochmuth et al., 1997; Mossler et al., 2013).

2.2.6. Cooling and storage

There is some variation among melons and watermelon cultivars and types, i.e. seeded vs. seedless, regardless of the recommended storage temperature but in general none are suitable for very long term storage under refrigeration conditions. Almost all, if not all, cultivars of melon and watermelon are sensitive to chilling but minimum temperatures at which they can be stored vary between cultivars. For instance, cantaloupe melons can be stored between 2 and 5 °C while honeydew melons withstand temperatures between 10 and 14 °C. However, other cultivars of melons should be stored up to 14 °C.

If melons and watermelons are bruised before cold storage, chilling will cause discolouration in the internal flesh after the melon is warmed to room temperature (Boyhan et al., 1999).

Guidelines on GAP indicate that melons need precooling soon after harvest to reduce field heat (Kemble, 1996). If field heat is not removed, melons will degrade prematurely, resulting in poor quality with a greatly reduced shelf life. Thus, temperature management is recommended for optimum melon and watermelon quality. For many cultivars, the optimum storage temperature for melons is around 10 °C with approximately 90 % RH, although transit temperatures between 13 and 21 °C with ventilation have also been recommended (Appendix A, Freshfel information; Boyhan et al., 1999). Nevertheless, cold storage of melons and watermelons should not exceed 5 days and the product should not be at room temperature for commercialization for long periods of time (Appendix A, Freshfel information). However, due to logistical issues, melons and watermelons are often stored at ambient temperatures. Pre-cooling can be done with cold water, cold air, or ice. Hydro-cooling is the most efficient method and can reduce a 35 °C melon to at least 15 °C at the centre of the flesh within 20 min (USDA, 2004). In general, the choice between cooling methods depends primarily on economic factors and the type of shipping container used. Room cooling and forced-air cooling are also suitable for melons. For watermelons, a process defined as conditioning consists of maintaining the product for 2 days at 20-27 °C is recommended before cool storage (Appendix A, Freshfel information).

Relative humidity should also be maintained between 85-95 % (Appendix A, Freshfel information). Conditions of higher humidity may cause stem-end rot (Mossler et al., 2013). Harvested melons and watermelons are normally not subjected to physical interventions that will eliminate the occurrence of *Salmonella*. Technologies currently available for use by the melon and watermelon industry fall short of being able to guarantee an absence of *Salmonella* at primary production.

2.3. Description of EU melons sector

This Section is based on information provided by Freshfel in September 2013 (Appendix A and B). The scale of production of melons and watermelons in the EU varies considerably between Member States and includes local production in Eastern European Countries (particularly for watermelons), with small producers for local consumption in Southern Europe, and large producers particularly (in order of production), from Spain, Italy, France, Greece and Romania. In 2011, of the 2.29 million metric tons of melon consumed in the EU, 83 % came from five Member States (Spain, Italy, France, Greece and Romania). Almost 15 % of the remainder came from outside the EU with the most common extra-EU producers (in order of production weight) being Brazil, Costa Rica and Morocco.

In 2011, of the 2.91 million metric tons of watermelon consumed in the EU, 88.9 % came from five Member States (Spain, Greece, Romania, Italy and Hungary). Almost 7 % of the remainder came from outside the EU with the most common extra-EU producers (in order of production weight) being Costa Rica, Brazil, and Panama.

A wide range of melon and watermelon cultivars are grown, the most common being galia, charentais, cantaloupe, honeydew and piel de sapo, together with seeded and seedless cultivars of watermelon. Approximately 75 % of melons are grown in soil in open fields, with 25 % being cultivated in greenhouses. The most common irrigation systems are drip or sprinkler irrigation and water is obtained from a wide variety of sources. The field picking staff mainly consists of both national and foreign migrant workers (often from North Africa for Spain and Italy) and harvest takes place with a chain of 3-5 people from removal of each melon from the plant to the placing in plastic harvest bin. Gloves are generally not worn during harvest.

3. Risk factors for microbiological contamination during agricultural production

Production practices, growth conditions and contact during growth of the outside fruit surface with the environment, particularly soil, in combination with intrinsic, extrinsic, harvesting and processing factors will affect the microbial status of melons and watermelons at the time of consumption in a similar way to that outlined for leafy greens (EFSA BIOHAZ Panel, 2014b) albeit with different water requirement during growth. Water requirements for the total melon growing period for a 100-day crop range from 400 to 600 mm while water requirement for lettuce vary from 200-400 mm depending on the climate. In addition the growing cycle for melons and watermelons varies between 30 to 90 days. The variability in the production systems and associated environments for melon and watermelon production can lead to a wide range of unintentional or intentional inputs that are potential sources of food safety hazards. The sources of contamination will vary considerably from one type of crop production to another as well as between one particular setting/context to another, even for the same crop. The following Sections are intended to identify and characterize potential risk factors for contamination of melons and watermelons in addition to those previously outlined for leafy greens (EFSA BIOHAZ Panel, 2014b) but may not be supported by epidemiological or experimental evidence, unless specified in the relevant following Sections.

For salmonellosis outbreaks, there are few investigations or research that has identified risk factors for microbial contamination of melons and watermelons during agricultural production. The available literature, however, highlights contaminated irrigation water sources or insufficiently disinfected process water as the most probable sources for contamination during melon and watermelon production (Gagliardi et al., 2003; Castillo et al., 2004; McCallum et al., 2010). Amongst the *Salmonella* outbreaks associated with melon consumption, risk factors at pre-harvest were identified with contaminated soil, manure, irrigation water, water used in pesticide application and animals (rodents, birds, insects or reptiles) in the production area (Bowen et al., 2006). Also poor temperature control (including extended holding at ambient temperature, e.g. temperatures higher than 15 °C) were important contributing factors (FAO/WHO, 2013). Problems with contamination of melons from transport equipment after harvest which were also used for a cattle operation were identified as a risk factor associated with contamination by *Listeria monocytogenes* in a large outbreak in the US (CDC, 2011; US-FDA, 2011).

3.1. Environmental factors

As with leafy green vegetables (EFSA BIOHAZ Panel, 2014b), environmental factors refer to the specific conditions of the primary production area, climate and type of crop. These factors may have an impact on the safety of the melons and watermelons, as well as microbial contamination routes, persistence of pathogens in fields, the use of fertilizers, sources, quality and frequency of irrigation water and other water uses, and pathogen prevalence and concentration. Some melons and watermelons have prolonged direct contact with soil during growth and/or harvesting. In addition, bird faeces and airborne contaminants (birds nesting around the growth and packing area, nearby livestock or poultry production, or manure storage or treatment facilities, etc.), and proximity with other wildlife, may also pose a risk of contaminating melons. Whether melons are produced in open fields, in protected cultivation, or in soil or soil-less environments, all impact the environmental risk factors. Each farm environment (including open field or greenhouse production) should be evaluated independently as it represents a unique combination of numerous characteristics that can influence occurrence and persistence of pathogens in or near melon and watermelon growing areas.

3.1.1. Factors linked to the adherence, survival and internalisation of pathogens with melons

Melons and watermelons may have smooth or netted rind surfaces. Morphological characteristics of certain types will be prone to attachments by microbial pathogens. Most of the foodborne outbreaks associated with this food type implicated cantaloupe melons that have netted rinds although consumption of other cultivars of melon and watermelon has also been associated with infection (Mohle-Boetani et al., 1999; Harris et al., 2003). Netted rind surfaces, in contrast to smooth rind surfaces, provide an environment where microbial pathogens more easily adhere to, survive on, and become more difficult to eliminate during post-harvest practices (FAO/WHO, 2013).

Salmonella adhere to the surface of cantaloupe melons, although there is variation between different serovars (probably based on surface charge and hydrophobicity) with *Salmonella enterica* serovars, Mbandaka, Michigan, Newport, Oranienburg demonstrating stronger adherence than Anatum, Gaminara, Hildalgo, Infantis, Poona, St. Paul, Stanley and Typhimurium (Ukuku and Fett, 2002, 2006). There is more limited information on a restricted range of *Salmonella* serovars available for adherence to the surface of melon and watermelon types other than cantaloupe (Gagliardi et al., 2003; Parnell et al., 2005).

In addition, stem scar tissue, cracks, wounds and wound tissue and ground spot areas which may occur during melon and watermelon growth and harvesting can provide environments which present an increased risk for *Salmonella* contamination and growth. Richards and Beuchat (2005a,b) demonstrated that mould growth can occur in wound tissue of cantaloupe rinds (particularly associated with the growth of *Cladosporium cladosporioides* and *Geotrichum candidum*) and this favoured the growth and migration of *Salmonella enterica* serovar Poona to edible melon tissue. Infiltration of cantaloupes was enhanced by the presence of certain moulds and *S.* Poona was shown to be capable of migrating to a depth of 3-4 cm into the flesh (Richards and Beuchat, 2005a). There was also evidence for antagonistic effects against *S.* Poona within the melon wound tissue associated with the presence of yeasts (Richards et al., 2004). Hence melons and watermelons products of lower quality (those with stem scar tissue, cracks, wounds and wound tissue as well as ground spot areas and mould growth) are of greater risk of allowing the growth of *Salmonella*, and these may not be accepted by major retailers but sold at lower prices in markets or are used for minimal processing.

Difficulties in interpreting evidence for internalization of *Salmonella* within the vegetative plant tissue based on experimental studies and exposures was previously discussed for leafy greens (EFSA BIOHAZ Panel, 2014b). Lopez-Velasco et al. (2012) were unable to demonstrate evidence for root uptake for field grown cantaloupe and honeydew melons from *S. enterica* serovar Typhimurium contaminated water or soil. *Salmonella* was however detected on the rind surface of both types of melons if fruit developed in contact with soil on the sides of the inoculated furrows. Following heavy rain during in-field fruit growth and maturation, melons collected from the central area of the beds were shown to harbour the furrow-applied *Salmonella*. Delivery of *S.* Typhimurium directly into the peduncle, after minor puncture wounding, resulted in detection of *S.* Typhimurium in the sub-rind tissue below the fruit abscission zone (Lopez-Velasco et al., 2012).

Failure to remove culled fruit from the field is a risk factor to healthy fruit since this will attract insect and mammalian pests. Furthermore, the possibility that lower eukaryotic organisms (particularly nematode worms) may act as a temporary reservoir for *Salmonella* in the soil and increase the dispersal and survival of pathogens in agricultural environments was discussed in relation to propagation on leafy greens (EFSA BIOHAZ Panel, 2014b). The same effects are applicable to melon and watermelon production. Caldwell et al. (2003) demonstrated the potential of the nematode *Caenorhabditis elegans* to serve as a vector for the transport of *Salmonella* Poona to cantaloupe rinds. Adult worms that were immersed in a suspension of *Salmonella* Poona were deposited 1 or 3 cm below the surface of soil on which a piece of cantaloupe rind was placed which was tested for the presence of the bacterium over 1 to 10 days at 21 °C. The presence of *Salmonella* Poona was detected more quickly on rinds positioned on soil beneath which *C. elegans* inoculated with *Salmonella* Poona was initially deposited than on rinds positioned on soil beneath which *Salmonella* Poona alone was deposited. The time required to detect *Salmonella* Poona on rinds was longer when the rind was placed 3 cm above the inoculum than when the rind was placed 1 cm above the inoculum.

3.1.2. Conditions in the field and adjacent land

The conditions at the growing field as well as in adjacent land were identified as playing a vital role in the microbial safety of leafy greens (EFSA BIOHAZ Panel, 2014b) and these risk factors are likely to be equally applicable to melons and watermelons. Risk factors for contamination with foodborne pathogens include contact of melons and watermelons with airborne contaminants as well as those from the soil, animal droppings, soil amendments (including natural fertilizers) or direct contact with irrigation water. Risks are consequently associated with runoff and flooding particularly where adjacent land use is associated with contamination from human or animal excreta. Where materials are used under the melons and watermelons during growing, the microbiological risks are reduced where these minimize contact of the fruit with the soil, e.g. by the use of a mulch or biodegradable materials (e.g. straw) or during harvest, e.g. plastic or biodegradable materials (e.g. leaves or papers as liners of biodegradable baskets used to collect harvested melons and watermelons). However, the use of plastic mulch has been proven to enhance dispersal of *Salmonella* compared to soil, while organic mulch reduced dispersal compared with plastic (Cevallos-Cevallos et al., 2012). In greenhouse grown crops, risks are reduced when contact with the soil is minimized. Soil-less systems, where melons are frequently grown high above ground level should be the least exposed to contamination by foodborne pathogens from adjacent land.

3.1.3. Climatic conditions

The effects of climatic conditions on the contamination sources and pathways for foodborne pathogens to contaminate leafy greens during the pre-harvest phase were previously outlined (EFSA BIOHAZ Panel, 2014b) and these risk factors are also applicable to melons and watermelons. Heavy rain may increase the exposure of melons and watermelons to pathogens if soil contaminated with pathogens splashes onto fruit surfaces as well as causing contamination through flooding and where floodwaters come into direct contact with the fruit. In addition, melons and watermelons are grown in warm, humid conditions which may favour growth and survival of foodborne pathogens (FAO/WHO, 2013). Consideration may be given to harvesting earlier if the weather forecast is for heavy rain or to delaying harvest and performing extra washing steps when heavy rains have recently occurred.

3.1.4. Contact with animal reservoirs

Domestic animals (cattle, sheep, chickens, dogs, cats, and horses) as well as wild animals (e.g. frogs, lizards, snakes, rodents, foxes, deer, badgers or wild boar) and birds can contaminate leafy green crops with their faeces if they are present in growing areas (EFSA BIOHAZ Panel, 2014b) and risk factors previously identified for these are also likely to be applicable to melons and watermelons.

Melons and watermelons have a very high sugar content and are extremely attractive to flies and other insects and free-living nematodes (see Section 3.1.1) that may cross-contaminate these types of products. It is recommended that an aggressive fruit cull disposal and waste removal program is implemented to reduce the potential for insect-to-crop contamination. While domestic animals may be separated from growing operations for melons and watermelons, it can be more difficult to control access by wild animals and birds. Wild and domestic animal species (as well as humans) represent risk factors for contamination of melon and watermelon with foodborne pathogens (including *Salmonella*) when they are present in the production environment and present a risk both from direct contamination of the crop and soil as well as from contamination of surface water sources and other (particularly water) inputs. Bird droppings and airborne contaminants (birds nesting around the packing area, nearby livestock, poultry areas or manure storage or treatment facilities, etc.) may also pose a risk of contaminating melons and watermelons with *Salmonella*.

Pests pose a risk to the safety of melons and watermelons. For instance, cantaloupes have very high sugar content and are extremely attractive to rodents, flies and other pests that may cross-contaminate this fruit. Good sanitation, inspection of incoming materials and active monitoring for pest activity can minimize the likelihood of infestation and thereby limit the need for pesticide use (PMA, 2013).

3.2. Organic amendments (manure, slurries, composts, wastewater treatment sludge and sewage)

The use of untreated manure and liquid manure are risk factors for *Salmonella* contamination of melons and watermelons. The persistence of foodborne pathogens (including *Salmonella*) has been highlighted previously for leafy greens (EFSA BIOHAZ Panel, 2014b) and, depending on the length of the production cycle, melons can become contaminated by foodborne pathogens from manure used during cultivation.

3.3. Water use during production (irrigation, pesticides and fertilizers, washing)

There is evidence that identifies irrigation water quality as an important risk for pre-harvest contamination of melons and watermelons (Materon et al., 2007; Lopez-Velasco et al., 2012). The available literature highlights contaminated irrigation water sources as one of the most probable sources of melon and watermelon contamination during production (Gagliardi et al., 2003; Castillo et al., 2004; McCallum et al., 2010). Thus, only clean water should be used for production, and water from contaminated sources represents a major risk factor for contamination with foodborne pathogens. The risk of sewage or wastewater contaminating vegetables with human foodborne pathogens, including *Salmonella*, has been reviewed (Bryan, 1977) and the risks are similar for melons and watermelons as for leafy greens (EFSA BIOHAZ Panel, 2014b).

Pathogens can persist in water and in many agrichemical solutions, including pesticides. The application of aqueous fertilizers and pest prior to and during harvest might represent a risk if water is contaminated with foodborne pathogens when used in water-based chemical treatments (PMA, 2013).

Water can also be used during post-harvest handling at production sites. Melon and watermelon cooled with sanitized water may reduce microbial loads on the outside surface of cantaloupe and honeydew melons by 2-3 logs CFU/melon (Park and Beuchat, 1999; Rodgers et al., 2004). Cooling water may however be a major source of microbial cross-contamination if this is of poor quality. Delays in melon and watermelon cooling when rinds are wet from cooling operations or from dew may permit multiplication of foodborne pathogens (including *Salmonella*) on the rind surface (Behrsing et al., 2003).

Although not very common, in some operations, melons and watermelons may be ‘top iced’ with crushed ice after cooling as a means of temperature control during transport and distribution. Ice in direct contact with the product will melt during transportation and distribution operations. Melting ice water flowing through boxes of melons or watermelons may be a source of foodborne pathogens if already contaminated as well as a risk factor for cross-contamination within and among pallets of melons and watermelons. Recommended temperatures for whole fruit storage are variable between 5 and 15 °C depending on the cultivar, mostly because melons and watermelons are sensitive to chilling (see Section 3.6). Therefore, the use of ice as a temperature control might contribute to deterioration in quality of some cultivars.

