In August of 2006, the National Pecan Sheller’s Association (NPSA) requested general guidelines for the control and inactivation of *Salmonella* (and, potentially, other microbial pathogens) during pecan processing. Development of specific guidelines is complicated by an absence of published information on the prevalence and levels of *Salmonella* on pecans. In addition, the only published research study addressing the inactivation of *Salmonella* on in-shell pecans or pecan nutmeats (Beuchat and Heaton) dates back to 1975 and may involve simulated process conditions no longer representative of those used by today’s shellers and processors.

This document is a revision of a 10/12/06 paper presented to the NPSA Technical Committee for review. In addition to general guidelines, it provides recommendations to the Technical Committee on research needed to address some knowledge gaps regarding Salmonella control on pecans. An attachment provides background information on *Salmonella*, on microbial interventions applied to almonds and other nuts, and on microbiological testing as well as various references on these subjects.

**Salmonella and nuts or peanuts**

Historically, foodborne illness linked to tree nuts or peanuts is rare. Documented illness has, to date, only involved *Salmonella* – a finding that is not unexpected. *Salmonella* is uniquely suited to causing foodborne illness associated with a nut product because the organism is:

- widespread in the natural environment and carried by a variety of warm blooded and cold blooded animals;
- capable of surviving for extended periods of time (potentially, years) on dry (and dried) products;
- especially heat resistant when dried or present on dried foods, foods with decreased water activity, or foods with a high fat content; and
- capable of causing human illness when present at low levels. The infectious dose for some strains is less than 10 to 20 organisms (= cells = colony forming units = CFU) so pathogen growth is not necessary to reach infectious levels.

I am not aware of any published data on the prevalence of *Salmonella* on pecans or levels or strains of salmonellae that might be found on positive pecans. When present, *Salmonella* contamination would probably be sporadic (present on some pecans but not all) and involve small numbers of cells. Contamination would be mostly confined to the surface of shucks and intact pecan shells but could also affect nutmeats if the shell was not intact due to insect damage, hairline cracks, or moisture-separated shell sutures. Limited evidence indicates that pecan packing material can prevent *Salmonella* growth and, at high levels, exhibit bactericidal effects (Beuchat & Heaton, 1975). Inhibitory activity would probably depend on moisture level.

**Control of Salmonella during shelling and processing**

Microbiological control of pecans and the pecan shelling/processing environment involves two distinct but complimentary strategies: inactivation (e.g. via “kill steps”) of any salmonellae that might be present on the in-shell pecans and prevention of cross contamination at subsequent processing steps. Cross-contamination results when microorganisms are transferred from one surface to another, either directly (e.g. a “clean” nutmeat contacts a contaminated shell fragment) or indirectly (e.g. via water used to condition contaminated in-shell pecans).

**Inactivation**

Depending on specific process parameters, primary processing steps (especially hot water bath conditioning and Propylene oxide (PPO) application) have the potential to achieve some degree of microbial inactivation (including *Salmonella* inactivation).

TRADE SECRET, Confidential Commercial Information
Exempt from Disclosure under 5 USC 552(b)(4)
Hot water conditioning
The 2004 NPSA “Kill steps” survey indicated that most shellers regard the hot water bath conditioning step for in-shell pecans as their primary kill step. I agree with this assessment, cautioning that effectiveness of the hot water bath is dependent on process control (e.g. in-shell pecan temperature, water temperature, dwell time) as well as equipment design (e.g. use of air agitation) and cleanliness of in-shell pecans entering the bath.

