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Prevention and control of *Salmonella* and enterohemorrhagic *E. coli* in tree nuts

Summary

- Tree nuts (such as raw pine nuts, raw almonds, dried coconut) can be a vehicle for foodborne pathogens, and have caused outbreaks of foodborne disease.
- *Salmonella* and enterohemorrhagic *Escherichia coli* (EHEC) are important causes of foodborne illness linked to the consumption of tree nuts.
- Even though tree nuts are too dry to support bacterial growth, pathogens, including *Salmonella* and EHEC, can cause illness when present at very low levels in foods.
- Tree nut handlers should consider *Salmonella* and EHEC as a major public health risk in their Hazard Analysis and Critical Control Points (HACCP) plans.
- The application of appropriate Good Agricultural Practices (GAPs) should minimize pre-harvest and harvest contamination.
- Inactivation treatments should be validated to determine if the treatment would effectively control enteric pathogens.
- Rigorous post-inactivation sanitation controls that include a Pathogen Environmental Monitoring (PEM) programme should be applied to prevent product recontamination.

Manual sorting of pine nuts.
Appropriate access to and use of personal protective equipment and documented hygiene training programmes are important to prevent contamination of the final product.

Background

Low-moisture foods, such as nuts, generally have been considered low risk for foodborne illness because they are consumed in a dry state. In low-moisture foods the water activity (available moisture) is too low to support microbial growth. For example, the water activity in tree nuts is generally less than 0.7. This may lead to the common misconception that low levels of pathogenic bacteria in foods such as tree nuts are not a food safety concern. However, it is increasingly recognized that many foodborne pathogens, including *Salmonella* and EHEC, can cause illness when present at very low levels, i.e. for illness to occur microbial growth does not need to take place. In addition, once ingested, the high fat content in tree nuts may protect pathogens from stomach acids allowing passage of viable organisms to the intestine. While a number of low-moisture foods have been associated with foodborne illness, e.g. spices, chocolate, powdered infant formula, the recognition of tree nuts as a potential source of foodborne pathogens and human illness is relatively recent.

Outbreaks of salmonellosis have been associated with the consumption of nuts including tree nuts such as raw almonds, raw pine nuts, dried coconut, as well as nut products such as roasted peanut butter and sesame seed products (e.g. halva and tahini).

To-date, most outbreaks associated with low-moisture foods have been linked to *Salmonella*. However, in 2011, there was an outbreak of EHEC-associated illness from consumption of in-shell hazelnuts, as well as an outbreak potentially linked to the consumption of walnuts.

In general, investigations of outbreaks linked to tree nuts are difficult because of the long shelf life of the product. In addition, pathogens are typically present in low numbers and may be stressed, challenging even the best of the established qualitative methods. Most of the documented outbreaks have been investigated because they were associated with relatively rare strains of *Salmonella* or EHEC such that sporadic or individual cases were recognized as a cluster of illnesses. In outbreaks for which data are available, cases have been spread out over many months and often over a wide geographic area. This means that product contaminated with a very common pathogenic strain may not be linked to an outbreak, even if illnesses have occurred. Traceback and identification of the initial source of contamination is a challenge. In many cases, months separate the initial contamination and the consumption/illness, and multiple distributors are often involved handling product from many growers.

In addition to outbreaks, tree nuts have been recalled after isolation of *Salmonella* or EHEC from the nuts during routine testing in the absence of any documented illnesses (e.g. hazelnuts, macadamia, pecans, pistachios, pine nuts and walnuts). Both outbreaks and recalls provide strong evidence that *Salmonella* and EHEC can be present on tree nuts and, occasionally, at the prevalence and levels that lead to recognized outbreaks.

Introduction to *Salmonella* and *E. coli* in tree nuts

Increased recognition of the association of *Salmonella* with tree nuts has lead to a number of surveys. These surveys have documented the isolation of *Salmonella* from a wide range of raw tree nuts grown and processed around the world. When present, both the prevalence (percent positive samples) and levels (number of cells) in a positive sample are low (typically 1% or less in 100 g samples at levels of just a few cells per 100 g). Although data are limited, when lots are positive, the distribution of the pathogen within the lot is often not uniform.

Post-harvest storage of pine cones. Tree nuts may be stored for weeks to months after harvest before extraction of the kernel. The impact of rainfall on food safety risks should be evaluated. Pest management programmes that protect the product from infestation and contamination should be in place.

There are likely multiple sources of *Salmonella* and *E. coli* in tree nuts. Significant evidence suggests that one source of contamination is the orchard itself. Many nuts are harvested directly from the orchard floor after being mechanically or hand shaken, cut from the tree by hand and then thrown to the ground, or allowed to fall naturally. This results in significant mixing of the nuts with soil and plant debris. Contaminants picked up at harvest may then be spread to the edible kernels before or during shelling. Moisture may also play a role in amplification of contaminants if the harvested and dry product is not protected from irrigation water or rainfall.

Water may intentionally be used for post-harvest handling of some types of nuts, for example to remove hulls or to soften shells before cracking. Spreading of contaminants can occur when nuts are exposed to untreated, recirculated water.