3.4. Equipment

Risks associated with contamination from equipment and handling were previously outlined for leafy greens (EFSA BIOHAZ Panel, 2014b), which can occur at any point in the farm-to-plate continuum, and these risks are equally applicable to melon and watermelon production. Fruit damage, however, is an additional risk factor for foodborne pathogen contamination during harvest, and sharp edged or poorly designed storage containers and liners are risk factors that may contribute to fruit damage and hence padding may be used. Cross-contamination of surfaces by workers handling contaminated melons and watermelons is possible. Harvest equipment (knives, pruners, machetes and other cutting equipment), together with transport containers and any farm machinery (gondolas, trailers or wagons), which comes into contact with melons and watermelons, represents a risk factor for contamination. Melons and watermelons may be unloaded from field bins, open flat-bed wagons or gondolas by dry dump or water dump operations. In some countries, such as USA, the fruit is sometimes floated out of gondolas by placing gondolas into water filled sumps. This practice is not very common in Europe. Under these conditions there is the potential for contact between melon and watermelons surfaces as well as cross-contamination via water (Gagliardi et al., 2003; Castillo et al., 2004; Akins et al., 2005; Leon, 2005). When melons and watermelons are transported by flotation, water may also be a major source of microbial cross-contamination if this is of poor quality or where there is insufficient disinfectant present. Thus, the microbial quality of the water should be monitored to avoid the use of contaminated water.

Melons and watermelons are typically cooled by forced-air or by use of a chilled water drench or immersion in flumes. Forced-air cooling operations may also spread product contamination if forced air cooling equipment is not cleaned and sanitized regularly (PMA and UFFVA, 2005).

3.5. Worker health and hygiene, worker training

The risk represented by people working with melons and watermelons through the transfer of micro-organisms of public health concern by direct contact is similar to that previously considered for leafy greens eaten raw as salads (EFSA BIOHAZ Panel, 2014b). Melons and watermelons are not harvested mechanically and are handled extensively during harvest and often by multiple handlers. Personal hygiene is therefore critical with manual harvesting due to the amount of human handling that could lead to contamination. The health and hygiene of pickers are critical factors in foodborne pathogen contamination and failure to adhere to scrupulous hand hygiene is one of the major risk factors. Therefore, improper, careless and poor handling both in the field and at packing stations is detrimental, not only for melon and watermelon quality, but also for product safety. Melon spoilage caused by improper handling has been also related to *Salmonella* survival (Bowen et al., 2006). As previously outlined in Section 3.1.1, migration of *S*. Poona to the interior of the cantaloupes, followed by growth, is enhanced by co-contamination with some species of moulds. Thus, improper handling that results in fruit damage may enhance fungal development and affect survival and growth of *Salmonella* (Richards and Beuchat, 2005b).

Risk factors due to cross-contamination from micro-organisms associated with harvesting methods, including the extent of soil and extraneous matter debris on the fruit during and after harvesting, may pose a risk of foodborne pathogen contamination (Sivapalasingam et al., 2004). Although this study did not concern melons and watermelons, an analysis of outbreaks linked to fresh produce in the US identified dropped fruit on the ground or in contact with the soil as a factor that could increase the risk of contamination with bacterial foodborne pathogens (Sivapalasingam et al., 2004). Poor sorting and selection of melons and watermelons is a risk factor and harvest workers should not handle culled fruit in the field in order to prevent cross-contamination of healthy melons and watermelons during harvest. Poor hygienic practices of agricultural workers in the field (including promiscuous defecation) can also substantially increase the risk of contaminating melons and watermelons and good hygienic practices during pre-harvest, harvest and post-harvest activities are important.

3.6. Conclusion

The risk factors for the contamination of melons and watermelons with *Salmonella* are poorly documented in the literature with limited available data but are likely to include the following, based on what is known for other pathogens or other fresh produce:

- evironmental factors, in particular proximity to animal rearing operations and climatic conditions (e.g. heavy rainfall) that increase the transfer to pathogens from their reservoirs to the melon and watermelon plants;

- contact with animal reservoirs (domestic or wild life) gaining access to melon and watermelon growing areas;

- use of untreated or insufficiently treated organic amendments;

- use of contaminated water either for irrigation or for application of agricultural chemicals such as pesticides;

- contamination or cross-contamination by harvesters, food handlers and equipment at harvest or post-harvest.

For *Salmonella*, processes at primary production which wet the external portions of the crop close to harvest represent the highest risk and these include spraying prior to harvest, direct application of pesticides and other agricultural chemicals and overhead irrigation.

Fruit damage during harvest as well as cracking before or during harvest are additional risk factors for *Salmonella* contamination since melon and watermelon flesh has an internal pH of 5.1-6.7 and represents a good substrate for the growth of this pathogen. In addition, growth may be enhanced by co-contamination with some spoilage-causing moulds. Sharp edged or poorly designed storage containers and liners are risk factors that may contribute to melon and watermelon damage.

Although cooling melons and watermelons with water during post-harvest handling may reduce microbial loads on their outside surface, this process may also be a source of microbial cross-contamination. Delays in melon and watermelon cooling from ambient temperatures (20-35 °C) to recommended temperatures between 10 and 14 °C, when melon and watermelon rinds are wet from cooling operations or from dew, may permit multiplication of fodborne pathogens on the rind surface of melons and watermelons. Recommended storage temperatures for most of the melons post-harvest are between 10 and 14 °C although some cultivars, such as honeydew, can be stored as low as 5 °C. Melting ice water flowing through boxes of melons or watermelons may be a source of foodborne pathogens if already contaminated as well as a risk factor for cross-contamination within and among pallets of this fruit.

4. Description of processing methods for melons

Melons and watermelons may be further minimally processed to obtain ready-to-eat products, and these steps include selection, washing, peeling, cutting, packaging and storage (Figure 1). Other types of processing (e.g. freezing, or mashing) are either never or very rarely used with melons and are not further considered in this Opinion. Unpasteurized juicing may take place at retail or catering and is considered in Section 6. Some melon products are subject to, pasteurized juicing, drying (e.g. of seeds) or other processes but these are also outside the scope of this Opinion.

Melons and watermelons are minimally processed and ready-to-eat foods, with a high internal pH of 6.13-6.58 for cantaloupe, 5.78-6.00 for casaba, 6.00-6.67 for honeydew, 5.90-6.38 for Persian and 5.18-5.60 for watermelons (US-FDA, 2007), 90 % water and high protein (0.8 %) and sugar which vary depending on the cultivar. Commercial melons commonly have a total soluble content between 10-15 ° Brix, while watermelons usually present a total soluble solid content between 7-9 ° Brix, although these values may vary between the different cultivars. These fruit are considered to be highly perishable and a good matrix for bacterial growth, including the growth of *Salmonella*, especially during cutting or if damage has occurred to the surface prior to consumption.

Within the EU, whole products are commonly sold to caterers and consumers without minimal processing: fresh-cut melons and watermelons are commercially available from a variety of retailers and pre-packed cubes and sections of melon and watermelon are also available at retail.

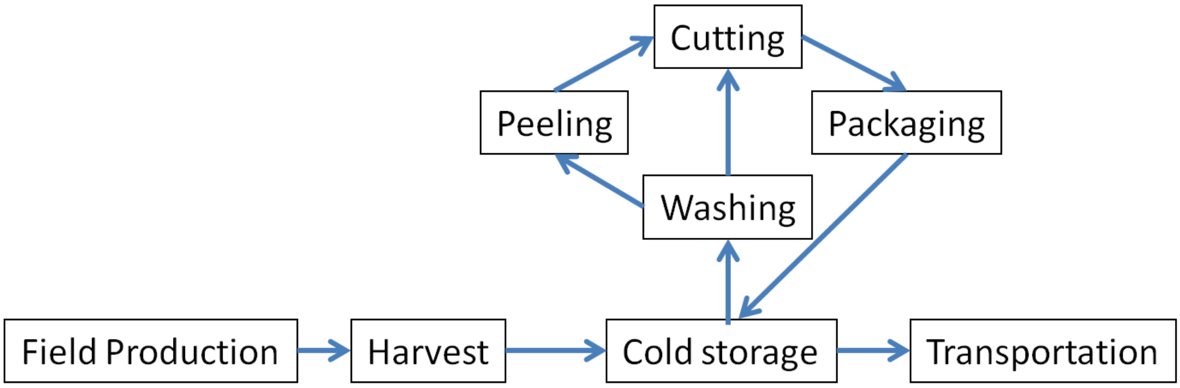

Figure 1: Summary of the main steps during production of whole and fresh-cut melons and watermelons

The 'commodity specific food safety guidelines for the melon supply chain' published by the US FDA (2005) described the most critical production points of the fresh-cut melon. Special consideration should be given to practices that prevent surface contamination of melons especially those with netted rinds as once surface contamination occurs, elimination of contamination is very difficult (US-FDA, 2005). Fresh-cut melon or watermelon is not as sensitive to chilling injury as the corresponding intact fruit before processing (USDA, 2004). Pre-cooling whole cantaloupes to below their optimal long-term storage temperature shortly before cutting has been shown to be effective for increasing product shelf life (Cantwell and Portela, 1997; Lange, 1998). Guidelines on GAP indicate that, once in the processing plant, it is recommended to maintain refrigerated conditions (US-FDA, 2005).

Whole melons and watermelons used for fresh-cut product are generally washed (spraying or dump tanked). In the case of products destined for the fresh-cut market, a dump tank will be used sometimes along with disinfectant (e.g. chlorine) to prevent cross-contamination (US-FDA, 2001a). Microbial reduction of melon and watermelon surface microbiota is dependent on the washing conditions such as water disinfectant concentration and contact time. However, it has been reported that if human pathogens are present on the surface of a melon they cannot be completely eliminated by washing (Parnell et al., 2005). Soaking melons and watermelons in aqueous solutions containing wash water disinfectants for very long periods of time is not an effective means of eliminating surface microbial contamination on the rind and may actually facilitate the infiltration of human pathogens into the edible portions (US-FDA, 2005). If melons or watermelons pass over brushes during processing, care should be taken to prevent the brushes acting as a source of cross-contamination or fruit damage. Thus, the quality and shelf-life of fresh cut melons and watermelons are likely to depend on the treatments applied to the whole fruit prior to cutting. It has been reported that before processing, whole melons can be washed using hot potable water, steam, or other treatments, mostly using chemical treatment with sodium hypochlorite to surface disinfect the melon rind before peeling or cutting operations commence (Suslow and Zuniga, 2001; Annous et al., 2004). These treatments are also applicable to watermelons but there may be variations across countries/producers regarding washing practices. In the United States, Fan et al. (2008) found, at the experimental level, that hot water treatment (76 °C for 3 minutes) of whole cantaloupes resulted in a longer shelf life of the cut fruit without affecting quality. The total plate count was about 2 log cfu/g lower with the hot water treatment than when cold water or chlorinated water were used to treat the cantaloupes prior to cutting.

Once washed, whole melons or watermelons can be cut into sections (sometimes with the rind) or into cubes without the rind. Melon and watermelon cubes are packaged alone, or mixed with other cut fruit (e.g. pineapple, mango or berries). Semi-automatic and automatic peeling machines are also available for processing as well as manual cutting. The use of a sharp knife to carefully slice off the top and the bottom is also used. Fresh-cut melon and watermelon should be stored between 0 and 5 °C for the whole of their shelf life to prevent the potential rapid and prolific growth of both spoilage micro-organisms and human pathogens including *Salmonella* (Escartin et al., 1989; Golden et al., 1993; Castillo and Escartin, 1994; Del Rosario and Beuchat, 1995). Cut melon and watermelon is generally packed and sold in modified atmosphere (MA) passively generated by the respiration rate of the product during storage. Common MA in fresh-cut packaged melon and watermelon is between 3 and 5 % O_2 and < 10 % CO_2. Some additives can be added to preserve quality of the product, such as ascorbic and citric acids (or their salts) at a maximum allowed concentration of '*quantum satis*'. Fresh-cut melons and watermelons require temperature control for quality and safety purposes and should be stored at 0-5 °C.

Shelf lives of whole melons and watermelons are 15 to 20 days (Appendix A, Freshfel information), whilst the cut fruit is 5 days without preservatives and 14 days if ascorbic and citric acids or their salts are added. Calcium compounds have been recommended to maintain the flesh firmness of fresh-cut melons. Dipping fresh-cut products in solutions of 0.5 to 1.0 % calcium chloride has been demonstrated to be very effective in maintaining product firmness (Ponting et al., 1971, 1972). However, calcium chloride may leave bitter off-flavours on some products. Quality and shelf life of melons and watermelons are related to maturity. Aguayo et al. (2008) reported that, experimentally, hot (60 °C) calcium dips increased bound calcium levels, maintained the firmness, reduced the microbial growth and improved sensory quality compared to control treatments washed with sterile water. They also found that the effect of calcium on fresh-cut melon quality depended on the type of calcium salts. Calcium chloride, and especially weak organic acid salts like calcium propionate and lactate, was effective in maintaining fruit firmness during 8 days storage at 5 °C.

5. Risk factors for microbiological contamination during processing treatments, including the main processing practices

Microbiological risks factors for minimally processed or ready-to-eat melons and watermelons are those that allow survival of pathogens acquired during harvest as well as providing opportunities to increase as a result of bacterial growth and through cross-contamination from water, plant or machinery as well as via food handlers. Risk factors associated with contamination by *Salmonella* in outbreaks associated with melon and watermelon consumption were wash water temperature, contaminated hydro-cooler water, damaged rind, rind fungus rot, workers' hands and contaminated conveyor belts and equipment (Bowen et al., 2006). Edible portions of the melon flesh may be contaminated in the cutting or rind removal process because the knife blade may spread microbial contamination on the outside rind of the melon to the inner edible portions (Lin and Wei, 1997; Ukuku and Davis, 2001; Ukuku and Fett, 2002). Thus, the most relevant risk factors during processing are environmental factors, water sources used for washing or treatment, worker health and hygiene and equipment.

For fresh cut melon and watermelon products, human pathogens (including *Salmonella*) may proliferate rapidly under temperature abuse conditions (Escartin et al., 1989; Golden et al., 1993; Castillo and Escartin, 1994; Del Rosario and Beuchat, 1995) partially due to relative high internal pH (5.1 to 6.7 depending on the cultivar) which is quite unusual for fruit. Li et al. (2013) confirmed that *Salmonella* can grow quickly and reach high concentrations when cut cantaloupe are stored at ambient temperatures, without visual signs of spoilage.

5.1. Environmental factors

Environmental factors refer to the specific conditions of the processing area, which can have an impact on the safety of the melons and watermelons and have been previously considered for leafy greens eaten raw as salads (EFSA BIOHAZ Panel, 2014b). The environment of the processing plant represents a risk for cross-contamination between products. The production environment is likely to be refrigerated which, if the product has not already been refrigerated, should be implemented immediately after harvesting and will prevent the growth of pathogenic bacteria. Recommended temperatures for most of the melons and watermelons cultivars are between 10-15 °C and 7 °C, respectively, as melons and watermelons are sensitive to chilling. However, fresh-cut melons are not sensitive to chilling so they can be stored close to 0 °C.

5.2. Water sources (washing)

Most melons and watermelons intended for direct consumption as fresh-cut fruit are washed after harvest, therefore contamination and cross-contamination from wash water may occur in a similar way identified for leafy greens (EFSA BIOHAZ Panel, 2014b). To maintain the microbial quality of the water avoiding cross-contamination in a washing tank, the use of disinfectant agents is recommended. Disinfection solutions should be monitored to ensure that the disinfectant is present at sufficient levels to achieve its intended purpose and does not promote the potential for cross-contamination. Other uses of water (e.g. for cooling or other uses) may be also a source of contamination. Wash water at a melon processing facility has been highlighted as a potential source of faecal contamination (Gagliardi et al., 2003). Therefore, processing and packing facilities should also focus on water quality as an important control point to reduce bacterial contamination on melon rinds.

Richards and Beuchat (2004) investigated the effects of attachment to, or infiltration of, *Salmonella enterica serovar* Poona on cantaloupe melons where the temperature differentials between the field and wash water was between 30 °C and 4 °C. Differences were detected between cantaloupes grown in different parts of the US. The percentage weight increase after washing due to ingress of water in Western grown cantaloupes was significantly greater than that in Eastern-grown cantaloupes. It was noted that *Salmonella* Poona attachment to or infiltration into, Eastern but not Western grown cantaloupe rind was enhanced when the fruit was pre-treated at 4 °C, compared with 30 °C, regardless of different immersion temperatures. Richards and Beuchat (2004) concluded that populations of *Salmonella* cells adhering to, or infiltrating into, cantaloupe tissues were not dictated entirely by temperature differentials between fruit and the immersion water; rather, they were also influenced by the properties of the melon surface tissues.

5.3. Equipment

Risks from contamination via process equipment were previously discussed for leafy greens (EFSA BIOHAZ Panel, 2014b). However, as outlined in the previous Section, melon and watermelon damage is a specific risk factor for pathogen contamination during production and storage. Therefore improper, careless and poor handling during post-harvest packing and processing can lead to damage occurring. Sharp edged or poorly designed storage containers and liners are also risk factors that may contribute to fruit damage. Cross-contamination of surfaces by workers handling contaminated produce is also possible. Several authors demonstrated that the edible parts of the fruit may be contaminated in the cutting or rind removal process (Lin and Wei, 1997; Ukuku and Davis, 2001; Ukuku and Fett, 2002). For instance, transfer of *Salmonella* from the cantaloupe rind into the melon flesh by the physical act of cutting the cantaloupe or direct contact with contaminated rinds has been reported (Ukuku and Sapers, 2001).

5.4. Worker health and hygiene, worker training

As previously discussed for leafy greens (EFSA BIOHAZ Panel, 2014b) as well as for any other sectors processing ready-to-eat foods, lack of compliance of workers with Good Manufacturing Practices (GMPs) and Good Hygiene Practices (GHPs) and failure to implement food safety management systems (including HACCP) are risk factors in melon processing. These systems include adequate training as well as hand washing and toilet facilities, which are further considered in later Sections (10.1.5).

5.5. Conclusion

During processing cross-contamination via equipment, water or food handlers are the main risk factors for contamination of melons and watermelons with *Salmonella*.

Risk factors associated with contamination by *Salmonella* in outbreaks in the US and Canada associated with melon and watermelon consumption were wash water temperature, contaminated hydro-cooler water, damaged rind, rind fungus rot, workers' hands and contaminated conveyor belts and equipment.

