# Microbial Safety in Spices

Spices have been used for centuries for both the flavor they impart to food as well as their ability to provide preservation of some foods. As with other raw agricultural-based food ingredients, they may be contaminated with microbial pathogens. Although drying may prevent the growth of some pathogens, it does not guarantee their elimination and a variety of microbial reduction techniques are routinely employed within the industry. A sound sampling and testing plan for pathogens can play a key role in a comprehensive food safety system to minimize food safety risks due to microbial contamination.

Although spices have not been historically associated with outbreaks or product recalls due to some bacterial pathogens (e.g. *Listeria monocytogenes*, *Clostridium perfringens*, *Bacillus cereus*, *Staphylococcus aureus*, etc.), they have been associated with foodborne illness due to *E. coli* and *Salmonella* contamination. While *E. coli* is sometimes implicated, *Salmonella* is the most common bacterial pathogen associated with product recalls and outbreaks in spices (see Table 1 and Case Scenario below).[(1)]

*Table 1. Selected Spice Recalls due to Bacterial Contamination*[a]

| YEAR | PRODUCT | PATHOGEN | NUMBER OF ILLNESSES |
|---|---|---|---|
| 2001 | Paprika | *Salmonella* Ohio | 0 |
| 2002 | Oregano | *Salmonella* Bispebjerg | 0 |
| 2002 | Sesame Seeds | *Salmonella* Senftenberg | 0 |
| 2002 | Basil Leaves | *Salmonella* Haifa | 0 |
| 2003 | Cumin, Ground | *Salmonella* Onderstepoort | 0 |
| 2003 | Paprika | *Salmonella* Karlshamn | 0 |
| 2003 | Sage, Ground | *Salmonella* Gaminara | 0 |
| 2003 | Cumin, Ground | *Salmonella* Salford | 0 |
| 2004 | Red Pepper, Powdered | *Salmonella* Derby | 0 |
| 2004 | Paprika | *Salmonella* spp. | 0 |
| 2004 | Sesame Seeds, White | *Salmonella* spp. | 0 |
| 2005 | Basil, Ground | *Salmonella* spp. | 0 |
| 2005 | Basil, Extra Fancy | *Salmonella* Blockley | 0 |
| 2006 | Veggie Booty (Seasoning) | *Salmonella* Wadsworth<br>*Salmonella* Typhimurium | 60 (mostly toddlers) |
| 2007 | Peppercorns[b] | *Salmonella spp.* | 0 |
| 2007 | Sesame Seeds[b] | *Salmonella* spp. | 0 |
| 2007 | Mojito Cocktail Garnish (Parsley Powder) | *Salmonella* spp. | 0 |

[a] Note: The names provided for *Salmonella* are the genus followed by the serovar, which is the current practice by the CDC for serovars within subspecies I of *S. enterica*. The unabbreviated name of *Salmonella* Ohio would be *Salmonella enterica* subsp. *enterica* ser. Ohio. Further information on *Salmonella* nomenclature is available in the Journal of Clinical Microbiology, July 2000, p. 2465-2467, Vol. 38, No. 7 (online at http://jcm.asm.org/cgi/content/full/38/7/2465).

[b] Recalls that occurred in Canada, all other recalls listed in table occurred in the U.S.

**Case Scenario: Outbreak of salmonellosis in Germany due to contaminated paprika in paprika-powdered potato chips**:

Between April and September, 1993, an estimated 1,000 cases of salmonellosis in Germany were traced to paprika and paprika-powdered potato chips. The majority of cases were in children aged 14 years or less. Enumeration of *Salmonella* in contaminated

product revealed levels of 0.04-0.45 organisms per gram. The infective dose was estimated at 4-45 organisms with an attack rate of 1 in 10,000 exposed persons.

This outbreak has several key learnings. First, *Salmonella* present in low numbers in spices can present a human health hazard when no kill step is applied prior to consumption. Second, *Salmonella* is very stable in dry environments and can survive through production, distribution, and eventually consumption. Third, the composition of a food ingredient (e.g., high in fat or oil) may protect *Salmonella* in low numbers from destruction by gastrointestinal acids, which may lead to illness. In such cases, a person does not need to consume a large amount of contaminated product to become ill.

## Food Safety Programs and Treatment Options

As a result of many well publicized food safety events, including those listed in Table 1 and the case study above, there is an increased global focus on food safety. Previous ASTA white papers have recommended that food companies institute programs such as Good Agricultural Practices (GAPs), Good Manufacturing Practices (GMPs), including pest management, and HACCP Plans. HACCP is the acronym for Hazard Analysis Critical Control Point and ASTA has developed a HACCP Guide to address critical food safety issues specific to the spice industry. In addition to the pre-requisite programs, companies are enhancing their quality and food safety systems to incorporate global food safety programs such as those defined by the Global Food Safety Initiative. [(2)]

In addition to the global collaboration taking place, the United States Congress increased the focus on food safety by holding hearings in 2007 and 2008 to discuss food safety issues. Among those testifying were the CEOs from several U.S. food companies, food industry organization representatives, and regulatory representatives from the FDA and USDA.