I am aware of only one published study on *Salmonella* inactivation/survival and pecan processing and storage conditions. That paper by Beuchat and Heaton (1975) reported that more than 5 minutes of exposure to 160 to 200°F water was needed before pecan temperatures equaled water temperature; pecans were held at 72°F overnight prior to conditioning. Treatment with 160, 180, or 200°F water for 2 minutes yielded 2.4 to 3.9-log reductions in *Salmonella* numbers on *Salmonella* Senftenberg-inoculated in-shell pecans. The authors cautioned that “thermal treatments normally carried out during the processing of pecans are inadequate to consistently destroy salmonellae in highly contaminated in-shell nuts”. This inadequacy is due, in part, to the shell and packing material insulating the nutmeat against rapid temperature changes. Beuchat and Heaton also reported a tendency for inoculated Schley pecans to have higher *Salmonella* counts on nutmeats compared to nutmeats from inoculated Stuart pecans. They hypothesized that Schley pecans may be more susceptible to the development of hairline cracks which would facilitate nutmeat contamination.

With one main exception (150°F for 2 minutes), the “Kill steps” survey indicates that hot water conditioning usually involves water temperatures in excess of 180°F (and often ≥190°F) for 3 minutes to as long as 12 minutes. Regrettably, the survey did not address the temperature of in-shell pecans going into the hot water conditioning process. We know, however, that some shellers condition in-shell pecans previously held under refrigerated or frozen storage. Processors using hot water conditioning on chilled or frozen in-shell pecans must recognize that water temperatures will drop substantially when pecans are added to the tank. An increased dwell time will be necessary to compensate for this “come-up time” and allow shell temperature to equilibrate to the hot water temperature. While it is impossible to recommend a specific hot water conditioning process in the near absence of data, a general recommendation is to use water temperatures of 190° (or above) and dwell times sufficiently long to insure that shell temperatures remain at water temperature for at least several minutes. Higher water temperatures and longer dwell times would be expected to achieve greater inactivation.

Propylene Oxide (PPO)
Application of PPO is regulated by the EPA under 40CFR§180.491 (http://a257.g.akamaitech.net/7/257/2422/08aug20051500/edocket.access.gpo.gov/cfr_2005/julqtr/pdf/40cfr180.491.pdf). It’s important to distinguish between the use of PPO as an insecticide and its’ use as an antimicrobial agent. Antimicrobial applications typically involve higher PPO concentrations for shorter times (than insecticide application) and require that both temperature and humidity be monitored. If used for control of *Salmonella* or another pathogen, PPO treatment must be validated.

Prevention of cross-contamination
Pathogen interventions are only worthwhile when good shelling and processing practices are followed to minimize the potential for subsequent cross-contamination. Especially important recommendations include:

- Separating the in-shell processing area from the area used for subsequent processing steps. Ideally, personnel, vehicles, containers, and utensils would also be segregated between the in-shell area and further processing areas.
General Guidelines on the control of *Salmonella* during pecan processing

Jennifer L. Johnson 3/2/07 Page 3

- Using conditioned intake air to maintain the nutmeat-processing areas under positive pressure (relative to in-shell processing).
- Insuring that water in ambient-temperature water conditioning tanks and nutmeat flotation tanks is replaced frequently and conditioned (e.g. via filtration and/or chlorination) so it doesn’t contribute to microbial cross-contamination or, worse yet, permit microbial growth to occur.
- Keeping the plant environment as dry as possible (especially in grading & sorting areas). Not only will this minimize issues with pecan-shell sludge but it will deprive *Salmonella* of the water it needs to grow.
- Conditioning process-critical air (e.g. air used to dry nutmeats) by moisture removal and filtration. It’s also important to consider the source (e.g. relationship between air intake, neighbors, and prevailing winds) of process-critical air and ensure that air filters and in-line moisture traps are properly maintained.
- Following proper sanitation procedures with regard to all equipment.
  - The destoner tank, for example, should be cleaned with detergent and physical scrubbing (as necessary) followed by a potable water rinse and application of a food-grade sanitizer applied at “no rinse” levels (see 21CFR§178.1010; [http://a257.g.akamaitech.net/7/257/2422/10apr20061500/edocket.access.gpo.gov/cfr_2006/apr qtr/pdf/21cfr178.1010.pdf](http://a257.g.akamaitech.net/7/257/2422/10apr20061500/edocket.access.gpo.gov/cfr_2006/apr qtr/pdf/21cfr178.1010.pdf)). Rinsing is inadequate to remove organic material and microorganisms, especially in areas with hard water.
  - Grading and inspection tables pose a risk of cross contamination unless they're properly cleaned and sanitized. Sanitation at this stage of the process is critical because nutmeats are unlikely to receive any subsequent interventions (other than an optional PPO step).
- Segregating reject streams and processing those pecans after 1st quality “accepts”
- Tightening up GMPs to further minimize the risk of cross contamination

