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# A Through-chain Analysis of Food Safety Hazards and Control Measures Associated with the Production and Supply of Seed Sprouts for Human Consumption

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## Authors' Contributions

*This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.*

Grey Literature

Received 5<sup>th</sup> May 2014  
Accepted 8<sup>th</sup> May 2014  
Published 20<sup>th</sup> July 2014

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## ABSTRACT

**Background:** Seed sprouts contaminated with pathogenic microorganisms, such as *Salmonella* spp. and Shiga toxin-producing *Escherichia coli* (STEC) present an unacceptable health risk to consumers. An outbreak that occurred in Australia during 2005 and 2006 due to the consumption of alfalfa sprouts contaminated with *Salmonella* Oranienburg resulted in 141 infected cases, and cost an estimated \$1.19 million to the Australian community. In Japan in 1996, consumption of radish sprouts contaminated with STEC O157:H7 affected more than 10,000 individuals. The outbreak of *E. coli* O104:H4 linked to the consumption of fenugreek sprouts that occurred in Europe in 2011 was an unprecedented foodborne outbreak. More than 4,000 individuals were infected by STEC O104:H4. Among them, 908 developed haemorrhagic uraemic syndrome (HUS), and 50 died of STEC infection. This demonstrates the potential food safety risk arising from seed sprouts and that the consequences can be devastating.

Food Standards Australia New Zealand (FSANZ) initiated the development of a primary production and processing standard for seed sprouts in 2009 to enhance the safety of seed sprouts produced and sold in Australia. After extensive consultations with the State and Territory food safety regulators, and a thorough investigation of the Australian

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industry practices in producing seed sprouts for human consumption, a technical paper was prepared to inform the design of potential risk mitigation measures for a national food safety standard on seed sprout production. This technical paper described the Australian seed sprout industry, depicted the steps involved in the production of seed sprouts for human consumption, and provided an analysis of potential food safety hazards that could occur during seed sprout production and processing. A food safety standard for the production and sale of seed sprouts in Australia was finalised in November 2011.

This extended abstract describes the key aspects of the technical paper.

**Aims:** To provide technical and scientific information to support risk management decisions aimed at maximizing the safety of seed sprouts produced for human consumption in Australia.

**Study Design:** A through-chain qualitative food safety risk analysis.

**Place and Duration of Study:** FSANZ, Canberra, Australia, between July 2009 and January 2010.

**Methodology:** This through-chain risk analysis was prepared upon a comprehensive review of literature available at the time on: investigations of foodborne outbreaks associated with consumption of seed sprouts; surveys of microbial contamination of seed sprouts; specific publications on crop production, seed harvest, post-harvest processing and storage of seeds; production of seed sprouts; risk assessments on seed sprouts; and regulatory guidelines published by Australian and international food safety regulatory authorities on seed sprouts.

Members of the FSANZ project team conducted field studies of sprout production, lucerne crop production, lucerne seed processing, wholesale and retail sale of seed sprouts. A survey was conducted on the variety, volume and value of sprouts produced, source and quantity of seeds used to produce sprouts for human consumption, trend of consumption of seed sprouts in Australia, as well as the size and the location of sprout producers in Australia.

Stakeholders were consulted through a FSANZ standard development committee with participants from State and Territory food safety regulators, peak sprout producer industry bodies, seed producers and seed processors, major food retailers, and consumer representatives.

The through-chain analysis of food safety hazards associated with the production and processing of seed sprouts was prepared in line with the principles of hazard analysis critical control points (HACCP).

**Results:**

Key pathogens of concern: Among the range of biological, chemical and physical food safety hazards that were likely to be associated with seed sprouts produced for human consumption, pathogenic microorganisms represent the highest risk to consumers. Outbreaks associated with the consumption of seed sprouts contaminated with pathogenic microorganisms were seen to be frequent events in developed economies despite food regulatory interventions. The key pathogenic microorganisms of concern

were *Salmonella* spp. and STEC. *Salmonella* spp. were found to be the causative pathogen almost five times more frequently than STEC.

Main varieties of seed sprouts causing foodborne illness: Among the 41 reported outbreaks that occurred worldwide between 1988 and 2007 involving consumption of seed sprouts contaminated with pathogenic microorganisms, alfalfa sprouts represented 68% of the outbreaks, followed by mungbean sprouts (22%), clover sprouts (5%), radish sprouts (2%) and clover sprouts (2%).

Source of pathogenic microorganisms: FSANZ divided the production and supply of seed sprouts for human consumption into eleven consecutive steps, starting with seed production in the field and ending with transportation and distribution of seed sprouts to retail establishments. This was to enable a systematic identification of the food safety hazards, sources of the hazards, specific controls that could be applied to control or eliminate food safety hazards, and the associated requirements of food safety management practices including food safety knowledge and food safety skills.

Contamination of seeds by pathogenic microorganisms such as *Salmonella* spp. and STEC can occur during seed production, seed harvest, seed processing, seed storage and transportation. The origin of these pathogenic microorganisms is animal faeces and manure present in the field where the crop is grown. Soil for growing the seed crop, water used for irrigation, and machinery used for crop management including the harvest of seeds, can be contaminated with pathogenic microorganisms and can transfer the contamination to seeds during crop production and seed harvest. Seed processing as a post-harvest step may also contribute to seed contamination. For example, blending different harvest lots of seeds for seed cleaning can spread what was originally a localised contamination into a larger volume of seeds. Rodent, insect and bird activities in seed processing and seed storage establishments can introduce and spread pathogenic microorganisms to seeds.