Edible portions of the melon and watermelon flesh may be contaminated in the cutting or rind removal process because the knife blade may spread microbial contamination on the outside rind of the melon and watermelon to the inner edible portions.

Salmonella may grow and penetrate into wound tissues in whole cantaloupe melons as well as on cut melon and watermelon and can multiply at temperatures allowing growth, without visual signs of spoilage. Unrefrigerated storage of cut melons and watermelons is likely to be an important risk factor at retail and catering, including in domestic and commercial environments.

6. Description of the distribution, retail and catering stages including domestic and commercial environments for melons

Melons, including watermelons, are almost always consumed fresh. These are commonly sold as whole fruit in various retail establishments (markets, supermarkets, shops etc.). Whole product can be cut and sold as segments of various sizes in any of the above retail establishments. As outlined in Section 4, cut melon and watermelons can be retailed in modified atmosphere packaging (with or without other fruit). Melons and watermelons are also sold as loose cut product in salad bars at both retail and in catering, sometimes allowing for self-selection and service by the consumer, and also used for production of unpasteurised juices and 'smoothies' (sometimes mixed with other fruit or vegetables) usually for immediate consumption or with very short shelf lives.

At catering and in domestic environments, melons and watermelons are served fresh, either at the start of a meal (sometimes with ham and other meat products) or as a dessert, either alone or with other fruit. Washing of product may take place in a similar manner to that outlined in primary processing, but is more likely to be in sinks with running potable water used for general food handling.

7. Risk factors for microbiological contamination during distribution, retail and catering including domestic and commercial environments

Risk factors during distribution, retail and catering for melons and watermelons are likely to be similar to those for leafy greens (EFSA BIOHAZ Panel, 2014b), although there is limited information from published studies. These risk factors include contamination from the environment (e.g. hygiene of premises and storage rooms), the quality of water and equipment used to wash melons and watermelons, the hygiene of the equipment, the hygiene and training of workers and chill temperature control particularly for cut products. Since there is the potential for growth of bacterial foodborne pathogens (including *Salmonella),* particularly for cut products, poor temperature and shelf life control are likely to be important risk factors here.

Risk factors associated with contamination by *Salmonella* in outbreaks in the USA and Canada associated with processed melons and watermelons were: cutting through contaminated rind, cutting with contaminated equipment or surfaces, ill food handlers, temperature abuse and cross-contamination from pooling cut fruit, as well as rind contamination (Bowen et al., 2006; Hanning et al., 2009). Outbreaks have been associated with the consumption of fresh-cut melon and watermelon juices (Mohle-Boetani et al., 1999; CDC, 2007).

7.1. Water sources (washing)

As outlined for leafy greens (EFSA BIOHAZ Panel, 2014b) water, which has been contaminated with bacteria and viruses and is then used in food preparation, can cause contamination of melons and watermelons. This represents a similar contamination or cross-contamination risk as occurs during processing (see Section 5.2).

To simulate washing conditions in food service or domestic environments, Parnell et al. (2005) evaluated the effects of soaking melons in water with or without 200 ppm total chlorine for 60 seconds plus a brush scrub for removal of *S.enterica* serovar Typhimurium from the surface of smooth (honeydew) or complex (cantaloupe) melon rinds. The presence of *Salmonella* was reduced on the rind of cantaloupe by 1.8 log CFU/melon after soaking for 60 s in 200 ppm total chlorine, which was significantly greater than the 0.7 log CFU/melon achieved when soaking in water alone. For both water and 200 ppm total chlorine, scrubbing with a vegetable brush was shown to be significantly (0.9 log CFU/cantaloupe) more effective in removal than soaking alone. When honeydew melons were soaked or scrubbed in water, reductions of 2.8 log CFU/melon or > 4.6 log CFU/melon were achieved respectively. When water or water plus scrubbing treatments were used, *Salmonella* was detected on un-inoculated surfaces of the cantaloupe and honeydew melons, but was not detected on these melons when chlorinated water was used, with or without scrubbing (Parnell et al., 2005). However, when water treatments were used, the presence of *Salmonella* next to and at sites remote from the inoculation indicated that the bacterium was spread from inoculated site on the rind to un-inoculated sites, either through the rinse water or scrubbing brush: transfer to other sites occurred more often with cantaloupe than honeydew melons. Although potentially unrealistic in the levels of chlorine used, this model system emphasises the importance of prevention of contamination during primary production, during minimal processing and during storage and transport, as well as the possibility of cross-contamination in kitchen environments if contamination has occurred.

7.2. Equipment

There is the possibility for pathogen contamination from various food products to spread via cross-contamination through contact with food processing or preparation surfaces as previously discussed (EFSA BIOHAZ Panel, 2014b). For example, this could occur through cutting of a contaminated item followed by using the same utensil to cut uncontaminated items without adequate cleaning, especially when contaminated from other foods. Ukuku and Sapers (2001) demonstrated that *Salmonella* present on the surface of melons and watermelons can contaminate the internal flesh (or juice) during cutting and preparation.

7.3. Worker health and hygiene, worker training

Contamination of leafy greens with pathogens through contact with the hands of infected persons during preparation was previously discussed for leafy greens (EFSA BIOHAZ Panel, 2014b), and similar risks occur for the contamination of melons and watermelons. Poor hand hygiene, e.g. not washing hands thoroughly following the use of toilet facilities and prior to handling of foodstuffs is an important and universal risk factor for contamination of food. An infected food handler was the likely source of contamination associated with 30 confirmed or probable cases of illness with *S.* Litchfield infection that were identified among those who had eaten honeydew melon within a fruit salad at a hotel restaurant (including 10 other restaurant food handlers) in the US in 2007 (CDC, 2008).

7.4. Storage temperature

Salmonella is able to survive and grow on melons and watermelons and will be influenced by storage temperature. Bradford et al. (1997) showed that two strains of *S. enterica* serovar Enteritidis PT4 transferred by intentional simulated cross-contamination within a kitchen or catering environment from egg droplets onto cut honeydew melon rapidly grew when melon cuts were stored at 20 °C. These growth predictions were further developed by Li et al. (2013) who validated mathematical model that predicts the growth rate of *Salmonella* on fresh-cut cantaloupe, honeydew and watermelon. This study showed, for example, that levels of *Salmonella* (serovars Agona, Enteritidis, Gaminara, Michigan and Montevideo) on fresh-cut cantaloupe with an initial load of 3 log CFU/g can reach over 7 log CFU/g at 25 °C within 24 h and showed that *Salmonella* can grow quickly and reach high concentrations when cut cantaloupe is stored at ambient temperatures, without visual signs of spoilage. This study showed that there was no growth, or a slight decline, observed at refrigerated (4 °C) temperatures for *Salmonella* on cantaloupe, honeydew, and watermelon. Li et al. (2013) reported that, despite their pH difference between watermelon (pH 5.1 to 5.6) and cantaloupe melons (pH 6.1 to 6.6), similar growth rates were detected using a cocktail of *Salmonella* serovars Agona, Enteritidis, Gaminara, Michigan and Montevideo providing validation for a model to estimate the effects of storage temperatures on cut melon from 4 to 25 °C.

Salmonella will grow and penetrate into wound tissues, especially when certain type of mould are present. However, the bacterium is able to survive on intact cantaloupe rind for days to several weeks at both ambient and refrigeration temperatures (Bowen et al., 2006). Annous et al. (2004) reported growth of *S*. Poona at ambient but not refrigeration temperatures after inoculation onto whole intact cantaloupes following a 'surface pasteurisation' (76 °C for 2-3 minutes) of the whole fruit.

Growth of *Salmonella enterica* serovar Enteritidis at temperatures allowing growth was demonstrated in unpasteurised melon ('Piel de sapo') and seedless watermelon juices that could be reduced by > 3.5 log_{10} units by high-intensity pulsed electric field or by > 5.5 log_{10} units after the addition of citric acid, or cinnamon bark oil (Mosqueda-Melgar et al., 2007, 2008). Growth of *Salmonella enterica* serovar Poona was also reported in cantaloupe juice at temperatures allowing growth together with antagonistic effects associated with yeast growth (Richards et al., 2004).

7.5. Conclusions

At distribution, retail and catering and in domestic and commercial environments, cross-contamination, in particular via direct or indirect contact between raw contaminated food and melons as well as watermelons, is a risk factor for *Salmonella.* Cross-contamination risks include the environments of salad bars. *Salmonella* is able to survive on intact cantaloupe rind for days to several weeks at both ambient and at refrigeration temperatures. *Salmonella* may grow and penetrate into wound tissues in whole cantaloupe melons as well as on cut melon and watermelon and can multiply at temperatures allowing growth, without visual signs of spoilage. Unrefrigerated storage of cut melons and watermelons is likely to be an important risk factor at retail and catering including in domestic and commercial environments. However, whole melons and watermelons should not be stored at too cold a temperature as they are sensitive to chilling (see Section on post harvest practices). Recommended storage temperatures for most of the melon cultivars are between 7 and 14 °C, however, cantaloupe melons can be stored between 2 and 5 °C. The recommended temperatures for watermelons are between 7 and 13 °C. However, in many cases, due to logistical issues, melons and watermelons are stored at ambient temperatures.

8. Analytical methods for the detection and enumeration of *Salmonella* in melons and watermelons

The analyses of pathogens on melons and watermelons is mainly performed on the rind. Various methods of sample preparation in the laboratory can be used. Annous et al. (2004, 2005) peeled off the whole rind (and the stem scar area and the opposite end of the melon or watermelon) with a mechanical peeler or used a composite sample of 20 rind plugs (with a sterile 20 mm diameter stainless steel cork bore) taken at random locations on the surface of the melon or watermelon. Contamination on the rind of the fruit may be heterogeneous. A disadvantage of taking rind plugs from a limited area of the rind is that restricted areas of contamination on the rind may not be detected. A disadvantage of peeling the whole rind is the fact that it is more labour intensive and that it may give a higher risk for cross-contamination (due to more intensive handling of the melon or watermelon). Castillo et al. (2004) used a sponge to sample the rind of a cantaloupe. *Salmonella* may form biofilms on the rind, which may be difficult to remove from netted rinds (e.g. of cantaloupes), even when firmly rubbed with a sponge. Hammack et al. (2004) compared two methods for the recovery of *Salmonella* from whole cantaloupes: the 'soak' method and the 'rinse' method. Cantaloupes were placed in sterile plastic bags with a non-selective pre-enrichment broth at a 1:1.5 cantaloupe weight-to-broth volume ratio. The cantaloupe broths were shaken for 5 min at 100 rpm after which 25-ml aliquots (rinse) were removed from the bags. The 25-ml rinses were pre-enriched in 225-ml portions of the same un-inoculated broth type at 35 °C for 24 h (rinse method). The remaining cantaloupe broths were incubated at 35 °C for 24 h (soak method). The soak method detected significantly more *Salmonella*-positive cantaloupes ($P < 0.05$) than did the rinse method. The latter soak method is also currently available in the US FDA Bacteriological Analytical Manual (US-

FDA, 2014). In ISO/CEN documents (EN ISO 6887-4) recommendations on (sub)sampling for microbiological testing are provided but this document does not include explicit recommendations for melons (sub)sampling.

As previously outlined (EFSA BIOHAZ Panel, 2014b), the methods for detecting *Salmonella* spp. in FoNAO are well developed and analytical reference methods are standardised and widely adopted across laboratories testing food, including that for Official Control: EN/ISO standard method 6579[12] is prescribed in Regulation 2073/2005[13] when analysing pre-cut ready-to-eat fruit and vegetables in the scope of the verification of compliance with the currently established food safety microbiological criterion for *Salmonella* spp. Alternative methods based on modifications of the ISO method using alternative enrichment media or isolation media (chromogenic media) or using immunoassays and real time PCR are also available for rapid detection of *Salmonella,* and many of these methods have been ISO 16140 validated showing performance characteristics equivalent to the EN/ISO standard method 6579 (EFSA BIOHAZ Panel, 2014b).

9. Data on occurrence and levels of *Salmonella* in melons and watermelons

There is no routine or regular monitoring of melons and watermelons for the presence of *Salmonella* in EU Member States and there is limited data on the occurrence of *Salmonella* in/on melons and watermelons in EU, although some studies of surveys in non EU countries are present in the peer reviewed world literature (Table 1). There is limited data available from studies on the occurrence of *Salmonella* on melons, and some of these studies are small (e.g. comprising < 20 samples). Most of the data is for cantaloupes (particularly from North and Central America) and there are only single studies on watermelon and muskmelon. Some of the surveys relate to surface sampling of melons, which unlike other FoNAO (e.g. berries and tomatoes) are not consumed, although it may present a risk of cross-contaminating to the inner edible parts during cutting or by damage and ingress. It is not possible to include occurrence data on contamination of melons and watermelons by *Salmonella* within zoonoses monitoring data (according to the Directive 2003/99/EC[14]) since these data are aggregated into broad food categories, e.g. the single category of vegetables and fruit. Furthermore, there is no data on the occurrence of *Salmonella* in samples collected in the EU. Finally, there is a variety of methods and sample sizes used in all the studies summarised in Table 1, some of which were collected during outbreak investigations. Consequently, there are difficulties in both making meaningful comparisons between individual studies as well as assessing the representativeness of these data to estimate the overall levels of contamination.

In January 2013, following a large outbreak of salmonellosis in several EU Member States in 2012 in which consumption of imported Brazilian watermelons was involved, the European Commission mandated the analysis of 5 % of all batches of watermelons from Brazil arriving at European ports (Commission Implementing Regulation (EU) No 618/2013[15]). During 2013, there were 525 consignments which were imported to the EU. Of these, there were 35 physical checks, each of which included testing for *Salmonella* in five 25 g samples. There were no non-compliances out of these 35 checks and the product was de-listed in October 2013 (Appendix C, Table 9).

[12] EN/ISO 6579:2002. Microbiology of food and animal feeding stuffs - Horizontal method for the detection of *Salmonella* spp. International Organization for Standardization, Geneva, Switzerland.
[13] Commission Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs. OJ L 338, 22.12.2005, p. 1-26.
[14] Directive 2003/99/EC of the European Parliament and of the Council of 17 November 2003 on the monitoring of zoonoses and zoonotic agents, amending Council Decision 90/424/EEC and repealing Council Directive 92/117/EEC. OJ L 325, 12.12.2003, p. 31-40.
[15] Commission Implementing Regulation (EU) No 618/2013 of 26 June 2013 amending Annex I to Regulation (EC) No 669/2009 implementing Regulation (EC) No 882/2004 of the European Parliament and of the Council as regards the increased level of official controls on imports of certain feed and food of non-animal origin Text with EEA relevance. OJ L 175, 27.06.2013, p. 34-42.

Table 1: Studies on the occurrence of *Salmonella* in melons and watermelons

Sampling place	Commodity	Country	Detection method	Number of samples analysed	Number of positive samples	% of positive samples	95 % CI[(a)]	Sample size	Reference
Field	Whole Cantaloupe	Mexico	Mexican Official method (NOM 114 SSA1-1994) (PCR)	35	9	25.7	[13.6,41.7]	25 g	(Espinoza-Medina et al.. 2006)
Field	Whole Cantaloupe	USA	Non-selective pre-enrichment, dual selective enrichment and highly specific genetic affinity test for *Salmonella*	2123 (survey years: 1999, 2000, 2001, 2002-03, 2003-2004)	0	0.0	[0,0.1]	NS	(Suslow, 2004)
Farms	Whole cantaloupe	USA	US-FDA BAM	35	0	0.0	[0,6.9]	25 g	(Mukherjee et al., 2006)
Farm	Whole cantaloupe	Mexico	Pre-enrichment lactose broth, enrichment in Rappaport-Vassiliadis and tetrathionate broth, differential selective plating and biochemical identification	19	0	0.0	[0,12.2]	NS	(Figueroa Aguilar et al., 2005)
Production	Whole cantaloupe	Mexico	Surface wash, pre-enrichment in BPW USDA MLD (cultural method)	20 batches of 5 (total 100 melons)	9	45.0	[25.1,66.2]	Whole melon washing	(Gallegos-Robles et al., 2009)
Production	Whole cantaloupe	Mexico	Surface wash, pre-enrichment in BPW USDA MLD (PCR)	20 batches of 5 (total 100 melons)	11	55.0	[33.8,74.9]	Whole melon washing	(Gallegos-Robles et al., 2009)
Production	Whole cantaloupe	Mexico	Surface wash, pre-enrichment in BPW USDA MLD	15	6	40.0	[18.8,64.7]	NS	(Gallegos-Robles et al., 2008)
Domestic production	Cantaloupe	USA	NS	164	4	2.4	[0.8,5.7]	16 oz	(US-FDA, 2003)
Farms and packing plants	Whole cantaloupe	USA	Rappaport-Vassiliadis enrichment, screening by Tecra immunoassay and cultural confirmation	950	5	0.5	[0.2,1.1]	100 cm^2	(Castillo et al., 2004)
Farms and packing plants	Whole cantaloupe	Mexico	Rappaport-Vassiliadis enrichment, screening by Tecra immunoassay and cultural confirmation	300	1	0.3	[0,1.5]	100 cm^2	(Castillo et al., 2004)
Field to packed	Whole cantaloupe	USA	US-FDA BAM	90	3	3.3	[0.9,8.6]	25 g	(Johnston et al., 2005)

Sampling place	Commodity	Country	Detection method	Number of samples analysed	Number of positive samples	% of positive samples	95 % CI[(a)]	Sample size	Reference
Packed	Whole cantaloupe	Mexico	Mexican Official method (NOM 114 SSA1-1994) (PCR)	34	7	20.6	[9.7,36.2]	25 g	(Espinoza-Medina et al., 2006)
Production (n = 36) and at import to USA (n = 6)	Whole cantaloupe	Mexico	US-FDA BAM	42	0	0.0	[0,5.8]	25 g	(Johnston et al., 2006)
At import	Whole cantaloupe	USA	NS, surface sampling	1440	12	0.8	[0.5,1.4]	NS	(Madden, 1992)
At import	Whole cantaloupe	USA	NS, surface sampling	2200	24	1.1	[0.7,1.6]	NS	(Madden, 1992)
Import	Whole cantaloupe	USA from various countries[(b)]	NS	151	8	5.3	[2.5,9.7]	16 oz	(US-FDA, 2001b)
Imported to Canada from USA,Central America, Mexico, Caribbean	Whole cantaloupe	Canada	NS	211	4	1.9	[0.6,4.4]	NS	(D'Aoust, 1994)
Wholesale and distribution centers (domestic and imported)	Cantaloupe	USA	ELISA	1077	0	0	[0,0.2]	NS	(USDA, 2002)
Retail (distribution centres and markets)	Whole Fresh organic muskmelon	Canada	Health Canada Compendium of Analytical Methods MFHPB-20	151	0	0.0	[0,1.6]	25 g	(Arthur et al., 2007)
Retail markets and street vendors	Cantaloupe	Saudi Arabia	Rappaport-Vassilidis enrichment screened by PCR	5	0	0.0	[0,37.9]	25 g	(Hassan et al., 2011)
Retail markets and street vendors	Watermelon	Saudi Arabia	Rappaport-Vassilidis enrichment screened by PCR	2	0	0.0	[0,66.7]	25 g	(Hassan et al., 2011)

NS = not stated.
(a): The credible interval was calculated using a Bayesian approach and taking as prior beta (1/2,1/2) (Miconnet et al., 2005).
(b): Canada, Costa Rica, Dominican Republic, Ecuador, Guatemala, Haiti, Honduras, Mexico, Nicaragua.