**Chlorine**

Most pecan shellers are familiar with the use of chlorine (sometimes called “bleach”) as a sanitizer applied to cleaned processing equipment. In that application, chlorine serves to inactivate any microorganisms not removed during cleaning operations. Chlorine in a water bath, however, is unlikely to achieve any microbial inactivation on pecan shells even if freshly added at 200 ppm to clean water in a cleaned and sanitized tank. Organic material (e.g. soil, leaf matter, shuck pieces, and even the shell itself) binds rapidly to chlorine, making it unavailable for microbial inactivation. Use of chlorine at water temperatures above 130°F is not recommended because chlorine dissipates rapidly at higher temperatures.

In order to minimize cross contamination in an ambient water-conditioning or flotation tank, food-grade chlorine should be present at 150 to 200 ppm (200 ppm is the maximum level permitted by FDA, [http://vm.cfsan.fda.gov/~dms/prodguid.html](http://vm.cfsan.fda.gov/~dms/prodguid.html)). Levels of chlorine found in municipal water (typically less than 2 ppm with a maximum EPA-permitted level of 4 ppm) are grossly inadequate for this purpose. Ideally, shell-cleaning baths should be used upstream of chlorinated water baths to assist in removal of organic matter but, even so, baths will require frequent water changes and frequent monitoring of available chlorine levels to insure that they remain between 150 and 200 ppm. Chlorine test strips are commercially available for use in monitoring chlorine levels of up to 200 ppm (e.g. Hydron Micro Chlorine #CM240, LaMotte #4250-bj from [https://www1.fishersci.com/Coupon?cid=1328&gid=2771019](https://www1.fishersci.com/Coupon?cid=1328&gid=2771019); “high range chlorine strips” from [http://www.sanitationtools.com/Products.asp?Product=1389&Category=65](http://www.sanitationtools.com/Products.asp?Product=1389&Category=65); “chlorine check ultra high-free, #480024” from [http://www.sensafe.com/480024.php](http://www.sensafe.com/480024.php)).
Process control

The “Kill steps” survey did not address monitoring of process parameters (e.g. temperature, time, chlorine level) yet monitoring is critical to process control. Monitoring must be done frequently enough to insure that the process remains in control. Monitoring results should always be documented together with monitor initials, date, time, and other applicable information (e.g. tank number).

Glass thermometers (especially those containing mercury) should never be used in a processing plant. Thermometers or temperature gauges used to monitor water temperatures must be regularly calibrated against a NIST-traceable reference thermometer. Calibration activities should always be documented.

Process parameters that should be monitored during hot water conditioning include pecan temperature, shell cleanliness, water cleanliness (too much debris will slow heating), water temperature, and dwell time in the tank. Water temperature will usually be monitored since it is difficult to measure temperature at the surface of an in-shell pecan (the likely site of microbial contaminants).

Potential future research approach

I will close with a brief discussion of research that would benefit NPSA members. One data gap is a lack of scientifically collected information on Salmonella prevalence, levels, and strains/serovars on in-shell pecans grown in various parts of the country. This information would facilitate a laboratory-based evaluation of potential interventions (“kill steps”) on inoculated in-shell pecans. The resistance of Salmonella serovars (e.g. S. Enteritidis) and strains (e.g. S. Enteritidis PT 30) to heat, acidity, and other adverse conditions can vary considerably. Knowing the serovars and strains of salmonellae likely to be found on pecans allows targeted research to be performed, thereby saving time and money while generating data with real-world utility.