Similarly, water introduced into shelling or further processing facilities has been associated with multiplication and potential persistence of some strains within the post-harvest environment. Facility contamination may lead to sporadic contamination of finished raw and processed product. For this reason, a robust environmental monitoring programme for *Salmonella* should be implemented for any facility processing, handling and/or packaging the final nut product.

Survival of *Salmonella* and EHEC in tree nuts

Tree nuts are microbiologically stabilized by drying to water activity levels below 0.7. At these low water levels, microorganisms do not multiply, and tree nut shelf life is usually limited by lipid oxidation (rancidity). The process of desiccation (drying) often reduces microbial populations by killing a portion of the cells. The scale of this reduction (from very little to several orders of magnitude) is dependent on a wide range of factors including strain and culture conditions as well as humidity and temperature during drying. However, once dried, the remaining populations of *Salmonella* and EHEC survive exceptionally well in tree nuts. When nuts are stored at refrigerator or freezer temperatures virtually no reduction is observed over more than a year of storage. At ambient temperature, a slow rate of reduction is common; an order of magnitude reduction may not be seen for several months.

Recommendations on prevention and control of *Salmonella* and EHEC in tree nuts

Pre-harvest and harvest controls for reducing the potential for contamination

As with most horticultural crops, the implementation of appropriate Good Agricultural Practices (GAPs) is considered important to reduce the opportunity for foodborne pathogens to contaminate the crop. This should start with a site- and crop-specific assessment of risks for contamination, and subsequent evaluation of practical means to reduce these risks. Because tree nuts are often harvested from the ground, it is particularly important to reduce factors that would increase the likelihood that foodborne pathogens would be present on the orchard floor at the time of harvest. The risk of application of animal-derived soil amendments that have not been composted by a validated treatment should be assessed; time between application and harvest should be maximized. Many tree nuts are mechanically harvested, and thus there is often little human contact prior to and during harvest. However, field employees should be aware of food safety risks through on-site training programmes, and they should have ready access to sanitary facilities to ensure that human waste does not enter the orchard. The microbiological quality of the water used for irrigation and for application of agricultural chemicals should be considered, especially when applied close to harvest or directly to the mature nuts. Grazing domestic animals in the orchard, especially close to harvest, is also a potential risk factor that should be evaluated; likewise, attempts should be made to minimize intrusion of wild animals and birds to the orchard.

Post-harvest reduction of *Salmonella* and EHEC in tree nuts

Post-harvest handling methods vary greatly among different nut types. Post-harvest storage can range from a few hours to a few months, often outside of physical structures or buildings. Thus during storage, consideration should be given to the use of tarpaulins or other means to protect the product from rain, and insects or other pests. Husk, hull, or shell removal may be achieved through either wet or dry processes, and nuts may be dried under ambient conditions before or after harvest or through the use of heated air dryers. Large amounts of dust are typical in nut hulling and shelling operations; microorganisms may grow to high numbers in wetted dusts. Wherever water is used, especially when product is co-mingled, consideration should be given to the use of an appropriate antimicrobial to maintain the microbiological quality of the water. High organic loads often inhibit the antimicrobial efficacy of

Dust piles at a pine nut shelling facility. Large amounts of dust made up of soil and small pieces of the nut (shells, cones, hulls, kernels, etc.) are a common by-product of the shelling process. Dusts should be managed as much as possible to reduce the spread of contaminants throughout the facility and especially to the finished product areas.

sanitizers and may limit their use. This should be taken into consideration when selecting an antimicrobial, determining the application rate, and choosing the point of application.

For final product processing, a validated kill step should be considered. The most common method for reducing pathogens in tree nuts is the application of heat. However, thermal processes previously validated in moist foods do not apply to nuts. *Salmonella* and EHEC have been shown to be more resistant to heat when they are present in or within a dry food environment – in most cases orders of magnitude more heat resistant.

Some thermal processes are relatively easy to validate by using published data (e.g. for oil roasting, blanching, or steam treatments for almonds). However, validation of a process for one nut type cannot be universally applied to all tree nuts. Differences in the inactivation of *Salmonella* and EHEC may exist among nut types due to shape, size, surface area, or other factors impacting heat transfer. For some thermal processes, such as flat bed dry roasting or the use of rotary roasters, process validation must be performed for each piece of equipment by using validated surrogate organisms, of which there are currently very few.

The potential to re-contaminate a finished nut product is high if adequate Good Manufacturing Practices (GMPs) are not in place. Facility design, product flow (separation of raw from finished product), equipment and facility maintenance, cleaning and sanitation, as well as human hygiene should be adequately controlled to prevent contamination. Cleaning and sanitation may be challenging in dry areas of the facility where moisture should usually be restricted; however, dry cleaning and sanitation programmes are available and widely used in the food industry. The efficacy of the cleaning and sanitation programme should be monitored through a robust environmental monitoring programme that includes assessment for *Salmonella* or other pathogens, if appropriate.

Further reading

GMA Nut Safety Task Force. 2010. Industry handbook for safe processing of nuts. Grocery Manufacturers Association, Washington, D.C. accessed at: http://www.gmaonline.org/downloads/wygwam/Industry_Handbook_for_Safe_Processing_of_Nuts_1st_Edition_22Feb10.pdf

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Additional resources

http://ucfoodsafety.ucdavis.edu/Nuts,_Legumes,_and_Seeds/n.asp

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