10. Mitigation options to reduce the risk for humans posed by *Salmonella* in melons and watermelons

10.1. Introduction

Many of the mitigation options previously outlined for leafy greens (EFSA BIOHAZ Panel, 2014b) are generic and equally applicable to other foods of non-animal origin, including melons and watermelons. However, there are some differences are inherent to melons and watermelons, which are substantially different commodities than leafy greens both with respect to the production system, their intrinsic characteristics and epidemiological evidence associating their consumption with foodborne outbreaks. Melons and watermelons are edible, sweet-fleshed fruit with a near neutral pH, high moisture content, and high sugar content. Although melons and watermelons have inedible skins, *Salmonella* has some properties for survival on their surface, particularly if physical damage has occurred, and once reaching the inner edible fruit it will readily grow in the absence of obvious signs of spoilage.

Melons and watermelons grow under warm conditions either in open fields or in greenhouses and are generally produced at ground level in close proximity to the soil or other growth substrates. Outbreaks of salmonellosis implicating whole as well as cut melons and watermelons have been reported. Although these salmonellosis outbreaks have been particularly associated with cantaloupe melons in North America and Canada, outbreaks have occurred in Europe and cases occurred which were associated with *Salmonella* Newport (Appendix B, Table 26 in (EFSA Panel on Biological Hazards (BIOHAZ), 2013)) across multiple Member States in 2012, caused by consumption of contaminated watermelon from Brazil.

10.2. General mitigation options

Appropriate implementation of food safety management systems including Good Agricultural practices (GAP), Good Hygienic Practices (GHP) and Good Manufacturing Practices (GMP) should be the primary objective of operators producing melons and watermelons. These food safety management systems should be implemented along the farm to fork continuum and will be applicable to the control of a range of microbiological hazards. Although some intervention strategies or control measures can be defined to prevent, limit the spread or sometimes reduce the level of contamination in melons and watermelons, the main focus for food safety management should be on preventive measures, as it is difficult to define critical control points (CCPs) that either eliminate the microbial hazard or substantially reduce it. Codes of practice and guidelines should encourage the use of appropriate good agricultural and hygiene practices at farm level. Food safety management based upon GMP and HACCP principles should be the objective of processors, distributors, retailers and caterers involved in production of melons and watermelons. In addition, the responsibilities of the food business operators producing or harvesting plant products require them to take adequate control measures as outlined in Regulation (EC) No. 852/2004 - and these are identical to those outlined previously (EFSA BIOHAZ Panel, 2014b). Where practicable, a comprehensive food safety control plan that includes a written description of each of the hazards identified in assessing environmental hygiene and the steps that will be implemented to address each hazard should be prepared at primary production (EFSA BIOHAZ Panel, 2014b), and there should be complete traceability through primary production, processing, distribution, retail, and catering to consumption of all products.

10.2.1. Environment

As outlined for leafy greens (EFSA BIOHAZ Panel, 2014b), primary production should not be carried out in areas where the known or presumptive presence of pathogens would lead to an unacceptable likelihood of transfer to horticultural crops intended for human consumption, which includes both melons and watermelons, without a validated process kill step (CAC, 1969, 2003). Production areas should be evaluated for hazards that may compromise hygiene and food safety, particularly to identify potential sources of faecal contamination. Each farm environment (including open field or greenhouse production) should be evaluated independently as it represents a unique combination of numerous characteristics that can influence the occurrence and persistence of foodborne pathogens in or near melon and watermelon growing areas. If the evaluation concludes that contamination in a specific area is at levels that may compromise the safety of crops, in the event of heavy rainfall and flooding for example, intervention strategies should be applied to restrict growers from harvesting or using this land for melon and watermelon production until the hazards have been addressed. Preventive measures are not always easy to implement as farmers may not control adjacent land activities or the land history does not include knowledge of the level of pathogens in the soil or time to reduce these to acceptable levels (Suslow et al., 2003; James, 2006; Gil et al., 2013). Since *Salmonella* (and probably other bacterial foodborne pathogens) grow on melon and watermelon tissue, cooling and cold storage as soon as possible after harvest is recommended to prevent multiplication of foodborne pathogens, if present, on or gaining access to the flesh from the melon and watermelon rind surface.

Domestic and wild animals should be excluded from production areas, to the extent possible, using appropriate biological, cultivation, physical and chemical pest control methods, although the melons and watermelons themselves may represent a risk since they will attract animals and insects as a source of food. Preventing wild life from causing damages to, and feeding on, melons and watermelons should also minimize the risk of contamination by pathogens excreted by wild animals.

Melons and watermelons may be in direct contact with soil during growth and/or harvesting. Bird droppings and airborne contaminants (birds nesting around the packing area, nearby livestock, poultry areas or manure storage or treatment facilities, etc.) may also pose a risk of melon and watermelon contamination. Growers should use production practices (e.g. site selection, wind breaks) to minimize the contact of melons and watermelons with airborne contaminants and limit contact with the soil, animal droppings, soil amendments (including natural fertilizers) or direct contact with irrigation water. Where materials are used under the melons and watermelons during growing, it is recommended to minimize contact with the soil, e.g. the use of mulch or biodegradable materials (e.g. straw) or during harvest, plastic or biodegradable materials (e.g. leaves or papers as liners or biodegradable baskets).

During growth of melons and watermelons, plastic surfaces, which can come into contact with this fruit, should be clean and sanitary, and if biodegradable materials and/or mulch are used, they should be applied only once and not reused in order to prevent cross-contamination. The impact of using plastic surfaces on *Salmonella* dispersal and survival in case of rain has not been studied in melons as it has been for tomatoes (Cevallos-Cevallos et al., 2012).

Growers should implement safe handling, transport and storage practices and immediately cool melons and watermelons after harvesting. Whenever pre-cooling is used (i.e. rapid removal of field heat e.g. within the first 2 hours post-harvest), hydro-cooling may spread contamination. Therefore melons and watermelons should be cooled and stored as soon as possible under temperature controls within the processes. When required, growers should use potable quality water for ice and hydro-coolers when pre-cooling to minimize risks of contamination. Melons and watermelons that have undergone cleaning and/or chemical treatment should be effectively separated, either physically or by time, from raw material and environmental contaminants. Cross-contamination should be prevented between raw and washed melons and watermelons, from sources such as wash water, rinse water, equipment, utensils and vehicles. Since melons and watermelons are intended to be consumed raw, sorting and selection should be implemented to avoid using fruit that has visible signs of decay or damage due to the increased risk of microbial contamination.

Premises and rooms should be designed to separate the area for incoming melons and watermelons from the field (areas for incoming soiled and outgoing washed fruit) from the area for handling. This can be accomplished in a number of ways, including linear product flow. Where feasible, raw material handling areas should be separated from processing/packing areas. Within each of these areas, cleaning operations should be conducted separately to avoid cross-contamination between equipment and utensils used in each operation. For products that are not immediately wrapped or packed (i.e. the melons or watermelons are exposed to contaminants from the environment), the rooms where final products are packaged and stored should be designed and maintained to be as dry as possible.

Special consideration should be given to production practices specific to melons and watermelons because of the characteristics of the rind of some cultivars and because they frequently come into contact with the soil directly during growth and development. Some growers place melons and watermelons on cups (i.e. small plastic pads) or plastic mulch-covered beds (wider and more elevated during the wet season), or halved bamboo segments to minimize direct melon-to-soil contact and thereby reduce ground spot development. Melons and watermelons may also be hand-turned multiple times by agricultural workers during the growing season to prevent sunburn or ground spot development or covered with biodegradable materials such as rice straw to prevent sunburn. Melon rind ground spots have been demonstrated to have substantially greater microbial populations than non-ground spot areas and, therefore, may be more susceptible to microbial contamination. If cups or biodegradable materials are used underneath melons and watermelons, the following are recommended:

- use plastic mulch under cups to minimize cup and melon and watermelon contact with the soil;
- ensure cups are clean, sanitary and without sharp edges before setting them under the melons and watermelons and do not result in water collection under the fruit surface;
- ensure that employees follow good hygienic practices when turning melons and watermelons on the cups or during harvesting operations. Use biodegradable materials only once to prevent cross-contamination.

Melons and watermelons are susceptible to damage during harvest and post-harvest handling operations. The following should be considered:

- avoid setting directly on soil after removal from the vine and before loading into transport vehicle to avoid contaminating the melon and watermelon with contaminants in the soil;
- when padding is used with post-harvest handling equipment to prevent damage to melons and watermelons, it should be constructed of material that can be cleaned and disinfected. Ensure that padding is cleaned and disinfected before and after use.
- minimise mechanical damage such as rind punctures, cracks, and bruising, as these wounds may provide entry points for pathogens and sites for microbial survival and multiplication;
- train agricultural workers to recognize and discard or segregate damaged melons and watermelons.

10.2.2. Manure and sewage sludge

Appropriate production, storage, management and use of manure or sludge is equally important for melon and watermelon production to reduce residual pathogen populations as outlined for leafy greens (EFSA BIOHAZ Panel, 2014b) and treatment procedures to reduce or eliminate pathogens from contaminated manure are, as with any ready-to-eat food, equally applicable. The same consideration for the use of sewage sludge previously outlined for leafy greens (EFSA BIOHAZ Panel, 2014b) also apply to melon and watermelon production.

10.2.3. Waters

The importance as a preventive measure of selection of appropriate irrigation sources and avoiding, if possible, uncontrolled sources of water such as rivers and lakes was previously outlined for leafy greens (EFSA BIOHAZ Panel, 2014b) and this is equally applicable to melon and watermelon production. Since melons and watermelons are intended for direct consumption, for washing, potable quality water should always be used. It is recommended that the quality of the water used in packing establishments be controlled and monitored, i.e. recording testing for indicator organisms and/or foodborne pathogens and if necessary treated before use.

10.2.3.1. Water in primary production

Risks can be minimised by growers identifying the sources of water used on the farm (municipality, re-used, irrigation water, reclaimed wastewater, discharge water from aquaculture, well, open canal, reservoir, rivers, lakes, farm ponds, etc.). Attention should be paid to the selection of the water sources for irrigation, agricultural chemical application (e.g. fungicide) and in particular to the avoidance of the use or the ingress of water contaminated by sewage.

Among the potential interventions, both water treatment or efficient drainage systems that take up excess overflows are needed to prevent the additional dissemination of contaminated water. Risk posed by water should be minimised by assessing the microbial quality of the sources of water used on the farm for the presence of pathogens. This should include a documented check detailing the potential for microbial contamination from all possible human and/or animal faecal sources of contamination (e.g. from animals, human habitation, leaks from on-field sanitary facilities, promiscuous defecation in production environments, sewage treatment, manure and composting operations) and the water's suitability for its intended use. In the case of identified contamination sources of the water used on the farm, corrective actions should be taken to minimize the risk of exposure to the fruit. The effectiveness of corrective actions should be verified. Identifying and implementing corrective actions is a means to prevent or minimize contamination of water for primary production (e.g. settling or holding ponds that are used for subsequent irrigation and/or harvesting may attract animals or in other ways increase the microbial risks associated with water for irrigation). Possible corrective actions may include fencing to prevent large animal contact, proper maintenance of wells, filtering water, not stirring the sediment when drawing water, building settling or holding ponds, and water treatment facilities and water treatment. Since *E. coli* is an indicator micro-organism for faecal contamination in irrigation water, growers should arrange for periodic testing to be carried out to inform preventive measures. Additional analytical testing may be necessary after a change in irrigation water source, flooding or a heavy rainfall when water is at a higher risk of contamination.

Netted melon and watermelon rind surfaces, in contrast to smooth rind surfaces, may foster greater attachment and survival of *Salmonella* as well as other foodborne pathogens. For this reason, the quality of irrigation water and type of irrigation method used is an important consideration. Growers should consider avoiding overhead irrigation methods, particularly with netted rind melons, because wetting the outer rind increases the risk of foodborne pathogen contamination. Subsurface or drip irrigation presents the least risk of contaminating melon and watermelon surfaces. For drip irrigation, care should be taken to avoid creating pools of water on the soil surface, on equipment used, and reducing contact of the fruit with the soil or in furrows that may come into contact with melon and watermelon rinds.

Water is sometimes used in dump tanks to transport melons and watermelons from field containers into the packing or processing establishment. If the temperature of the water in the dump tank is cold and the internal temperature of the fruit is hot from field heat, a temperature differential is created that may aid in the infiltration of microbial pathogens into the rind and/or the edible portion of the fruit. The following should be considered when using post-harvest water:

- water temperatures should be higher than the internal temperatures of melons and watermelons, so as to minimise the risk of water infiltration;
- it is recommended that the time melons and watermelons remain in dump tank water be minimised, and
- to minimise or avoid fully submerging melons and watermelons in colder dump tank water.

10.2.3.2. Process wash water

Mitigation strategies aiming to reduce risks of microbial contamination for all water used during processing was previously discussed for leafy greens (EFSA BIOHAZ Panel, 2014b). Only potable water should be used during processing and this should include wash-water where used, as well as that used for refrigeration, cooling, ice or other uses. To maintain the microbial quality of the water avoiding cross-contamination in a washing tank, the use of disinfectant agents is recommended. Processing waters should be monitored to ensure that, if used, the disinfectant is present at sufficient concentrations to achieve its intended purpose and does not promote the potential for cross-contamination.

Water that is used in hydro-coolers should be of potable quality. In particular hydro-cooler water is by definition colder than the melons, which may increase the risk of infiltration of foodborne pathogens when present on the rind surface. Water that is used only once and not recirculated is preferable. If water is used for cooling and is recirculated, it should be evaluated and monitored to ensure that water management is documented and part of the HACCP plan.

Forced air cooling operations can avoid the risk of melon and watermelons infiltration with cooling water, but also may spread product contamination if forced-air cooling equipment is not cleaned and disinfected regularly.

10.2.4. Equipment

The importance of clean equipment as a preventive measure to avoid contamination of equipment associated with growing and harvesting was previously outlined for leafy greens (EFSA BIOHAZ Panel, 2014b) and similar considerations apply to melon and watermelon production and processing. Growers should ensure that clean pallets and containers (disinfected where necessary) are used and take measures to ensure that the containers do not come into contact with soil and manure during field packing operations.

If melons or watermelons pass over brushes, care should be taken to ensure they do not damage or cross-contaminate the fruit. They should be routinely inspected, cleaned and adjusted as needed.

Cooling equipment should be cleaned and disinfected on a regular basis according to written procedures to ensure that the potential for cross-contamination is minimized.

Melons and watermelons should be washed with potable quality water before cutting or peeling. Cutting or peeling knife blades should be cleaned and disinfected on a regular basis according to written procedures to reduce the potential for cross-contamination during the cutting or peeling process.

Before cutting or other processing, a further reduction in microbial contamination may be achieved by scrubbing in the presence of a sanitizer or application of an alternative surface decontamination process such as hot water, steam or other treatments. Knife blade disinfection solutions should be monitored to ensure that the disinfectant is present at sufficient levels to achieve its intended purpose and does not promote the potential for cross-contamination.

10.2.5. Workers

The importance of standard enforceable policies and provision of training in sanitation for all employees working in primary production, processing, retail and catering was emphasised for leafy greens (EFSA BIOHAZ Panel, 2014b). Compliance with hygiene requirements, in particular hand hygiene, is an absolute necessity for food handlers at all stages of the melon and watermelon production and supply chain to reduce the risks of *Salmonella* contamination. Only workers who have been trained in hygienic handling should be assigned to pick, pack or process melons and watermelons. It is also important to recognize and record field contamination indicators (e.g. broken fences, animal droppings, high incidence of insects) and take appropriate measures to mitigate the risks. In addition the importance of proper handling techniques to minimize or prevent damage to the fruit and microbial contamination should be implemented. All persons involved in the handling of melons and watermelons should receive hygiene training appropriate to their tasks and receive periodic assessment while performing their duties, to ensure tasks are being completed with due regard to good hygiene and hygienic practices.

10.2.6. Final product

Since *Salmonella* is able to survive on intact cantaloupe rind for days to several weeks at both ambient and refrigeration temperatures, may penetrate into wound tissues, and grow inside whole cantaloupe melons, other melon and watermelon cultivars, as well as on cut fruit, adequate refrigeration control should be applied to product, particularly to cut fruit.