The hot water bath conditioning step for in-shell pecans is the logical focus of a research study; the 2004 NPSA “Kill steps” survey identified that process as the primary microbial intervention used by NPSA members. If not already available, NPSA would need to identify the various commercially-important pecan cultivars grown around the country. As illustrated by the Beuchat and Heaton study, pecan cultivar may influence Salmonella inactivation because of differences in shell strength, quantity of packing material, fat content, etc. NPSA would also have to identify commonly-used hot water conditioning parameters (e.g. in-shell pecan temperature, water temperature, dwell time) and assess operational variables like shell cleanliness. The main objective of the research study would be to quantitate Salmonella inactivation on inoculated in-shell pecans (and the resulting nutmeats) using different hot water conditioning process parameters and different pecan cultivars.

Typically, the first step is to secure funding for the research study. The level of available funds largely determines the scope of the research. A request for proposals (RFP) identifying specific research objectives is then issued to universities and/or independent laboratories with expertise in intervention/challenge studies. The universities and independent labs are invited to generate proposals addressing the required research objectives. RFPs may be very prescriptive in describing the research approach or open to directions provided by the researchers.
Foodborne illnesses associated with tree nuts and peanuts

Searches of the scientific literature indicate that foodborne disease is rarely associated with nuts and nut products. This is true of most dry foods; moisture is necessary for microbial growth and typically promotes survival. To date, foodborne illness outbreaks linked to nuts and peanuts have only been caused by Salmonella (see table, below). I am not aware of any documented outbreaks or cases of foodborne illness specifically linked to pecans.

<table>
<thead>
<tr>
<th>Food</th>
<th>Dates</th>
<th>Place</th>
<th>Pathogen(s)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peanut-butter flavored savory snack</td>
<td>November 1994 to January 1995</td>
<td>Israel, England, Wales, &amp; US</td>
<td>Salmonella Agona PT15 (S. Enteritidis was recovered from snacks but not from patients)</td>
<td>Killalea et al., 1996; Shohat et al., 1996</td>
</tr>
<tr>
<td>Peanut butter</td>
<td>February to June, 1996</td>
<td>Australia</td>
<td>Salmonella Mbandaka &amp; Salmonella Senftenberg</td>
<td>Ng et al., 1996; Scheil et al., 1998; Wood, 1999</td>
</tr>
<tr>
<td>Flavored or roasted in-shell peanuts</td>
<td>May to October, 2001</td>
<td>Australia, England, Wales, &amp; Scotland</td>
<td>Salmonella Stanley, S. Newport, &amp; S. Kottbus (S. Lexington and unnamed Salmonella strains were recovered from peanuts but not from patients)</td>
<td>Kirk et al., 2004</td>
</tr>
<tr>
<td>Raw whole almonds</td>
<td>October 2000, to July 2001</td>
<td>Canada &amp; US</td>
<td>Salmonella Enteritidis PT30</td>
<td>Isaacs et al., 2005</td>
</tr>
<tr>
<td>Raw whole almonds</td>
<td>September 2003, to April 2004</td>
<td>Canada &amp; US</td>
<td>Salmonella Enteritidis PT9c</td>
<td>Keady et al., 2004</td>
</tr>
</tbody>
</table>