According to the 2005 Food Code, the FDA considers spices by nature to be a Ready-To-Eat (RTE) product. [(5)] The general public would not consider spices to be a food safety risk and frequently uses them without subsequent cooking. Although most foods made by food manufacturers are cooked or processed prior to consumption many are also consumed without the benefit of a lethality step, such as cooking at the appropriate temperature and time by boiling, baking, etc. [(5)].

In order to provide a greater assurance of food safety, a variety of microbial reduction techniques are employed within the spice industry. These include fumigants (ethylene oxide and propylene oxide), steam and irradiation. Each technique has advantages and limitations in effectiveness, quality impact and consumer acceptance. Even with these treatments, testing is frequently used as a measure of food safety and to meet customer specifications.

## Role of Microbiological Testing

Test protocols for microbiological contamination must incorporate sound handling methods and statistically-guided sampling plans. Routine microbiological testing of products is used to determine the acceptance of purchased ingredients, raw materials, and finished products. Testing of spices for pathogens, including *Salmonella,* may be useful to screen for high rates

of contamination entering a plant, but cannot completely eliminate risk. In instances where the contamination rate is low, the reliance on microbiological testing as the lone measure of food safety may be misleading as negative results do not always ensure safety.[6] For more information on the usefulness of pathogen testing, the International Commission for the Microbiological Safety of Foods has provided a decision tree.[7]

**Sample Collection and Preparation**

Samples of product must be collected in order to perform microbiological testing. More stringent sampling plans are typically required for untreated products than for those that have undergone microbial reduction. In fact, when spices are treated by validated methods such as irradiation, ethylene oxide, or steam, extensive testing post-treatment adds little to ensure food safety, increases cost, and may be unnecessary.

If sampling and testing is appropriate, the procedure for the collection of samples is key to ensuring accurate results. Collection instruments, such as scoops and bags, must be sterile to prevent cross-contamination. Proper hand washing techniques and the use of gloves is recommended. If product samples are collected prior to final processing and packaging, microbiological results may not be representative of product shipped due to cross-contamination in the processing or packaging equipment. Additional information regarding sample collection is available the FDA. [8]

A fundamental principle of lot acceptance sampling plans is that the samples collected will reflect the lot as a whole. For this reason, it is critical that the samples be collected at various points throughout the entire lot. This is particularly important where the microbial population is not homogenous, such as imported raw spices that may be comprised of many batches or sub-lots. For non-homogenous lots, an increased number of samples may be required to properly evaluate the lot.

An analytical unit is the aliquot of a sample that is actually tested. A typical analytical unit is 25 to 375 grams per sample, although this may be increased if desired. When testing for indicator microorganisms, such as aerobic or coliform bacteria, compositing multiple samples is a common technique to decrease the cost of testing. The disadvantage of compositing samples is that an individual sample with high levels of contamination may be diluted by mixing with samples with much lower or no contamination.

When more than one sample is analyzed for a microbiological attribute, a two- or three-class sampling plan may be applied to evaluate results. The attributes of these sampling plans are given below:

*n* = number of analytical samples
*c* = number of samples that may be tolerated in the marginally acceptable range (area between *m* and *M*)
*m* = value below which all values are acceptable
*M* = value at which all values above are defective

*Two-Class Sampling Plans*

A two-class sampling plan is appropriate when zero positives are permitted (*e.g.* testing for *Salmonella*). In a two-class sampling plan, $c = 0$ and $m = M$ in that there is no marginal range of acceptance and no sample may contain levels greater than *m*.

For *Salmonella* analysis, no greater than fifteen (15) analytical units (25 grams each) may be composited into one 375 gram test sample and tested in its entirety. When compositing is performed, it is important to ensure that equal amounts of each sample be included in the composite. Pulling a 375 gram sample from a bag of unequally mixed portions of analytical units is not acceptable. For spices imported into the United States and submitted for approval for reconditioning due to the detection of *Salmonella,* the FDA defines the sampling plan. [9]

*Three-Class Sampling Plans*

A three-class sampling plan may be appropriate when a proportion of sample units may yield test values in a marginally acceptable range without causing consequent problems.[6] This is often true for testing indicator microorganisms, such as aerobic bacteria, coliforms, yeast, and mold. It may also be appropriate for certain bacterial pathogens where a tolerance can be established in a product without jeopardizing safety, such as *C. perfringens*, *B. cereus,* or *S. aureus*. In a three-class sampling plan with $n = 5$, $c = 1$, $m = 1{,}000$, and $M = 10{,}000$, one out of five samples may test above 1,000 but lower than 10,000 with the lot still being considered acceptable.