Consumers should be provided with advice on safe handling of melons and watermelons. This includes avoiding the purchase of damaged melons and watermelons (whether or not showing any signs of spoilage) which increase the risk of contamination of the melon flesh with *Salmonella*. For pre-cut melons and watermelons, transit between retail/market and home should be as short as possible, as the increase in product temperature during transportation can be considerable. It is recommended that pre-cut melons and watermelons should be wrapped/packaged distributed under refrigeration temperatures (i.e. ideally 4 °C or less) and also kept refrigerated in consumers' home. Pre-cut fruit should be consumed as soon as possible after removal from the refrigerator.

Consumers need to be advised on how to handle, prepare, and store melons and watermelons safely (preferably in a cool environment) and to avoid cross-contamination with foodborne pathogens from various sources (e.g. hands, sinks, cutting boards, utensils, raw meats), and advised on correct hand washing methods. Melons and watermelons should be consumed as soon as possible and consumers should be advised to wash and/or scrub whole melons and watermelons, particularly the netted cultivars, (i.e. cantaloupes) using potable running water and where appropriate, disinfectant solutions. Pre-cut products should not be rewashed. Melons cut at home and not consumed immediately should be kept refrigerated.

10.3. Specific mitigation options to reduce the risk of *Salmonella* contamination

As previously considered for leafy greens (EFSA BIOHAZ Panel, 2014b), *Salmonella* have their reservoirs in domestic as well as wild animals, birds and humans. The main mitigation options for reducing the risk of contamination of melons and watermelons are, consequently, to prevent direct contact with faeces as well as indirect contact through organic amendments, contaminated soil, water, equipment or food contact surfaces. Scrupulous compliance with hand hygiene is an absolute necessity for all food handlers.

At primary production, assessment of risks for *Salmonella* contamination from the environment could inform the measures to reduce risks from previous cultivation or adjacent land use (particularly when associated with domestic animal production) as well as attractants and harbourage of wild animals and pests. Attention should be directed towards water quality since *Salmonella* can survive in water, including water used for irrigation and for dilution and application of agricultural chemicals. Attention should also be paid to appropriate treatment, storage and application of organic amendments if used. Care should be taken to prevent the use of equipment contaminated with *Salmonella*, particularly segregation from equipment that has come into contact with animals or their excreta. Persons handling food during harvesting or minimal processing are potential sources of *Salmonella* contamination, and adequate toilet and hand-washing facilities must be provided at production areas together with the exclusion of persons with symptoms of gastroenteritis. Scrupulous compliance with hand hygiene practices such as effective washing is an absolute necessity for all food supply chain employees, and should be emphasised in local codes of practice and training manuals.

During minimal processing, cooling and washing, all necessary steps to prevent contamination by *Salmonella* should be carried out, however these processes, at best, are aimed at preventing contamination or subsequent growth. Where contamination has occurred at primary production, even with adequately operated and monitored washing procedures, at best, only a 1-2 log unit reduction of *Salmonella* can be achieved in the final product. In addition, in case of contamination, immersion in water may disseminate *Salmonella* among melons and increases the risk of infiltration of the bacterium inside the fruit, where it will found conditions favourable for growth.

During distribution, retail, catering and handling in domestic environments, all reasonable steps should be taken to prevent cross-contamination of *Salmonella* from other foods, as well as from food handlers. *Salmonella* may grow and penetrate into wound tissues in whole cantaloupe melons as well as on cut melon and watermelon and can multiply at temperatures allowing growth, without visual signs of spoilage. Refrigerated storage of cut melons and watermelons is an important mitigation at retail and catering including in domestic and commercial environments.

As stated previously for leafy greens (EFSA BIOHAZ Panel, 2014b) washing alone will have some effect in reducing the microbiological (including pathogen) biota whilst also having the potential for cross-contamination, and identical effects for melons will occur. Washing with water alone was shown to result in reductions of about 1 log cfu/g of *Salmonella* for cantaloupes (Alvarado-Casillas et al., 2007). Washing of rind surfaces with sanitizers will have an effect on surface contamination by *Salmonella* (as well as the microbiota); however, this will not guarantee to eliminate *Salmonella* as well as other bacterial foodborne pathogens. Various sanitizers evaluated have included hydrogen peroxide sodium hypochlorite, and ethanol (Bowen et al., 2006). Additional experimental treatments with low strength of evidence, have included: antimicrobial coatings containing chitosan and allyl isothiocyanate (Chen et al., 2012); X rays (Mahmoud, 2012); chlorine dioxide gas (Mahmoud et al., 2008; Trinetta et al., 2011, 2013); alginates (Raybaudi-Massilia et al., 2008); ozone (Selma et al., 2008; Trinetta et al., 2011; Vadlamudi et al., 2012); electron beam irradiation (Trinetta et al., 2011), and lactate (Vadlamudi et al., 2012).

11. *E. coli* as a microbiological indicator in melons and watermelons

Monitoring of indicator organisms is routinely used by the industry, environmental agencies and public health organizations to verify effective implementation of Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP) for a wide range of foods and food manufacturing processes (Efstratiou et al., 2009; Wilkes et al., 2009; Ferguson et al., 2012). However, it should be emphasised that testing should never be relied upon as a food safety management strategy, but rather should verify the effectiveness of existing risk management strategies (Good Agricultural Practices (GAP), Good Hygiene Practices (GHP), Good Manufacturing Practices (GMP) and HACCP).

As previously outlined for leafy greens (EFSA BIOHAZ Panel, 2014b), when testing pre-cut ready-to-eat fruit and vegetables in the scope of the verification of compliance with the currently established processing hygiene microbiological criterion for *E. coli,* EN/ISO standard methods 16649-1[16] or 16649-2[17] are prescribed in Regulation 2073/2005.

12. Data on occurrence of *E. coli* in melons and watermelons

Few studies have enumerated *E. coli* on whole and pre-cut melons and watermelons and data available are presented in Table 2. These studies are limited, none are from the EU and most have taken relatively few samples (e.g. comprising < 20 samples). Most of the data are for cantaloupes and there are only single studies on watermelon and muskmelon. Furthermore, there are no data on the occurrence of *E. coli* in samples collected in the EU. Finally, there is a variety of methods and sample sizes used in all the studies summarised in Table 2. Consequently there are difficulties in both making meaningful comparisons between individual studies as well as assessing the representativeness of these data to estimate the overall levels of contamination.

[16] EN/ISO 16649-1:2001. Microbiology of food and animal feeding stuffs - Horizontal method for the enumeration of betaglucuronidase-positive *Escherichia coli* - Part 1: Colony-count technique at 44 degrees C using membranes and 5-bromo-4-chloro-3-indolyl beta-D-glucuronide. International Organization for Standardization, Geneva, Switzerland.

[17] EN/ISO 16649-2:2001. Microbiology of food and animal feeding stuffs - Horizontal method for the enumeration of betaglucuronidase-positive *Escherichia coli* - Part 2: Colony-count technique at 44 degrees C using 5-bromo-4-chloro-3-indolyl beta-D-glucuronide. International Organization for Standardization, Geneva, Switzerland.

Table 2: Studies on the occurrence of *E. coli* in melons and watermelons

Sampling place	Commodity	Country	Detection method	Number of samples analysed	Number of positive samples	% of positive samples	95 % CI[(a)]	Detection limit	Observed *E. coli* levels	Reference
Field to packed	Whole Cantaloupe	USA	US-FDA BAM	90	NS	NA	NA	NA	Geometric means: 1.5 ± 1.1 log cfu/g Per sample location: 0.8 cfu/g (before wash), 0.7 cfu/g during wash, 1.3 cfu/g (after wash), 2.5 cfu/g packed in box	(Johnston et al., 2005)
Production (n = 36) and at import to USA (n = 6)	Whole Cantaloupe	Mexico	Petrifilm	36	NS	NA	NA	NA	Geometric means: 0.7 ± 0 cfu/g (before wash), 1.0 ± 0.6 cfu/g during wash, 1.3 ± 0.7 cfu/g (after wash), 2.1 ± 1.1 cfu/g packed in box	(Johnston et al., 2006)
Retail (distribution centres and markets)	Whole fresh organic muskmelon	Canada	Petrifilm	151	NS	1.3	[0.1,3.4]	<5 cfu/g	<5 – 5 cfu/g	(Arthur et al., 2007)
Retail markets and street vendors	Whole Cantaloupe	Saudi Arabia	Eosin methylene blue agar (AOAC Compendium of Methods for Microbiological examination of Foods 2001)	5	NS	NA	NA	NA	Mean =2 log cfu/g	(Hassan et al., 2011)
Retail markets and street vendors	Whole Watermelon	Saudi Arabia	Eosin methylene blue agar (AOAC Compendium of Methods for Microbiological examination of Foods 2001)	2	NS	0	[0,66.7]	NA	ND	(Hassan et al., 2011)

NA = not applicable; NS = not stated; ND = not determined.
(a): The credible interval was calculated using a Bayesian approach and taking as prior beta (1/2,1/2) (Miconnet et al., 2005).

13. Microbiological criteria for melons and watermelons

EU Food hygiene legislation (Regulation (EC) No 852/2004) lays down minimum hygiene requirements; official controls are in place to check food business operators' compliance and food business operators should establish and operate food safety programmes and procedures based on HACCP principles. Regulation (EC) No 2073/2005 on microbiological criteria (MC) for foodstuffs is an implementing measure of the food hygiene legislation applicable since January 2006. It is important to emphasize that the safety of food is predominantly ensured by a preventive approach, such as implementation of GAP, GMP, GHP and application of procedures based on HACCP principles while microbiological criteria can be used for validation and verification of these procedures. This is also the main principle in the legislation. In the European Union legislation, in relation to melons and watermelons, microbiological criteria have been established for *Listeria monocytogenes* in a ready-to-eat food, and for *Salmonella* in ready-to-eat pre-cut fruit and vegetables, and for unpasteurised fruit and vegetable juices (see Sections 15.2.1 and 15.2.2).

Considerations on the establishment of Microbiological Criteria should be made on the basis of public health goals, which are intended to inspire actions to improve the future public health status and reduce the disease burden (EFSA, 2007). From 2007-2011, there was one outbreak *Salmonella* Newport reported associated with Brazilian watermelon where 17 cases were reported in 2011 in Germany and 8 were hospitalized (EFSA Panel on Biological Hazards (BIOHAZ), 2013). The outbreak extended into 2012 with 63 confirmed cases from six countries, with at least 5 hospitalisations and 2 deaths associated to whole, sliced and mixed watermelon from Brazil (Byrne et al., 2014). No further outbreaks were reported in the EU during 2012-13 (EFSA and ECDC, 2014), however this food has been associated with salmonellosis outbreaks, e.g. Bowen et al. (2006) reported on 23 salmonellosis outbreaks which occurred in the USA and Canada between 1984 and 2002 where 1432 people became ill, 42 were hospitalised and 2 died.

13.1. Hygiene Criteria for melons and watermelons at primary production

The current legal framework does not include microbiological criteria applicable at the primary production stage. It is proposed here to further use criteria proposed for leafy greens (EFSA BIOHAZ Panel, 2014b) to validate and verify Good Agricultural Practices (GAP) and Good Hygiene Practices (GHP) for melon and watermelon production. These criteria are designated as Hygiene Criteria and are defined as criteria indicating the acceptable functioning at pre-harvest, harvest and on farm post-harvest production prior to processing.

There are limited studies available on the presence and levels of enteric bacteria such as *E. coli* on melons and watermelons and none of these studies were conducted in the EU, therefore it is currently not possible to assess the suitability of an EU-wide *E. coli* Hygiene Criterion at primary production. Using *E. coli* as an indicator of recent human or animal faecal contamination is likely to be useful for verification of GAP and GHP at individual production sites (e.g. to assess the cleanliness of the water used for irrigation and other water uses such as for the application of pesticides and fertilizers), for example during prerequisite compliance audits, where epidemiological studies indicated a higher risk of infection or at the discretion of the FBO. Consequently, if water is contaminated with *E. coli* there is a higher risk of occurrence of *Salmonella* and hence melons and watermelons will also have a higher risk of contamination by *Salmonella*. Since *E. coli* is an indicator micro-organism for faecal contamination in irrigation water, this should be periodically tested. Establishment of such an EU *E. coli* Hygiene Criterion would inform the evaluation of the food safety control systems at primary production and on the basis of this evaluation, growers should take corrective actions based on the main mitigation options previously described. These mitigation options should focus on the appropriate implementation of Good Agricultural Practices (GAP) and Good Hygiene Practices (GHP) with special attention to: 1) appropriate management of manure which might include aerobic composting, anaerobic digestion, aeration of sludge, and stabilization; 2) maintenance of the microbial quality of irrigation water, for which a water treatment might be necessary; 3) cleaning and disinfection of equipment, and 4) strict control of worker hygiene. In addition, growers should provide information to the manager of the subsequent step in the food chain.

13.2. Process Hygiene Criteria for melons and watermelons

As defined in the legislation, a Process Hygiene Criterion is a criterion indicating the acceptable functioning of a production process. In Regulation (EC) No 852/2004), processing is defined as any action that substantially alters the initial product, including heating, smoking, curing, maturing, drying, marinating, extraction, extrusion or a combination of those processes. In the scope of this Opinion, only minimally processed melons and watermelons are considered here, i.e. those where any action is applied to the initial product (e.g. cleaning, coring, peeling, chopping, slicing or dicing and washing) and which is not included above in the definition of processing. Process Hygiene Criteria are only applicable to food business operators and not to primary producers.

Both Enterobacteriaceae and *E. coli* are commonly used as microbiological indicators in Process Hygiene Criteria for many different food commodities, for example in the production of certain meat and meat products, dairy products and shellfish. The acceptable figures of m, and M in an *E. coli* Process Hygiene Criterion differ and cannot be compared since the different type of products and production processes offer different possibilities for contamination, growth and inactivation. There are currently process hygiene microbiological criteria for *E. coli* in samples collected during the manufacturing process (n = 5; c = 2; m = 100 cfu/g and M = 1,000 cfu/g) for ready-to-eat pre-cut fruit and vegetables as well as unpasteurised fruit and vegetable juices (Regulation (EC) No 2073/2005).

The existing Process Hygiene Criterion for *E. coli* in pre-cut melons and watermelons aims to indicate the degree to which GAP, GHP, GMP or HACCP programmes have been implemented. However, there is insufficient information available on the occurrence and levels of *E. coli* in pre-cut melons and watermelons and therefore the suitability of this criterion cannot be assessed. However, using *E. coli* as an indicator for verification of GMP and food safety management systems (including HACCP) might be useful for melons and watermelons in individual processing premises e.g. during food safety management audits, where epidemiological studies indicated a higher risk of infection or at the discretion of the food business operator.

A Process Hygiene Criterion should be seen in connection with all the preventive measures in place (including verification of HACCP) and an appropriate testing frequency should be applied. Based on the obtained data, if specified levels of a Process Hygiene Criterion such as *E. coli* are exceeded, processors should take internal corrective actions based on the main mitigation options previously described in the Section 12 of this Opinion. These mitigation options should focus on the appropriate implementation of Good Hygiene Practices (GHP) and Good Manufacturing Practices (GMP) with special attention to: 1) suppliers' selection by audit, inspection or the control of the microbial quality of the raw material; 2) treatment and quality maintenance of washing water to reduce the build-up of micro-organisms; 3) cleaning and disinfection of equipment, and 4) strict control of worker hygiene.

13.3. Food Safety Criteria for melons and watermelons

As previously outlined for leafy greens (EFSA BIOHAZ Panel, 2014b), the EU Food Safety Criteria defined in EU legislation are for the microbiological acceptability of food products. These criteria apply to products at the end of production or placed on the market. If the criteria are not met, the product/batch is expected to be withdrawn from the market. The following conclusion on Food Safety Criteria were previously stated (EFSA, 2007):

(a) An advantage of establishing Food Safety Criteria for pathogenic micro-organisms is that harmonised standards on the acceptability of food are provided for both authorities and industry within the EU and for products imported from third countries.

(b) Food Safety Criteria will impact the entire food chain, as they are set for products placed on the market. Risk of recalls and the economic loss as well as loss of consumer confidence will be a strong motivation to meet the criteria. Therefore, Food Safety Criteria are assumed to have an effect on food safety and public health where there is an actual or perceived risk. However, it is not possible to evaluate the extent of public health protection provided by a specific Food Safety Criterion.

(c) Microbiological testing alone may convey a false sense of security due to the statistical limitations of sampling plans, particularly in the cases where the hazard presents an unacceptable risk at low concentrations and/or low and variable prevalence.

(d) Food safety is a result of several factors. Microbiological criteria should not be considered without other aspects of EU Food legislation, in particular HACCP principles and official controls to audit food business operators' compliance.

In order to establish Food Safety Criteria, it is a prerequisite that methods to properly detect the hazard are available. The sensitivity and specificity of the detection method should always be taken into account. Regulation (EC) No 2073/2005 on microbiological criteria does not prescribe any sampling/testing frequencies except for minced meat, mechanically separated meat and meat preparations. While this leaves flexibility to tailor the intensity of testing according to the risk, it also leaves the possibility of inconsistency in testing and control (EFSA, 2007).