Salmonella contamination of tree nuts and peanuts

Published data on Salmonella prevalence or levels on contaminated peanut or tree nut products are very limited. I am not aware of any published data on the prevalence of Salmonella on pecans or levels or types of salmonellae that might be found on positive pecans. When present, Salmonella contamination would probably be sporadic (present on some pecans but not all) and involve small numbers of cells. This contamination pattern has been demonstrated with other nuts and with peanuts. Guangwei Huang (Almond Board of California, ABC) estimates that almonds associated with the 2000/2001 outbreak typically carried fewer than 10 CFU/100 grams; the highest levels were approximately 100 to 1000 CFU/100 grams (personal communication, 5/2006). Salmonella was not detected in almonds associated with the 2003/2004 outbreak. The study by Kirk et al. (2004) is one of the few to quantitate salmonellae on peanuts, reporting that levels were “generally very low, ranging from < 0.03 to ~ 2 organisms per gram of peanuts in the shell”. Scheil et al. (1998) reported levels of Salmonella Mbandaka as low as 3 CFU/gram in peanut butter implicated in a foodborne outbreaks.
Lessons from the Almond Industry
Following two food safety incidents involving “raw” almonds contaminated with *Salmonella* Enteritidis, ABC formalized guidelines for almond growers (http://www.almondboard.com/files/PDFs/FQSP_GAPs.pdf) and Good Manufacturing Practices (GMPs) for almond handlers (http://www.almondboard.com/files/PDFs/FQSP_GMPs.pdf). My review of these documents indicates that they are sound and very comprehensive. Despite being developed for almonds, I believe that many of the recommended practices may also be applicable to pecans.

The epidemiological investigation of the 2000/2001 *Salmonella*/almond outbreak revealed some information that may be of interest to pecan shellers. Investigators isolated the *Salmonella* outbreak strain from processing equipment at the huller-sheller facility some 6 to 7 months after the equipment was last used. The outbreak strain could also be recovered from relatively small areas of orchard surfaces in a number of orchards implicated in the outbreak a year after implicated almonds were harvested from these orchards (Isaacs et al., 2005). Follow-up sampling of a single orchard recovered the outbreak *Salmonella* strain over a 4-year period with the most frequent isolation occurring during harvest months (Uesugi et al., 2005). These findings confirm the ability of *Salmonella* to survive on inadequately cleaned equipment and in the external environment for extended periods of time.

ABC has funded a variety of research projects aimed at better understanding factors that may contribute to almond contamination or inactivate *Salmonella* on raw almonds while minimally affecting sensory qualities. Information on much of the ABC-funded research is available via the ABC website or at websites archiving abstracts from presentations made at various scientific conferences (see “References” section at the end of this document). Research has identified several technologies capable of achieving a minimum 4-log (= 10,000-fold) inactivation of salmonellae on inoculated raw almonds. The FDA performance standard for *Salmonella* requires a 5-log (100,000-fold) reduction. FDA has issued letters of determination indicating that, when applied according to specific parameters, several technologies (e.g. hot water blanching, hot oil roasting, a proprietary high temperature/short time moist heat treatment, and propylene oxide (PPO)) are capable of obtaining a 5-log reduction of *S. Enteritidis* PT30. Raw almonds that have received an approved 5-log inactivation treatment using validated equipment or parameters may be labeled “pasteurized”. This information can be found on the January, 2007, ABC “Action Plan and Pasteurization FAQ” website (http://www.almondboard.com/files/January%202007%20FS%20Pasteurization%20treatments.pdf).

While there are obvious differences between the structure and composition of almonds and pecans, the ABC-funded research can be viewed as a general road map for research directions of potential interest to other nut commodity groups. It is important to note, though, that almond research has focused on a single problem strain of *Salmonella*, *S. Enteritidis* PT30, which was associated with human illness and raw almonds in the 2000/2001 outbreak. The absence of definitive information on *Salmonella* serotypes and strains that may be associated with pecans would mandate the use of a “cocktail” of various *Salmonella* strains in research studies involving pecans.

**Temperature**
Under otherwise ideal conditions, *Salmonella* can grow at temperatures between 44.6 and 115°F with growth being fastest between 95 and 109°F (ICMSF, 1996). Refrigeration below 44°F will prevent growth but will not inactivate the organism. In fact, studies indicate greater *Salmonella* survival (32+ weeks) on inoculated pecans when held at refrigeration/freezer...
Salmonellae begin to die at temperatures of 120°F when moisture is present. At temperatures above 120°F, microbial inactivation is a function of both time and temperature – lower temperatures coupled with longer times can provide equivalent heat lethality to higher temperatures for shorter times.