Provided that seeds delivered to sprout production sites are free of pathogenic microorganisms, activities of rodents, insects, and infected workers in seed receipt, storage, sprout production, sprout storage and transportation at sprouting establishment can lead to contamination of seed sprouts by pathogenic microorganisms. So is the use of contaminated water for sprouting. Much of these are also applicable to retail handling and storage of seed sprouts.

Investigations into the source of sprout contamination for outbreaks that occurred between 1988 and 2007 found that in almost every case the pathogenic microorganisms causing the outbreaks were present in the seeds used for sprout production. In approximately 20% of the outbreaks, contamination in sprouting establishments was also identified as a likely source of contamination.

Identified risk mitigation measures: Based on an analysis of a wide range of possible recommendations aimed at improving the safety of seed sprouts, the through-chain analysis recommended the following good agricultural practices to be implemented in the primary production phase of seeds:

- Environment - soil and environment where seeds are grown for the production of seed sprouts as a human food should be suitable.
- Inputs - manure, biosolids and other natural fertilisers should only be used for the

growth of seed crops when a high level of pathogen reduction has been achieved; equipment (bins, containers, silos, vehicles) and machinery are maintained and used in a manner that minimises and/or avoids contamination of seeds with pathogenic microorganisms.

- Protection - grazing animals and wild animals are prevented from entering the field where seeds are grown; and seed crops are protected from contamination by human, animal, domestic, industry and agricultural wastes.
- Segregation - seeds produced for the production of sprouts for human consumption are segregated from seeds produced for the production of animal feed and are clearly labelled.

The through-chain analysis also recommended the following components to be included in a Food Safety Program that must be effectively implemented in sprout production establishments:

- Environment – the sprouting facility (including the seed storage area) should not allow access of rodents, insects, pests or animals; sprouting facility and equipment are effectively cleaned and sanitised to ensure the environment is suitable for producing ready-to-eat foods.
- Input – each seed lot is tested for the presence of microbial pathogens of concern and seeds should not be used unless the testing results are negative; solid medium supporting sprout growth and water for sprouting are treated to eliminate pathogenic microorganisms; seeds are disinfected prior to sprouting to eliminate microbial pathogens.
- Separation – seed rinsing and microbiological decontamination, seed germination/sprouting, and storage of seed sprouts are physically separated from each other to prevent cross contamination.
- Monitoring – implement appropriate sampling/testing programs to regularly monitor microbial pathogens during and at the end of production of seed sprouts.

Implementation of food safety controls on farm presents many challenges. One of the main obstacles is the inability to control environmental factors under conventional farming practices. The environment under which seeds are produced for the production of seed sprouts for human consumption should exclude animal grazing and minimise and avoid pest and wildlife interference. The cost involved in growing seeds under these conditions can be prohibitive unless sprout producers are willing to pay a premium price for such seeds. As a result, the primary production and processing standard developed by FSANZ limited the control measures to sprout production. The standard is available at <http://www.comlaw.gov.au/Details/F2012L00023>.

A number of chemical and physical means have been investigated by different research organisations around the world for effective seed decontamination. As a result of the FSANZ standard development activity, a subsequent research and development study funded by the Australian Government and the Australian sprout industry investigated the efficacy of various disinfectants applied to seed decontamination. The study, *Improving Seed Sprout Food Safety – a farm to retail assessment*, recommended the use of multiple hurdles, such as a combination of heat treatments and chemical decontamination of seeds, to control the potential presence and growth of foodborne pathogens during sprout production. The full report of this study is available at <https://rirdc.infoservices.com.au/items/13-010>.

**Conclusion:** Seed sprouts, particularly those that are consumed raw, are one of the food vehicles frequently implicated in foodborne outbreaks. Pathogenic microorganisms, such as *Salmonella* spp. and STEC, are key food safety hazards associated with past outbreaks involving consumption of seed sprouts.

Seeds used for sprouting are the primary source of contamination with pathogenic microorganisms that originate from animal faeces, untreated fertilisers, contaminated soils and water.

Seed decontamination prior to sprouting is considered the critical control point in producing safe seed sprouts.

Through-chain food safety management presents the ultimate solution to the reduction of foodborne illnesses associated with the consumption of seed sprouts. In addition to sprout producers, seed producers, seed processors and seed merchants have a role to play in ensuring seed sprouts produced for human consumption are safe.

*Keywords: Seed sprouts; alfalfa sprouts; mungbean sprouts; shiga-toxin producing Escherichia coli; Salmonella; HACCP; risk assessment; food safety.*

## ACKNOWLEDGMENTS

The authors wish to acknowledge the support and assistance provided to this study by the following organisations: Australian Mungbean Association, Australian Seed Federation, Booborowie Seeds Pty. Ltd., Grain Research and Development Corporation, Flowerdale Sprout Farm, Healthy Sprout Company, Horticulture Australia Limited, Lucerne Australia, Parilla Fresh, and Rural Industry Research and Development Corporation.

The complete report of this technical paper and other relevant documents can be found at <http://www.foodstandards.gov.au/code/proposals/Pages/proposalp1004primary4361.aspx>.

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