Epidemiological data from both the EU and North America have identified salmonellosis outbreaks associated with both pre-cut and whole melons and watermelon consumption. There are Food Safety Criteria for the absence of *Salmonella* in 25 g samples (n = 5; c = 0) of ready-to-eat pre-cut fruit and vegetables which is applicable to cut melon and watermelon placed on the market during their shelf life (Regulation (EC) No 2073/2005). This regulation is also applicable to unpasteurised melon and watermelon juices placed on the market during their shelf life (Regulation (EC) No 2073/2005). Although there are no data for *Salmonella* on whole melons and watermelons in the EU, from the reported studies in North America (Table 1), the occurrence of *Salmonella* in melons and watermelons is variable. Based on outbreak data from the EU and USA/Canada, a Food Safety Criterion for *Salmonella* in whole melons and watermelons could be considered as a tool to communicate to producers and processors that *Salmonella* should not be present in the product. Since the occurrence of *Salmonella* is likely to be low, testing of whole melons or watermelons for this bacterium could be limited to instances where other factors indicate breaches in GAP, GHP, GMP or HACCP programmes.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

- The term melon usually refers to members of the plant family *Cucurbitaceae*, which are edible, sweet-fleshed and usually large, multiple-seeded fruit. In botanical terms, melons fall into two plant genera: *Citrullus* to which the watermelon belongs and *Cucumis*, which contains all commonly cultivated types of melon other than watermelons.
- A wide range of melon and watermelon cultivars are grown, the most common being galia, charentais, cantaloupe, honeydew and piel de sapo, together with seeded and seedless cultivars of watermelon.
- Guidelines on GAP indicate that melons need pre-cooling soon after harvest to reduce field heat. Almost all, if not all of the melons and watermelons, are sensitive to chilling but minimum temperatures at which they can be stored vary between cultivars. For instance, cantaloupe melons can be stored between 2-5 °C while honeydew melons withstand temperatures between 10-14 °C.

- The majority of watermelons and other cultivated types of melon are typically used whole or as fresh-cut products and they can also be processed into fresh juices. Fresh melon and watermelon juices are not commercially produced except for fresh unpasteurised juices and 'smoothies' (sometimes mixed with other fruit and vegetables) usually for immediate consumption or with very short shelf lives.
- Melons and watermelons are minimally processed and ready-to-eat foods, with an internal pH of 6.13-6.58 for cantaloupe, 5.78-6.00 for casaba, 6.00-6.67 for honeydew, 5.90-6.38 for Persian and 5.18-5.60 for watermelons, 90 % water as well as high amounts of protein (0.8 %) and high amount of sugars which vary depending on the cultivar. These fruit are considered to be highly perishable and a good matrix for bacterial growth, including the growth of *Salmonella*, especially if damage has occurred to the surface of the whole melon or watermelon or during cutting prior to consumption.
- Despite the large variety of cultivars of melon and watermelon produced, most information on risk factors and mitigation options for *Salmonella* contamination is for cantaloupe melons and there is little or no information for watermelons and other melon cultivars.
- Melons and watermelons are normally not subjected to physical interventions that will eliminate the occurrence of *Salmonella*.

Answers to the Terms of Reference

TOR 3. To identify the main risk factors for the specific food/pathogen combinations identified under ToR 2, including agricultural production systems, origin and further processing

- The risk factors for the contamination of melons and watermelons with *Salmonella* are poorly documented in the literature with limited available data but are likely to include the following, based on what is known for other pathogens or other fresh produce:
  - environmental factors, in particular proximity to animal rearing operations and climatic conditions (e.g. heavy rainfall) that increase the transfer to pathogens from their reservoirs to the melon and watermelon plants;
  - contact with animal reservoirs (domestic or wild life); gaining access to melon and watermelon growing areas;
  - use of untreated or insufficiently treated organic amendments;
  - use of contaminated water either for irrigation or for application of agricultural chemicals such as pesticides;
  - contamination or cross-contamination by harvesters, food handlers and equipment at harvest or post-harvest.
- For *Salmonella*, processes at primary production which wet the external portions of the crop close to harvest represent the highest risk and these include spraying prior to harvest, direct application of pesticides and other agricultural chemicals, and overhead irrigation.
- Fruit damage during harvest as well as cracking before or during harvest are additional risk factors for *Salmonella* contamination since melon and watermelon flesh has an internal pH of 5.1-6.7 and represents a good substrate for the growth of this bacterium. In addition, growth may be enhanced by co-contamination with some spoilage-causing moulds. Sharp edged or poorly designed storage containers and liners are risk factors that may contribute to melon and watermelon damage.

- Although cooling melons and watermelons with water during post-harvest handling may reduce microbial loads on their outside surface, this process may also be a source of microbial cross-contamination. Delays in melon and watermelon cooling from ambient temperatures (20-35 °C) to recommended temperatures between 10 and 14 °C, when melon and watermelon rinds are wet from cooling operations or from dew, may permit multiplication of foodborne pathogens on the rind surface of melons and watermelons.

- Melting ice water flowing through boxes of melons or watermelons may be a source of foodborne pathogens if already contaminated, as well as a risk factor for cross-contamination within and among pallets of this fruit.

- During minimal processing, cross-contamination via equipment, water or food handlers are the main risk factors for the contamination of melons and watermelons with *Salmonella*.

- Risk factors associated with contamination by *Salmonella* in outbreaks in the US and Canada associated with melon and watermelon consumption were wash water temperature, contaminated hydro-cooler water, damaged rind, rind fungus rot, workers' hands and contaminated conveyor belts and equipment.

- Edible portions of the melon and watermelon flesh may be contaminated in the cutting or rind removal process because the knife blade may spread microbial contamination on the outside rind of the melon and watermelon to the inner edible portions.

- *Salmonella* may grow and penetrate into wound tissues in whole cantaloupe melons as well as on cut melon and watermelon and can multiply at temperatures allowing growth, without visual signs of spoilage. Unrefrigerated storage of cut melons and watermelons is likely to be an important risk factor at retail and catering, including in domestic and commercial environments.

- At distribution, retail and catering and in domestic and commercial environments, cross-contamination, in particular via direct or indirect contact between raw contaminated food and melons and watermelons, is a risk factor for *Salmonella*.

TOR 4. To recommend possible specific mitigation options and to assess their effectiveness and efficiency to reduce the risk for humans posed by food/pathogen combinations identified under ToR 2

- Appropriate implementation of food safety management systems including Good Agricultural Practices (GAP), Good Hygiene Practices (GHP) and Good Manufacturing Practices (GMP) should be the primary objective of operators producing melons and watermelons. These food safety management systems should be implemented along the farm to fork continuum and will be applicable to the control of a range of microbiological hazards.

- Attention should be paid to the selection of the water sources for irrigation, agricultural chemical (e.g. fungicide) application.

- Production areas should be evaluated for hazards that may compromise hygiene and food safety, particularly to identify potential sources of faecal contamination. If the evaluation concludes that contamination in a specific area is at levels that may compromise the safety of crops, in the event of heavy rainfall and flooding for example, intervention strategies should be applied to restrict growers from harvesting or using this land for melon and watermelon production until the hazards have been addressed.

- Each farm environment (including open field or greenhouse production) should be evaluated independently for hazards, as it represents a unique combination of numerous characteristics that can influence the occurrence and persistence of foodborne pathogens in or near melon and watermelon growing areas.

- Among the potential interventions, both water treatment and efficient drainage systems that take up excess overflows are needed to prevent the additional dissemination of contaminated water. Since *E. coli* is an indicator micro-organism for faecal contamination in irrigation water, growers should arrange for periodic testing to be carried out to inform preventive measures.

- At primary production, assessment of risks for *Salmonella* contamination from the environment could inform the measures to reduce risks from previous cultivation or adjacent land use (particularly when associated with domestic animal production) as well as attractants and harbourage of wild animals and pests.

- Attention should be directed towards water quality since *Salmonella* can survive in water, including water used for irrigation and for dilution and application of agricultural chemicals. Attention should also be paid to appropriate treatment, storage and application of organic amendments if used.

- Care should also be taken to prevent the use of equipment contaminated with *Salmonella*, particularly segregation from equipment that has come into contact with animals or their excreta. Persons handling food during harvesting or minimal processing are potential sources of *Salmonella* contamination, and adequate toilet and hand-washing facilities must be provided at production areas together with the exclusion of persons with symptoms of gastroenteritis.

- Scrupulous compliance with hand hygiene practices such as effective washing is an absolute necessity for all food supply chain employees, and should be emphasised in local codes of practice and training manuals.

- During minimal processing, cooling and washing, all the necessary steps to prevent contamination by *Salmonella* should be carried out, however, these processes, at best, are aimed at preventing contamination or subsequent growth. Where contamination has occurred at primary production, even with adequately operated and monitored washing procedures, at best, only a 1 to 2 log unit reduction of *Salmonella* can be achieved in the final product.

- For *Salmonella*, the risk of cross-contamination during washing or hydro-cooling is reduced if the microbial quality of the water is maintained using disinfectant agents. Processing waters should be monitored to ensure that, if used, the disinfectant is present at sufficient concentrations to achieve its intended purpose.

- During distribution, retail, catering and handling in domestic environments, all reasonable steps should be taken to prevent cross-contamination of *Salmonella* from other foods, as well as from food handlers.

- Refrigerated storage of cut melons and watermelons is an important mitigation at retail and catering, including in domestic and commercial environments.

TOR 5. To recommend, if considered relevant, microbiological criteria for the identified specific food/pathogen combinations throughout the production chain

- Epidemiological data from both the EU and North America have identified salmonellosis outbreaks associated with both pre-cut and whole melons and watermelon consumption.

- There is no routine or regular monitoring of melons and watermelons for the presence of *Salmonella* in EU Member States and there is limited data on the occurrence of *Salmonella* in/on melons and watermelons in EU although some studies of surveys in non EU countries are present in the peer reviewed world literature. There are difficulties in both making meaningful comparisons between individual studies as well as assessing the representativeness of these data to estimate the overall levels of contamination.

- The current legal framework does not include microbiological criteria applicable at the primary production stage. There are limited studies available on the presence and levels of enteric bacteria such as *E. coli* on melons and watermelons and therefore it is currently not possible to assess the suitability of an EU-wide *E. coli* Hygiene Criterion at primary production.

- Using *E. coli* as an indicator of recent human or animal faecal contamination is likely to be useful for verification of GAP and GHP at individual production sites (e.g. to assess the cleanliness of the water used for irrigation and other water uses such as for the application of pesticides and fertilizers).

- The existing Process Hygiene Criterion for *E. coli* in pre-cut melons and watermelons aims to indicate the degree to which GAP, GHP, GMP or HACCP programmes have been implemented.

- There is insufficient information available on the occurrence and levels of *E. coli* in pre-cut melons and watermelons and therefore the suitability of this criterion cannot be assessed. Using *E. coli* as an indicator for verification of GMP and food safety management systems (including HACCP) might be useful for melons and watermelons in individual processing premises e.g. during food safety management audits, where epidemiological studies indicated a higher risk of infection or at the discretion of the food business operator.

- There are Food Safety Criteria for the absence of *Salmonella* in 25 g samples of ready-to-eat pre-cut fruit and vegetables which is applicable to cut melon and watermelon placed on the market during their shelf life (Regulation (EC) No 2073/2005). This regulation is also applicable to unpasteurised melon and watermelon juices placed on the market during their shelf life.

- A Food Safety Criterion for *Salmonella* in whole melons and watermelons could be considered as a tool to communicate to producers and processors that *Salmonella* should not be present in the product. Since the occurrence of *Salmonella* is likely to be low, testing of whole melons or watermelons for this bacterium could be limited to instances where other factors indicate breaches in GAP, GHP, GMP or HACCP programmes.

RECOMMENDATIONS

- More detailed categorization of food of non-animal origin should be introduced to allow disaggregation of the currently reported data collected via EFSA's zoonoses database on occurrence and enumeration of foodborne pathogens.

- Risk assessment studies should be performed to inform the level of hazard control that should be achieved at different stages of melon and watermelon production and minimal processing. Such studies should be supported by targeted surveys on the occurrence of *Salmonella* in melons and watermelons at specific steps in the food chain, to identify the level of hazard control and efficacy of application of food safety management systems, including GAP, GHP, GMP and HACCP, that has been achieved at different stages of production systems.

- There should be implementation and evaluation of procedures such as sanitary surveys, training, observational audits and other methods to verify agricultural and hygiene practices for melon and watermelon at primary production.

- Further data should be collected to evaluate the suitability of *E. coli* criteria at both primary production and during minimal processing of melons and watermelons.

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APPENDICES

Appendix A. List of questions to be addressed by the European Fresh Produce Association (Freshfel) and information received from Freshfel (22 July 2013, 9 July and 29 August 2014) and Annecoop (9 July 2014: original provided in Spanish, EFSA provided the translation)

1. How do you categorise melons according to different:
   - production systems,
   - processing (excluding thermal treatment or any equivalent (e.g. blanching as well as shelf stable juices) and
   - presentation at retail?

   All questions below aim at characterizing the melons sector in the EU.

PRODUCTION SECTOR

2. Provide an overview of this sector listing the most commonly produced botanical varieties of melons in the EU?
3. Which are the top 10 types of melons produced in EU?
4. Which are the top 10 types of melons sold in EU?
5. Which countries are the major producers in the EU?
6. Which are the main third countries providing the EU with melons?
7. Which is the share of the market covered by imported production versus intra-EU production of melons?
8. What is the share of producers of melons which are not members of Freshfel in the EU?

   Which volume of production do these producers represent?
9. Are there any figures in the EU to characterize the proportion of the production of melons from "home/small scale" producers when compared to "large-scale" production?
10. Provide available figures on (i) production, (ii) producers, (iii) trade, (iv) certification and (v) distribution (type of outlets) of the melons.

AGRICULTURAL PRODUCTION SYSTEMS

11. Are there any producer's survey results which could help to describe how melons are produced in the EU?
12. Characterise the profile of workers in the production of melons (e.g. training, casual workers, foreign workers etc).
13. Please indicate percentages of production of melons (i) in fields, (ii) in greenhouses, (iii) soilless (hydroponics) or (iv) in soil?
14. Are there any additional production systems in place in the EU (as well as for imported products)?
15. Which melons can be produced as hydroponic crop?
16. Indicate the major irrigation systems and water sources in the agricultural production of melons.

    Is the water quality controlled (microbiologically)? If so and if available, provide data on the microbiological quality of the water used in the agricultural production of melons.

PROCESSING OF MELONS

17. Which are the most common processing practices for melons in the EU?
18. Which agricultural practices and processing steps - can be executed (i) only manually, (ii) both manually or mechanically or (iii) preferentially mechanically?

    What are the percentages of manual versus mechanical practices?
19. Indicate the major water sources in the processing of melons.

    Is the water quality controlled (microbiologically)? If so and if available, provide data on microbiological quality of the water used in the processing of melons.
20. How important is the share of production in the EU for different melons categories proposed in the scope of the answer to question 1?

    Which proportion of melons are (i) sold directly (without further processing) or (ii) undergoing processing (pre-cutting and packaging)?

DISTRIBUTION AND RETAIL

21. Which are the procedures and conditions for transport and distribution of melons in the EU?

    Are there any specific cooling practices in place for melons at harvest or post-harvest storage (or long distance transport)?
22. Are there any specific control measures in place in the EU to maintain the cold chain during storage and distribution of melons?

    Are there any specific control measures in place to maintain long term storage?
23. Which proportion of melons may be sold without temperature control during distribution in the EU?
24. Describe how traceability of melons is addressed for the different agricultural production systems and processing options?

SYSTEMS IN PLACE TO ENSURE SAFETY OF PRODUCTS

25. Are there any European guidelines/codes available from Freshfel or other associations of producers on practices (including pre-cutting and packaging) to ensure food safety in the production of melons?
26. In your view, what are the strengths and weaknesses of the current GAPs, GMPs and standards to ensure microbiological quality of melons?
27. In your view, which are the major weak points from the microbiological point of view in the agricultural production systems as well as in the processing of melons?
28. Do the producers of pre-cut/pre-packaged melons in the EU need to be registered as food processing establishments?
29. What are the hygienic requisites that these processing establishments need to comply with?

    How is compliance with these hygienic requisites verified?
30. Are there any central repositories of data on non-compliance with the GAPs, GMPs, standards as well as on the analysis of these data?
31. Are there many companies producing melons which are applying the “test to release” for microbiological parameters? If so, are companies using presence/absence tests? In case enumeration testing is used, which are the threshold levels (cfu/g) used for interpretation of the analysis results?

32. Are the producers, producer associations or any other stakeholders (e.g. retail) also doing regular testing/monitoring of melons?
33. Which are the sampling plans used in the scope of this testing/monitoring of melons?
34. Is there any additional testing/monitoring in place for imported melons?
35. Does Freshfel have any available data in the EU on levels of detection and enumeration of *Salmonella* in melons?
36. Which methods for detection and enumeration of *Salmonella* in melons are being used in the food chain in the EU?
37. Which are the differences on the hygienic requisites for the production of organic melons when compared to conventional production?

    How is compliance with these hygienic requisites verified?
38. What are the hygienic requisites in place for imported melons?

    How is compliance with these hygienic requisites verified?
39. Which chemical and/or physical decontamination methods are being used in the EU for the treatment of soil, substrates, manure or compost?
40. Which chemical and/or physical decontamination methods are being used in the EU for the treatment of water (reservoirs, irrigation systems, processing water)?
41. Describe the practices in use in the EU for chemical and/or physical decontamination of melons? Which are the main methods in place in the EU?
42. Which chemical and/or physical decontamination methods are allowed in the EU among Member States?
43. Does Freshfel provide specific recommendations on methods used to reduce contamination of melons by *Salmonella*?

Information received from European Fresh Produce Association (Freshfel) on 22 July 2013, 9 July and 29 August 2014

freshfel
EUROPEAN FRESH PRODUCE ASSOCIATION

Enjoy Fresh
Fruits & Vegetables

22 November 2013

Background information melon category

Opinion EFSA-Q-2012-00178

Definitions (questions 1-2)

(1)Categorisation

A. Production

- Open air / protected

B. Processing

<u>Fresh</u>

- Washed
- Unwashed

<u>Processed (see also question 17)</u>

- Manual / Mechanical cut

C. Retail presentation

<u>Fresh</u>

- Open cardboard boxes or bins

<u>Processed</u>

- Part or slice of melon fruit
- Fruit salads
  - Melon only (minority)
  - Fruit mix (with pineapple, table grapes, citrus fruit, apples, ...)