Moist heat applications (other than those addressed in the Guidelines)
Steam represents another moist heat application that could be applied to pecans to reduce or eliminate microbial pathogens such as Salmonella. Research on steam treatment of raw almonds and raw shelled pistachios indicates that a high level of Salmonella inactivation can be achieved under certain treatment conditions (Lee et al., 2006; Tanus et al., 2005a; Tanus et al., 2005b; http://www.almondboard.com/files/January%202007%20FS%20Pasteurization%20treatments.pdf). The inherent complexity of commercial steam pasteurization/application equipment makes validation of this process an absolute necessity.

Should future events indicate a high risk of Salmonella contamination on pecan nutmeats, hot water treatment may be one option for reducing contamination if such treatment doesn’t adversely impact quality. ABC-funded research on hot water blanching of raw almonds indicates that treatment at 190°F (min. temp at coldest point in pasteurizer) for 2 minutes (minimum) gives 5-log inactivation of Salmonella Enteritidis PT30 (Uesugi et al., 2005; http://www.almondboard.com/files/January%202007%20FS%20Pasteurization%20treatments.pdf).

Dry heat
Salmonella is especially heat resistant when dried or present on dried foods or foods with decreased water activity (Doyle and Mazzotta, 2000). In contrast to documented pasteurization of raw almonds using oil roasting and water blanching, the ABC believes that “Other thermal processes have shown limited effectiveness in achieving a 4-log reduction in Salmonella contamination. Dry roasting processes may achieve a 4-log reduction under certain parameters; however, this is equipment/process specific” (http://www.almondboard.com/files/January%202007%20FS%20Pasteurization%20treatments.pdf). Achieving a consistent level of Salmonella inactivation with dry heat is especially difficult.

Nutmeat drying operations using low-temperature air (below 120°F) are especially ineffective at inactivating salmonellae. I would advise against the use of air temperatures below 115°F, if only because it would be difficult to justify those temperatures under HACCP. Higher temperature air (especially in excess of 180°F) may achieve a limited degree of inactivation but only if nutmeat moisture levels are relatively high (e.g. because of a previous flotation step) and times are sufficiently long to permit nutmeat temperature to equilibrate with air temperature and remain there for several minutes.

Propylene Oxide (PPO)
Research funded by ABC indicates that 0.5 oz PPO/ft³ in vapor is sufficient for almond pasteurization (5-log reduction) as long as the initial product temperature is at least 86°F (30°C), a ventilation treatment is used, and other parameters are met (http://www.almondboard.com/files/PPOSOP%2DFINAL.pdf; Danyluk et al., 2005).
Microbiological testing

Microbiological testing may be done for a variety of reasons. Oftentimes, customers demand microbiological sampling and testing and require that the results comply with certain product specifications. A processing facility may also use testing to assess process control, evaluate raw material suppliers, and/or gauge sanitation effectiveness. The key thing is that microbiological test results should be used for some purpose. Otherwise, why go to the trouble and expense of doing the testing?

Results of the “Kill steps” survey indicate a degree of confusion on the subject of microbiological testing, specifically the distinction between pathogens (organisms that can make people sick) and general groups of microorganisms (e.g. Aerobic Plate Count = APC, generic E. coli) used to assess product quality or evaluate sanitation effectiveness. Some of this confusion may stem from the historical use (in the late 1890s) of generic E. coli (and, later, Coliforms) as an index of the presence of Salmonella in drinking water. That application spawned a myth of sorts – that the presence of E. coli or Coliforms on a food product is indicative of fecal contamination (and, potentially, the presence of fecal pathogens like salmonellae). Numerous studies on a variety of foods have failed to confirm a correlation between the presence of Salmonella and generic E. coli, Coliform, or “Fecal” Coliform counts on foods (Kornacki and Johnson, 2001). The only way to gauge Salmonella contamination on a food product is to use a statistically valid sampling plan and validated Salmonella detection methods.