To further assist in the development of a three-class sampling plant, a statistician should be consulted in order to select appropriate values for *m* and *M*. Additional information on sampling plans is available from ICMSF [7] and the FDA.

**Statistical Basis of Lot Acceptance Sampling Plans**

Factors that influence the effectiveness of a sampling plan include whether random samples can be collected from a lot, how samples are prepared, and the sensitivity and specificity of the analytical method. [6] Lot acceptance sampling plans assume the microbial population to be randomly distributed throughout the lot. This is often not true, especially for foods that are not liquids. For this reason, better information about the true microbiological population within a lot can be obtained by analyzing more than one sample. The number of samples that are collected from a lot is a balance between risk, accuracy, available resources, time, and cost.

Table 2 demonstrates the relation of number of samples collected to the contamination (defect) rate. Table 2 indicates that:

- If 10 samples are collected across a lot that has *Salmonella* in 1% of samples, there is a 90% probability that *Salmonella* will be not detected and the lot will be accepted.
- If 10 samples are collected across a lot that has *Salmonella* in 10% of samples, there is a 35% probability that *Salmonella* will be not detected and the lot will be accepted.
- If 15 samples are collected across a lot that has *Salmonella* in 5% of samples, there is a 45% probability that *Salmonella* will be not detected and the lot will be accepted.

*Table 2. Probability of acceptance ($P_a$) of defective product using a two-class sampling plan*

| PERCENT DEFECTS | NUMBER OF SAMPLES | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 5 | 10 | 15 | 20 | 30 | 60 |
| 1 | 0.99 | 0.95 | 0.90 | 0.86 | 0.82 | 0.74 | 0.55 |
| 2 | 0.98 | 0.90 | 0.82 | 0.74 | 0.67 | 0.55 | 0.30 |
| 5 | 0.95 | 0.77 | 0.60 | 0.46 | 0.36 | 0.21 | 0.05 |
| 10 | 0.90 | 0.59 | 0.35 | 0.21 | 0.12 | 0.04 | <0.005 |
| 20 | 0.80 | 0.33 | 0.11 | 0.04 | 0.01 | <0.005 | <0.005 |

## Conclusions

Although it is clear that raw spices may be contaminated with microbial pathogens, there are treatment and testing options available to ensure food safety and minimize risk. Comprehensive food safety plans must always include knowledge of ingredients, controlling the supply chain, auditing suppliers, and planning for supply chain interruptions.[11] Food manufacturers must then consider these programs when determining if use of a treated or untreated spice. All of this is then taken into account to design a sound sampling and testing regime can help to minimize food safety risk.

## References


1. Vij, V., E. Ailes, C. Wolyniak, F.J. Angulo, and K.C. Klontz. 2006. Recalls of Spices Due to Bacterial Contamination Monitored by the U.S. Food and Drug Administration: The Predominance of *Salmonella*. *J. Food Prot*. 69:233-237.
2. Global Food Safety Initiative: http://www.ciesnet.com/2-wwedo/2.2-programmes/2.2.foodsafety.gfsi.asp
3. *USDA Prerequisite Program Training* http://www.fsis.usda.gov/PDF/Training_Prerequisite_Programs.pdf
4. *HACCP Guide for Spices and Seasonings* 2006. American Spice Trade Association. www.astaspice.org
5. 2005 Food Code. U.S. Food and Drug Administration. Available at: http://www.cfsan.fda.gov/~dms/fc05-toc.html.
6. IFT Expert Report on Emerging Microbiological Food Safety Issues, Implications for Control in the 21st Century. www.ift.org
7. International Commission for the Microbiological Safety of Foods. 2002. Microorganisms in Foods 7, Microbiological Testing in Food Safety Management. Kluwer Academic Plenum Publishers. New York, NY.
8. FDA *Investigations Operations Manual 2008*, 4.3 Collection Technique: http://www.fda.gov/ora/inspect_ref/iom/ChapterText/4_3.html#SUB4.3
9. FDA *Investigations Operations Manual 2008*, 4.5 Sampling: Preparation, Handling, Shipping, Sample Schedule 1, Salmonella Sampling: http://www.fda.gov/ora/inspect_ref/iom/ChapterText/sschedule.html
10. FDA *Investigations Operations Manual 2008* http://www.fda.gov/ora/inspect_ref/iom/iomtc.html
11. American Spice Trade Association. 2007. White Paper. *Importing Spices from China and Other Countries*. http://www.astaspice.org/i4a/pages/index.cfm?pageid=3776