EUROPEAN FRESH PRODUCE ASSOCIATION A.I.S.B.L

Rue de Trèves 49-51, bte 8 - 1040 Brussels - Belgium Tel: +32 (0)2 777 15 80 Fax: +32 (0)2 777 15 81

e-mail: info@freshfel.org - www.freshfel.org - www.freshquality.org - www.freshcongress.com - www.enjoyfresh.eu

(2) Varieties

The following botanical varieties are commonly produced (see also OECD interpretative brochure on commercial types of melons, 2006):

- Melon – Cucumis Melo L.
  - Ananas
  - Baskavas
  - Branco
  - Western shipper
  - Yellow Eastern Shipper
  - Green Eastern Shipper
  - Canari
  - Yellow Charentais
  - Green Charentais
  - Galia
  - Honeydew
  - Kirkagac
  - Ogen
  - Piel de Sapo
  - Rochet
  - Tendral

- Watermelon - Citrullus lanatus (Thunb.) Matsum. et Nakai
  a. Seeded / Seedless
  b. Red / Yellow flesh

EU market (questions 3-10, 20)

(10) Detailed statistics have been prepared for both melons and watermelons. The data provided relate to the production in the EU, imports from 3rd countries and intra-EU import flows for each product. Production data have been obtained from FAOSTAT, whereas trade data have been obtained from EUROSTAT.

(5-7) Melons on the EU market are pre-dominantly produced in Southern Europe (Spain, Italy, Franc and Greece). The share of imports from 3rd countries amounts to 15% corresponding to counter-seasonal supplies originating mainly from Brazil, Costa Rica and Morocco. Watermelons are primarily sourced from both Southern and Eastern Europe (Spain, Greece, Romania, Italy and Hungary) with only 7% originating from 3rd countries (wide range of countries).

(3-4) The most important melons varieties are Galia, Charentais, Cantaloupe, Honey dew and Piel de Sapo. Seedless watermelons with red flesh are the most popular segment in the watermelon category.

EUROPEAN FRESH PRODUCE ASSOCIATION A.I.S.B.L

Rue de Trèves 49-51, bte 8 - 1040 Brussels - Belgium Tel: +32 (0)2 777 15 80 Fax: +32 (0)2 777 15 81

e-mail: info@freshfel.org - www.freshfel.org - www.freshquality.org - www.freshcongress.com - www.enjoyfresh.eu

(20) There are no specific data available on the various market outlets for melons/watermelons. The great majority of melons and watermelons is however sold fresh.

(9) With regard to the differentiation between commercial production and home or small-scale production, there are no reliable figures available. Whereas home or small-scale production of melons considered as marginal in Western Europe, it is more prevalent in certain Eastern European countries (particularly for watermelons). The economic crisis and certain trends (local produce, authenticity) may however have contributed to an increased popularity of the segment.

Agricultural production systems (questions 11-16)

(11) There are no survey results describing how melons are produced in the EU.

(13-15) Melons and watermelons are mostly (75%) grown in open air and in soil. The early season is taking place in greenhouses (25%). In many cases low net tunnels are used for melons grown in open air with a view to prevent infestation by pests. The melons are growing on bare soil.

(16) The major irrigation systems used in agricultural production are drip irrigation and sprinkler irrigation. The main water sources include surface waters (river, lake), reservoirs supplied by well water or rain water, and well water. In the case of products destined for the fresh market, the water quality is mostly controlled just once per year. In general E. Coli, Salmonella, Streptococcus faecalis, and total coliforms are the parameters being analysed.

(12) The field staff in the production of melons mainly consists of seasonal workers from various countries depending on the production countries (e.g. North Africa in the case of Italy or Spain). In the packinghouse, there's a mix between national and foreign workers. The workers are trained with regard to the prevention of food safety incidents, which is generally a prerequisite.

The harvest is taking place through a line of 3-5 people which transfer the melons to each other from the picking place to the plastic bins in which the melons are collected. Generally no gloves are worn during harvest operations.

Processing melons (questions 17-19)

(17) The most common processing practices include:

- Washing: all melons and watermelons for processing are washed in a dump tank whereby a disinfectant is added to prevent cross-contamination
- Peeling: for fruit salads, the peel needs to be removed
- Cutting: in parts, slices or pieces depending of the retail presentation
- Packing: in closed plastic punnets (heat sealed or clip-lids) or foil wrapped in case of melon parts, additives may be added to increase the shelf life.

(18) All agricultural practices are taking place manually, in case of processing (i.e. cutting) peeling takes mostly place mechanically, while cutting can take place both manually and mechanically depending on the flesh structure (e.g. watermelons and Galia melons will be cut manually). In many cases melons are also manually cut in the final consumer outlet (restaurant, supermarket). The packing of fruit salads is performed manually or mechanically depending on the size of the operation.

(19) The main water sources used in the processing practices are drinking water and potable well water. The water is tested according the applicable microbiological standards for potable water.

Distribution & retail

(21) Melons and watermelons are generally cooled. The optimal temperature ranges from 5 to 8 °C for melons, while 12 °C for watermelons. Provided the cold chain is well managed, sound fruit of traditional varieties can last a maximum of 25 days from harvesting (i.e. 14 days transit, a week to ten days on the shelves; or for longer voyages, 21 days transit and 3-4 days on the shelves). Newer varieties, can last up to 30 days. Generally watermelons will last somewhat longer (up to 5 days) than melons.
The optimal temperature for processed melons is below 7 °C with a shelf life of approximately 5 days without additives or up to 14 days through the use of additives (e.g. citrates).

Systems in place to ensure safety of products

(41) Melons and watermelons are generally washed (spraying or dump tank). In the case of products destined for the fresh-cut market or products originating from third countries, a dump tank will be used along with a disinfectant (chlorine, peroxyacetic acid, ...) to prevent cross-contamination. With a view to protect products originating from third countries during transport, fungicides (e.g. imazalil) may be applied on the product directly (spraying/dip) or via a coating (in combination with waxes).

<u>Other questions on distribution & retail and systems in place to ensure safety of products are of horizontal nature and apply to all fresh produce categories. The responses to these questions are available in a separate document.</u>

EUROPEAN FRESH PRODUCE ASSOCIATION A.I.S.B.L

Rue de Trèves 49-51, bte 8 - 1040 Brussels - Belgium Tel: +32 (0)2 777 15 80 Fax: +32 (0)2 777 15 81

e-mail: info@freshfel.org - www.freshfel.org - www.freshquality.org - www.freshcongress.com - www.enjoyfresh.eu

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EUROPEAN FRESH PRODUCE ASSOCIATION

Enjoy Fresh
Fruits & Vegetables

19 July 2013

Background information distribution & food safety practices

Distribution & retail (questions 21-24)

(21) No particular transport and distribution conditions apply for leafy greens destined for fresh market (i.e. transport under ambient temperature), for quality reasons many operators will nevertheless try to ensure the cold chain, particular for long haul transport (<10°C). In the case of fresh-cut, transport and distribution need to take place under regulated temperature. The practices vary per country and are fixed in national legislation (BE, DE, NL: <7°C, FR: 1-4°C, IT: <6°C, SE: 2-5°C). In general operators will apply lower temperatures to optimise quality and shelf life. Some species (e.g. herbs),however, do not support such lower temperatures.

(22) The control of the cold chain will be under the responsibility of the manufacturer until the delivery, whereby the temperature will be checked during loading and unloading of the truck as well as being registered during transport. From delivery until the purchase by the consumer, the control of the cold chain will be under the responsibility of the retailer. In the case of long term storage (e.g. cabbage, carrots, onions), cabbage and carrots are stored in cold stores whereby temperature and moisture are set. Onions are stored similarly to potatoes in ventilated cold stores whereby sprout suppressants are used.

(23) All vegetables for the fresh market may be sold under ambient temperature. In general most vegetables will however be sold under regulated temperature to maintain quality and ensure longer shelf life. Fresh-cut produce may only be sold under regulated temperature (see also question 21).

(24) Traceability: see presentation

Food safety systems (questions 25-42)

(25-26) Guidelines for good hygiene practices in fresh produce are available at national level, with separate guidance for primary production, distribution & trade as well as processing (fresh-cut). All guidance documents are generic and apply to both fruit and vegetables, although they include specific provisions for certain product categories where needed.

EU guidelines are not available, private certification systems (e.g. GlobalGAP, QS, IFS, BRC, ...) however provide a broader scope.

The main strength of these schemes consists in the identification of hazards and establishment of preventive measures from field to distribution. A weakness in the guidelines on primary production is the lack of attention to microbiological and emerging risks. These are however gradually being addressed.

(27) Major weak points in agricultural production system include the irrigation with surface

EUROPEAN FRESH PRODUCE ASSOCIATION A.I.S.B.L
Rue de Trèves 49-51, bte 8 - 1040 Brussels - Belgium Tel: +32 (0)2 777 15 80 Fax: +32 (0)2 777 15 81
e-mail: info@freshfel.org - www.freshfel.org - www.freshquality.org - www.freshcongress.com - www.enjoyfresh.eu

water, contamination by pests or animals and contact with the soil for certain salad types. The principal weak point for fresh-cut produce is a possible major rupture of the cold chain after delivery.

(28) EU Hygiene rules (Reg. 852/2004) require the registration as food processing establishment of any company producing fresh-cut produce. The hygienic requirements these companies need to comply with are provided in Annex II which are further clarified in national good hygiene practices guidelines or private certification schemes. Control of these requirements take place through control plans, internal and external audits as well as official inspections.

(29) There is no central repository of non-compliances at EU or national level. Generally companies analyse non-compliances in order to improve their practices. Some national industry associations pool microbiological test results on fresh produce as well as chlorine data to enable collective improvement actions or monitor the state of play regarding pathogens for which no microbiological criteria have been established.

(30) Positive release schemes are not used in the fresh-cut segment given the short shelf life of fresh-cut produce and the time needed for microbiological analysis.

(31) Producers and producer associations do carry out regular testing, a microbiological control plan is defined by each party involved in primary production. A retail level a random control plan is implemented.

(32) Sampling plans for microbiological testing/monitoring are defined in the legislation and are set by each food business operator on the basis of a risk analysis.

(33 and 37-38) Imported produce is treated similarly to EU produce and is not subject to additional testing or specific other hygiene requirements.

(34) Freshfel does not have centralised data available regarding the detection of Salmonella and Norovirus on leafy greens, or Salmonella, Yersinia, Shigella and Norovirus on bulb and stem vegetables and carrots.

The French fresh-cut industry association (SFPAE) collected data for Salmonella on leafy greens, from 2010 to 2012 more than 1.000 samples per year (all negative). The association is also carrying out further research regarding norovirus (results expected in 2014).

Belgium, Germany and the Netherlands have set-up a monitoring scheme for various fruit and vegetables which will be implemented in the coming months.

(35) Detection methods being used:

- Salmonella: NEN-EN-ISO 6579:2002, BRD 07/11-12/05, Rapid Salmo AES 10/4-05/04
- Norovirus: no validated method to date (research French association SFPAE)
- Shigella: NEN-EN-ISO 21567:2004
- Yersinia: NEN-EN-ISO 10273:2003

Commercial kits are sporadically used, generally companies prefer accredited methods in order to avoid discussions in case of complaints.
Commonly vegetables in the fresh-cut segment are tested on Salmonella, E. Coli and Listeria; other pathogens may be tested for on specific request of customers.

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Rue de Trèves 49-51, bte 8 - 1040 Brussels - Belgium Tel: +32 (0)2 777 15 80 Fax: +32 (0)2 777 15 81

e-mail: info@freshfel.org - www.freshfel.org - www.freshquality.org - www.freshcongress.com - www.enjoyfresh.eu

(36) There is no difference in hygienic requirements for the production of organic versus conventional leafy greens.

(39) Decontamination methods used in primary production:

- Soil treatment: Metam-sodium, Dazomet, 1,3-Dichloropropone, steam, solarisation
- Manure treatment: composting

These treatments are primarily meant to combat pests (nematicide) and disease, and limit weed competition (herbicide). Assurance schemes generally recommend to maximise the time between manure application and harvest. GlobalGAP recommends untreated organic fertiliser should not be used from 60 days previous to the harvest season.

(40) Water treatment methods:

- Water reservoir: mostly no treatment, where allowed oxidative or copper compounds as well as chlorine
- Irrigation system: chlorydric acid
- Processing water
    - Chemical: chlorine solutions; ozone; peracetic acid
    - Physical: UV-light, ultrasound

(41) Decontamination methods of produce:

- Chemical: not available
- Physical: grading (optical and visual), recovery of foreign bodies by difference in density in the cleaning trays, leaching during the cleaning process, rinsing with drinking water

(42) Freshfel does not provide specific recommendations on methods used to reduce contamination by pathogens on fresh produce.

Key differences EU vs US fresh produce practices

- Preventive approach (GAP, GHP) EU versus curative approach US => disinfection in the field and of finished product
- Production concentrated in South West => transportation time =>longer shelf life (14-18 days vs 7-11 days in EU)
- Processing facilities near the production sites in US vs processing facilities nearby the consumer market in EU
- Transport under regulated temperature in EU vs transport with crushed ice (source of contamination) in US
- Presence of large cattle farms with flood washing systems nearby rivers which are used for irrigation in US
- Scale of operators is much larger in US vs EU
- Larger market penetration of fresh-cut produce in US vs EU

EUROPEAN FRESH PRODUCE ASSOCIATION A.I.S.B.L
Rue de Trêves 49-51, bte 8 - 1040 Brussels - Belgium Tel: +32 (0)2 777 15 80 Fax: +32 (0)2 777 15 81
e-mail: info@freshfel.org - www.freshfel.org - www.freshquality.org - www.freshcongress.com - www.enjoyfresh.eu

Information received from Annecoop on 9 July 2014 (Original provided in Spanish, EFSA provided translation).

MELONS:

PRECOOLING, STORAGE AND REFRIGERATED TRANSPORT

8.1. REFRIGERATED STORAGE

Whenever melons are stored, they should be in very good condition from the point of view of ripeness and absence of defects, especially fruit bruising damage. Melons are stored under specific conditions according to the melon cultivar and for a maximum of five days. The ideal storage conditions for each cultivar of melon are described below. Melons can be stored before or after being packed, although it is better to do so before.

Table 8.1 Temperature and relative humidity conditions for the precooling, transport and refrigerated storage of melons

Melon cultivar	T (ºC) and RH (%) Conditions
Yellow Melon (Honey Dew Type)	10-14 ºC / 85-95 %[1]
Cantaloupe	2-5 ºC / 85-95 %[1]
Galia	6-9 ºC / 85-95 %[1]
Green Melon (Piel de Sapo Type)	10-14 ºC / 85-95 %[1]

[1] The system to humidify the storage room should function properly to avoid condensation forming on the melons. If melons are stored after packaging, the relative humidity should stay at 85-90 %.

The conditions above should always be followed. In addition, it is recommended to store the melons in the absence of ethylene. To ensure this, it is necessary to install ethylene-absorbing devices and/or to change the air in the storage room at least once every night.

8.2. PRECOOLING AND REFRIGERATED TRANSPORT

Cooling is the only tool available to prolong the shelf life of melons. Precooling of all consignments of melons is necessary to ensure correct pulp temperature during refrigerated transport. If this is not the case, problems of rotten or overripe melons could arise.

MELONS:

PREENFRIADO, ALMACENAMIENTO Y TRANSPORTE FRIGORÍFICO

8.1. ALMACENAMIENTO FRIGORÍFICO

En caso de que se almacenen melones, estos deben estar en muy buenas condiciones, desde el punto de vista de madurez y ausencia de defectos, sobre todo golpes. Se almacenarán en condiciones adecuadas según cada tipo de melón y un máximo de 5 días. Las condiciones adecuadas para el almacenamiento de cada tipo de melón se establecen a continuación. El almacenamiento se puede realizar antes o después de la confección de los melones, aunque es preferible que se realice antes.

Tabla 8.1 Temperaturas y condiciones para el preenfriado, transporte y almacenamiento frigorífico de melones

Tipo de Melón	Condiciones T (ºC) y HR (%)
Amarillo ovalado	10-14 ºC / 85-95 %[1]
Cantaloup	2-5 ºC / 85-95 %[1]
Galia	6-9 ºC / 85-95 %[1]
Verde ovalado	10-14 ºC / 85-95 %[1]

1. El sistema de humidificación de la cámara debe funcionar correctamente de modo que no se mojen los melones. En el caso de almacenarse el melón ya confeccionado la HR debe mantenerse en 85-90 %.

Estas condiciones son de obligado cumplimiento, adicionalmente es recomendable que el almacenamiento se realice en atmósfera libre de etileno. Para conseguirla es necesaria la instalación de absorbedores de etileno y/o programar como mínimo un cambio de aire cada noche en las cámaras.

8.2. PREENFRIADO Y TRANSPORTE FRIGORÍFICO

El frío es la única herramienta de que disponemos para alargar la vida comercial de los melones. El preenfriado de todos los envíos de melones es necesario para que el transporte frigorífico se realice a las temperaturas de pulpa correctas. En caso contrario, pueden aparecer problemas de podrido y de exceso de madurez.