Food processors commonly test raw materials or finished products for pathogens without regard to the appropriateness of their sampling plan. Collection and analysis of a single sample per lot, for example, is inappropriate for foods in which Salmonella contamination would be expected to be sporadic and present at low levels. A common sampling plan for the detection of salmonellae on a dried product (e.g. pecans) would involve the collection of 10 samples per lot, analysis of a 25-g analytical unit from each sample, and rejection of any lots represented by a positive Salmonella result. That ICMSF Case 11 sampling plan will reject a lot having 1 Salmonella (or more) organism per 83 grams product with at least 95% probability (ICMSF, 2002).

As discussed (above), Salmonella is the only pathogen known to have caused foodborne illness linked to nuts or peanuts. This explains customer specifications requiring sampling and testing for salmonellae and provision of a “not detected” Certificate of Analysis prior to lot acceptance. Pathogen testing typically uses a qualitative method – results indicate either the presence or absence of the pathogen.

Several “Kill steps” survey participants indicated that they test pecans for Listeria (or L. monocytogenes the only human pathogen in the Listeria group) and Staphylococcus (= staphylococci). My expectation is that these tests are conducted at customer request. From the public health perspective, pecans are unlikely vectors for Listeria or Staphylococcus foodborne illness. These types of illness require high pathogen numbers (> 100,000 to 1,000,000 cells) and product conditions suitable for pathogen growth. If pecan nutmeats were contaminated, however, they would be expected to carry only small numbers of pathogens (< 10 to 100 cells) and be too dry to support pathogen growth and toxin production (in the case of Staphylococcus).

The greatest application of APC, yeast & molds, generic E. coli, and coliform testing is to assess the overall quality of a food and the hygienic conditions present during food
processing. These tests are nearly always quantitative, allowing processors to compare (for example) the APC obtained on in-shell pecans coming from different orchards. APC methods requiring incubation at 86 to 95°F (30 to 35°C) are sometimes called "mesophilic" counts. I would remind readers that generic *E. coli* should not be confused with known pathogenic strains of *E. coli* (e.g. *E. coli* O157:H7, the pathogen linked to foodborne illness outbreaks involving contaminated raw spinach, under-cooked ground beef, and un-pasteurized fruit juices.

I would like to offer three comments on the subject of microbiological testing.

- When asked what tests are appropriate for a particular type of sample, most food testing laboratories will list off a number of tests. In reality, some of these tests (e.g. *Staphylococcus* on in-shell pecans) may not provide useful information. Your lab should be ethical and knowledgeable enough to tell you which tests are useful and which only help their bottom line.

- Request that your lab provide a statement (on letterhead) identifying exactly which microbiological methods they’re using. The majority of responses to the “Kill steps” survey did not cite method references (e.g. AOAC 1234) for pathogen analyses.

- Whenever finished product samples are tested for a microbial pathogen (e.g. *Salmonella*, *L. monocytogenes*), I strongly recommend that the tested lot be held until the test results are obtained. Release of a lot subsequently found to be contaminated with a pathogen will result in a recall and that’s one event you do not want to experience!

References (links are to full text papers whenever possible but some journals only permit abstracts to be accessed free of charge)


http://www.ingentaconnect.com/content/iafp/jfp/2005/00000068/00000001/art00032

http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5322a8.htm

http://bmj.bmjournals.com/cgi/content/full/313/7065/1105?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&RANK=1&RESNOHITS=10&RESULTSOHITS=10&RESULTSMAXHITS=10&RESULTSOFAST=1&RESULTSOFRANK=1&FIRSTINDEX=0&sortspec=relevance&resourcetype=HWCIT

http://www.foodprotection.org/meetingsEducation/IAFP%202006/IAFP%2006%20Poster%20Abstracts.pdf – search for “P4-17”


http://www.ingentaconnect.com/content/iafp/jfp/2006/00000069/00000003/art00017