Appendix B. Melons production statistics tables (EUROSTAT, FAOSTAT) provided by Freshfel

Table 3: Melon production in metric tons (Source: FAOSTAT)

Producing Country	2007	2008	2009	2010	2011	Share in 2011
Spain	1 183 154	1 042 439	984 786	626 639	871 996	38.0 %
Italy	616 664	653 309	621 267	666 383	536 229	23.4 %
Extra-EU	365 943	361 809	331 123	339 399	339 122	14.8 %
France	234 543	278 938	301 965	290 101	276 728	12.1 %
Greece	174 033	167 000	166 000	167 000	170 863	7.4%
Romania	33 437	53 794	50 031	52 250	53 272	2.3%
Portugal	27 662	22 350	22 400	23 388	20 714	0.9 %
Hungary	14 200	14 157	12 283	8 593	9 030	0.4 %
Cyprus	10 070	9 577	10 366	11 200	8 656	0.4 %
Malta	4 593	4 329	3 977	2 926	3 953	0.2 %
The Netherlands	2 300	2 398	2 498	2 520	2 658	0.1 %
Austria	400	500	300	455	516	0.0 %
Slovakia	1 097	858	984	719	321	0.0 %
Total	**2 668 096**	**2 611 458**	**2 507 980**	**2 191 573**	**2 294 058**	**100.0 %**

Table 4: Melon import from intra-EU in metric tons (Source: EUROSTAT)

Importing Country	2007	2008	2009	2010	2011	2012	Share in 2012
France	9 273	9 513	9 429	10 041	9 531	11 566	20.1 %
Germany	11 220	11 250	10 347	11 260	9 860	10 588	18.4 %
The United Kingdom	7 825	7 543	6 410	6 647	6 054	6 755	11.8 %
Portugal	5 098	5 273	5 094	4 998	5 206	5 302	9.2 %
The Netherlands	6 663	3 927	4 043	4 923	5 309	5 266	9.2 %
Belgium	3 015	3 215	3 053	3 092	3 017	3 454	6.0 %
Italy	1 845	1 981	2 444	2 456	2 436	2 590	4.5 %
Sweden	1 653	1 987	1 738	1 675	1 984	2 420	4.2 %
Denmark	2 025	2 053	2 111	1 753	1 935	1 885	3.3 %
Austria	998	971	999	1 619	1 538	1 669	2.9 %
Poland	739	755	518	719	848	843	1.5 %
Lithuania	385	522	396	546	552	799	1.4 %
Spain	364	492	314	680	1 457	698	1.2 %
Finland	370	393	403	476	514	520	0.9 %
Ireland	496	625	435	370	384	506	0.9 %
Latvia	292	246	254	358	324	420	0.7 %
The Czech Republic	337	474	362	374	432	412	0.7 %
Slovenia	305	432	404	453	390	409	0.7 %
Bulgaria	140	143	316	362	575	284	0.5 %
Romania	125	144	90	88	289	250	0.4 %
Estonia	128	154	168	204	186	229	0.4 %
Luxembourg	184	185	194	238	223	205	0.4 %
Slovakia	166	425	149	186	220	152	0.3 %
Hungary	208	234	225	387	126	83	0.1 %
Greece	146	119	169	102	118	68	0.1 %
Malta	113	86	105	93	70	59	0.1 %
Cyprus	2	5	1	11	17	5	0.0 %
Total	**54 118**	**53 144**	**50 172**	**54 109**	**53 596**	**57 438**	**100.0 %**

Table 5: Melon import from extra-EU in metric tons (Source : EUROSTAT)

Exporting Country	2007	2008	2009	2010	2011	2012	Share in 2012
Brazil	192 303	193 024	173 408	168 903	157 484	166 307	47.2 %
Costa Rica	68 426	50 969	43 176	59 656	65 214	69 820	19.8 %
Morocco	47 101	56 544	55 310	54 316	51 728	50 485	14.3 %
Honduras	13 726	17 380	23 171	21 471	34 379	32 277	9.2 %
Senegal	2 142	2 571	3 319	5 565	8 920	11 336	3.2 %
Turkey	6 718	7 841	6 832	6 235	4 494	4 485	1.3 %
Panama	18 225	20 128	13 222	11 277	4 278	3 934	1.1 %
Guatemala	97	490	NR	NR	NR	2 415	0.7 %
Israel	7 850	4 073	4 606	4 630	4 204	2 048	0.6 %
Nicaragua	NR	NR	NR	NR	NR	1 658	0.5 %
South Africa	2 025	1 948	1 289	1 483	1 827	1 473	0.4 %
Kazakhstan	186	486	1 247	1 290	910	1 148	0.3 %
Iran	1 007	819	660	789	917	848	0.2 %
Dominican Republic	1 863	1 284	785	602	831	830	0.2 %
Ukraine	38	133	1 130	19	415	663	0.2 %
Egypt	1 755	1 570	1 276	1 469	781	642	0.2 %
Colombia	0	16	48	222	720	640	0.2 %
Tunisia	287	1 059	838	802	925	484	0.1 %
Uzbekistan	287	333	164	80	511	325	0.1 %
Peru	NR	NR	158	139	108	229	0.1 %
Other	1 910	1 141	487	453	478	353	0.1 %
Total	**365 943**	**361 809**	**331 123**	**339 399**	**339 122**	**352 400**	**100.0 %**

NR: Not reported.

Table 6: Watermelon production in metric tons (Source: FAOSTAT : 2007/2011 ; EUROSTAT: 2012)

Producing country	2007	2008	2009	2010	2011	2012	Share in 2011
Spain	790 947	723 164	851 976	782 430	766 301	871 300	26.3 %
Greece	663 389	629 000	623 000	492 700	648 000	565 000	22.3 %
Romania	374 536	508 466	602 813	610 613	592 214	491 900	20.3 %
Italy	437 512	434 602	463 306	477 858	378 220	NR	13.0 %
Extra-EU	183 360	214 127	175 533	191 737	192 691	186 231	6.6 %
Hungary	163 800	224 380	220 426	141 086	202 920	178 300	7.0 %
Bulgaria	95 667	93 348	110 653	70 808	83 163	55 700	2.9 %
Cyprus	29 310	20 809	22 829	22 634	20 147	22 200	0.7 %
France	7 519	8 122	25 151	15 761	16 919	7 700	0.6 %
Portugal	3 500	4 000	4 250	4 437	3 930	NR	0.1 %
Malta	4 766	4 922	3 934	3 248	3 572	3 800	0.1 %
Slovakia	5 625	4 088	4 479	2 790	1 847	2 500	0.1 %
Austria	401	489	317	455	516	NR	0.0 %
Total	**2 760 332**	**2 869 517**	**3 108 667**	**2 816 557**	**2 910 440**	**2 384 631**	**100.0 %**

(a): NR: Not reported.

Table 7: Watermelon import from intra-EU in metric tons (Source: EUROSTAT)

Importing Country	2007	2008	2009	2010	2011	2012	Share in 2012
Germany	198 574	225 119	223 267	309 391	230 178	268 533	31.0 %
France	70 044	76 820	103 656	103 095	100 330	105 538	12.2 %
Poland	85 925	94 069	90 637	82 813	89 738	87 293	10.1 %
The Czech Republic	71 849	67 170	75 303	79 291	64 046	67 532	7.8 %
The United Kingdom	34 529	31 212	29 986	43 087	39 593	45 811	5.3 %
The Netherlands	22 806	23 802	26 592	31 647	29 878	31 686	3.7 %
Italy	30 905	39 271	35 872	50 060	23 295	31 571	3.6 %
Slovakia	22 838	22 523	21 921	24 452	23 422	26 546	3.1 %
Austria	15 136	24 912	24 057	19 080	20 212	24 205	2.8 %
Portugal	12 951	18 154	22 004	24 932	17 937	23 546	2.7 %
Sweden	18 472	17 439	20 565	19 611	22 768	23 536	2.7 %
Denmark	14 269	17 671	19 045	18 486	15 344	18 815	2.2 %
Bulgaria	10 622	6 801	9 943	19 017	18 543	18 347	2.1 %
Lithuania	10 547	12 298	15 942	16 246	14 551	15 589	1.8 %
Belgium	10 955	11 859	11 947	12 428	10 011	14 724	1.7 %
Romania	6 878	6 322	4 906	7 528	14 869	13 914	1.6 %
Finland	12 006	11 234	11 621	12 724	13 368	13 039	1.5 %
Latvia	10 169	9 199	9 788	10 166	10 758	9 950	1.1 %
Slovenia	6 308	6 798	6 462	7 005	5 919	7 704	0.9 %
Hungary	7 719	6 308	5 762	9 680	4 194	4 181	0.5 %
Ireland	3 897	4 021	4 099	4 620	4 062	3 912	0.5 %
Spain	5 623	7 608	8 797	7 297	4 350	3 623	0.4 %
Estonia	3 455	4 265	5 102	4 623	4 648	3 592	0.4 %
Greece	4 039	2 957	963	2 964	1 022	2 636	0.3 %
Luxembourg	715	772	806	1 001	845	907	0.1 %
Malta	285	275	233	344	250	323	0.0 %
Cyprus	32	66	104	75	140	93	0.0 %
Total	**691 546**	**748 944**	**789 381**	**921 662**	**784 270**	**867 144**	**100.0 %**

Table 8: Watermelon import from extra-EU in metric tons (Source: EUROSTAT)

Exporting Country	2007	2008	2009	2010	2011	2012	Share in 2012
Costa Rica	19 833	23 567	28 185	30 957	26 329	31 211	16.8 %
Brazil	28 133	32 132	30 957	23 769	25 554	30 157	16.2 %
Panama	28 192	32 526	24 156	33 811	25 315	27 293	14.7 %
Turkey	16 910	32 857	4 241	13 694	18 804	19 587	10.5 %
FYROM[(a)]	32 571	29 218	17 316	16 810	25 773	15 482	8.3 %
Tunisia	9 982	17 264	9 768	14 246	12 005	11 916	6.4 %
Russia	11 990	10 899	10 027	6 883	9 079	11 162	6.0 %
Ukraine	6 136	3 917	19 096	25 197	14 754	9 274	5.0 %
Senegal	118	21	499	1 607	7 409	8 320	4.5 %
Morocco	5 510	5 640	7 646	3 369	5 560	4 884	2.6 %
Serbia	7 064	12 330	8 224	1 619	3 087	4 300	2.3 %
Iran	632	767	1 632	1 377	1 381	2 906	1.6 %
Albania	1 129	321	417	2 741	3 998	2 314	1.2 %
Peru	1 206	904	2 280	2 975	4 179	1 620	0.9 %
Egypt	5 504	3 743	4 106	5 146	3 144	1 479	0.8 %
Jordan	3 294	4 269	5 172	5 525	4 267	1 406	0.8 %
Other	5 156	3 753	1 813	2 011	2 055	2 919	1.6 %
Total	**183 360**	**214 127**	**175 533**	**191 737**	**192 691**	**186 231**	**100.0 %**

(a): FYROM: Former Yugoslav Republic of Macedonia

Appendix C. Results of controls carried out on consignments of watermelons originating from Brazil during the period 1 January – 30 September 2013 in EU 27 plus Norway

Table 9: Results of controls carried out for *Salmonella* on consignments of watermelons originating from Brazil during the period 1 January – 30 September 2013 in EU 27 plus Norway

Year 2013	Consignments	Analysed	Non-compliant[(a)]
Quarter 1: 1 January – 31 March 2013	353	24	0
Quarter 2: 1 April – 30 June 2013	8	0	0
Quarter 3: 1 July – 30 September 2013	164	11	0
Quarter 4: 1 October – 31 December 2013	Delisted		
Total for 2013	**525**	**35**	**0**

(a) *Salmonella* detected

GLOSSARY

Abscission zone is the separation zone through which a plant drops one or more of its parts, such as a leaf, fruit, flower, or seed formed at the base of the petiole.

Brix (Degrees Brix, °Bx) is the sugar content of an aqueous solution. One degree Brix is 1 gram of sucrose in 100 grams of solution. If the solution contains dissolved solids other than pure sucrose, then the °Bx only approximates the dissolved sucrose content.

Clean water is clean seawater (natural, artificial or purified seawater or brackish water that does not contain micro-organisms, harmful substances or toxic marine plankton in quantities capable of directly or indirectly affecting the health quality of food) and fresh water of a similar quality (Regulation (EC) No 852/2004)[18].

Climacteric/non-climacteric: fruit such as apples, bananas, tomatoes and most of the melon's cultivars that continue to ripen after harvest are termed **climacteric**, while those such as watermelons, citrus and strawberries that do not ripen after harvest are termed **non-climacteric**. This means that in climacteric fruit, the ripening process continues after fruit abscission (when the fruit drops).

Decontamination treatments are mechanical, physical, and chemical treatments, which are applied to eliminate contaminants, including microbial contamination. They can be applied to water, surfaces, equipment and areas.

Disinfectants are agents or systems that kill or eliminate bacteria found on inanimate surfaces or environments. Within this Opinion, disinfectant agents or systems are defined as those decontamination agents applied to eliminate micro-organisms in wash water.

Fertigation is the application of fertilizers, soil amendments, or other water-soluble products through an irrigation system.

Flume is an artificial channel of water where the flowing water is used to transport materials, such as fruit.

Food of non-animal origin include those derived from plants and comprise a wide range of fruit, vegetables, salads, juices, seeds, nuts, cereals, herbs, spices, fungi and algae, which are commonly consumed in a variety of forms. Categorisation of FoNAO, as considered in the scope of this Opinion, is discussed in Chapter 2.2 of EFSA Panel on Biological Hazards (BIOHAZ) (2013).

Food Safety Criteria are defined in EU legislation for the microbiological acceptability of food products and are criteria defining the acceptability of a product or a batch of foodstuff applicable to products placed on the market (Regulation (EC) No 2073/2005)[19]. If a Food Safety Criterion is not met for a product or batch of foodstuff, then this should not be placed on the market or, if it already has, be considered for recall.

Fresh Produce refers to fresh fruit and vegetables that are likely to be sold to consumers in an unprocessed or minimally processed (i.e. raw) form and are generally considered as perishable. Fresh produce may be intact, such as strawberries, whole carrots, radishes, and fresh market tomatoes, or cut

[18] Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs. OJ L 139, 30.4.2004, p.1-54.

[19] Commission Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs. OJ L 338, 22.12.2005, p.1-26.

during harvesting, such as celery, broccoli, and cauliflower[20]. In the scope of this Opinion fresh produce also applies to fresh-cut produce, such as pre-cut, packaged, ready-to-eat salad mixes.

Fruit abscission zone is the separation zone through which a plant drops the fruit formed at the base of the petiole.

Fungicide is a specific type of pesticide that controls fungal diseases by specifically inhibiting or killing the fungus or fungal spores.

Good Agricultural Practices (GAP) apply available knowledge to address environmental, economic and social sustainability for on-farm production and post-production processes resulting in safe and healthy food and non-food agricultural products (FAO, 2003).

Good Hygiene Practices (GHP) relate to general, basic conditions for hygienic production of a foodstuff, including requirements for hygienic design, construction and operation of the plant, hygienic construction and use of equipment, scheduled maintenance and cleaning, and personnel training and hygiene. A developed and implemented GHP programme is a pre-requisite for HACCP system (EFSA, 2005).

Good Manufacturing Practices (GMP) cover the principles needed to design plant layout, equipment and procedures for the production of safe food. This includes hygienic operation and cleaning and disinfection procedures. The codes and requirements may be formally specified by e.g. Codex Alimentarius Committee on Food Hygiene (EFSA, 2005).

Harvest is the process of collecting mature crops from the fields and immediate handling.

Hygiene Criteria are criteria indicating the acceptable functioning at pre-harvest, harvest and on farm post-harvest production prior to processing and are proposed to verify and validate Good Agricultural Practices (GAP) and Good Hygiene Practices (GHP).

Maturity index for a commodity is a measurement or measurements that can be used to determine whether a particular example of the commodity is mature (Reid, 1992). The maturity indices are based on characteristics that are known to change accordingly to the maturity stage of the commodity, e.g. stem separation and/or background rind colour. Maturity indices can be either subjective or objective.

Minimal processing is any action applied to the initial product (e.g. cleaning, coring, peeling, chopping, slicing or dicing, freezing and washing) and which is not included below in the definition of processing (e.g. heating, smoking, curing, maturing, drying, marinating, extraction, extrusion or a combination of those processes). Minimal processing may occur at harvest as well as on farm post-harvest and at processing.

Pesticide covers insecticides, acaricides, herbicides, fungicides, plant growth regulators, rodenticides, biocides and veterinary medicines. Pesticides are chemical compounds: a substance or mixture of substances, or micro-organisms including viruses used in plant protection to: (i) kill, repel or control pests to protect crops before and after harvest; (ii) influence the life processes of plants; (iii) destroy weeds or prevent their growth; (iv) preserve plant products[21].

Peduncle is a stalk bearing a flower, flower cluster, or fructification (Burns et al., 1990).

Petiole is the stalk by which a leaf is attached to the stem. It is the transition between the stem and the leaf blade (Mauseth, 2003).

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[20] FDA Guidance for Industry: guide to minimize microbial food safety hazards for fresh fruits and vegetables. 1998. Available at: http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/ProducePlantProducts/ucm064574.htm

[21] Based upon definition available at: http://ec.europa.eu/food/plant/plant_protection_products/index_en.htm

Potable water is water which meets the requirements laid down in Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption (mainly microbiological and chemical criteria) (Regulation (EC) No 852/2004).

Post-harvest is the stage of crop production after harvest and includes on-farm cooling, cleaning, sorting and packing.

Pre-harvest incorporates all activities on the farm that occur before crop products are harvested.

Process Hygiene Criteria are criteria indicating the acceptable functioning of the production process. Such criteria are not applicable to products placed on the market. They set an indicative contamination value above which corrective actions are required in order to maintain the hygiene of the process in compliance with food law (Regulation (EC) No 2073/2005).

Processing are any actions that substantially alter the initial product, including heating, smoking, curing, maturing, drying, marinating, extraction, extrusion or a combination of those processes (Regulation (EC) No 852/2004).

Ready-to-eat food: food intended by the producer or the manufacturer for direct human consumption without the need for cooking or other processing effective to eliminate or reduce to an acceptable level micro-organisms of concern (Regulation (EC) No 2073/2005).

Sanitizers are chemical agents that reduce micro-organisms on food contact surfaces by at least 99.999 %. Within this Opinion sanitizers are defined as those decontamination agents applied to reduce the level of micro-organisms on melons.