california almonds
Almond Board of California

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Guidelines for Validation of Dry Roasting Processes

Overview

The Almond Board of California (ABC), working with researchers from universities and commercial laboratories, initiated several projects addressing lethality of dry heat processes. Thermal death time (TDT) studies were conducted using laboratory-scale hot air ovens and a pilot-scale hot air roaster for *Salmonella* Enteritidis Phage Type 30 (SE PT 30) identified in the 2001 outbreak, and potential bacterial surrogates. *Salmonella* challenge studies were also conducted in a commercial-scale dry (hot air) roaster to evaluate the lethality of typical dry roasting parameters. The results from several studies show that SE PT30 on almonds is quite heat resistant to hot air. Studies of commercial roasting parameters confirmed the findings of high heat resistance and demonstrated that some typical industry roasting parameters did not deliver a minimum 4-log reduction of SE PT 30.

While research on surrogates and *Salmonella* TDT studies continues, and a standardized validation procedure is being developed, this document provides guidance to process authorities for conducting validation testing for dry heat processes utilizing hot air. The guidelines are also applicable for hot air roasting of pre-wet almonds by water or brine solution.

Current Recommendations for Dry Roasting Studies

Currently, ABC is sponsoring additional research in an attempt to determine definitive data for use with dry roasting processes. In order to assist the needs of the industry and potential Direct Verifiable (DV) users for validation methodologies for dry heat processes, ABC's Technical Expert Review Panel (TERP) recently issued the following recommendations for surrogate and SE PT 30 validation. These recommendations are based on evaluation of the information and data from the studies available to ABC, and they will be updated when warranted based on new information.

1) *Enterococcus faecium* NRRL B-2354 (*Pediococcus*), a recently accepted surrogate for SE PT 30 under dry and wet heat almond processing conditions, can be used for validation of dry roast processes. Guidelines for process validation using *E. faecium* NRRL B-2354 were developed and posted in ABC Action Plan web page. The guidelines should be followed in any validation tests using this surrogate.

2) *Pantoea agglomerans* can be used as a dry heat surrogate for SE PT 30 at temperatures 250, 265 and 280°F with the following *P. agglomerans* destruction being equal to a 4.0-log destruction of SE PT 30:

4.7-log destruction at 250 °F

5.5-log destruction at 265 °F

6.3-log destruction at 280 °F

These log destruction equivalents are based upon general method calculations of data from the studies sponsored by ABC and provide conservative estimates from data points from two studies conducted with the organism at these three temperatures. The log destruction equivalents also are based upon having a *P. agglomerans* culture with a dry heat D-value at 250 °F of at least 21.1 minutes when studies are conducted in a Fisher Scientific Isotemp 851F oven with temperatures measured at the center of an aluminum almond. Since the log destruction equivalents are based upon specific study results at the temperatures noted, **no attempt should be made to extrapolate and interpolate the data to other temperatures.**

3) A 4.0-log destruction of SE PT 30 will be obtained with processes that provide aluminum almond, or equivalent device, temperatures that are equal to general method calculations of:

100 minutes at 250 °F

50 minutes at 265 °F

23 minutes at 280 °F

12 minutes at 295 °F

9 minutes at 300 °F

Note: These processes for SE PT 30 are based upon the most conservative data from two ABC-sponsored studies and yield a z-value of approximately 47 F°.

Understanding the Dry Roast Process

Dry (hot air) roasting is a thermal process used by the almond industry. A dry roast can be achieved via a continuous conveyor roaster or rotary roaster. The continuous conveyor roaster can be single-stage or have multiple-stages with a variety of temperature controls. Common temperatures used for hot air roasting range from 265°F to 310°F. At the lower temperature, it may take 40-55 minutes to obtain a light to medium roasted product while at the higher temperature, it may take 10-15 minutes to obtain a light to medium roasted product.

In general, time/temperature combinations vary with the desired degree of roast, product bed depth and speed (or throughput), initial moisture levels and initial temperatures of almonds, hot air dynamics and/or air velocity of a roaster, etc. Equipment design varies from one brand to another, and from one style to another. This consequently will impact heat transfer and microbial reduction obtained during roasting. For example, in a single-stage conveyor roaster, the hot air comes through the conveyor from below. Almond kernels close to the conveyor would receive more heat exposure than the kernels on the top of the bed of product. For some two-stage roasters, hot air blows from the bottom of the first zone then from the top of the second zone, therefore the kernels at the bottom, middle and top would not receive the same heat exposure. The individual kernels from a rotary roaster generally receive more uniform heat exposure.

The degree of roasting is dictated by customer specifications, and it is generally categorized as light, medium and dark roast, defined by color and moisture levels of a roasted product. Typically, light-roasted products require less heat treatment than dark-roasted product. However, the color and moisture or degree of roast of the finished product does not necessarily correlate with the amount of heat exposure the products received. In other words, the same degree of roast can be achieved from different heat exposures (i.e. time/temperature combinations). Sometimes, a set of roasting parameters will be established for certain product specifications. The roasting parameters may be altered to meet the specification if the initial moisture and initial temperature of the almonds are changed. Thus, there may be many parameter settings for each roasting line or even many versions of parameters for a single product specification.

Validation of Dry Roasting Processes

Currently, the validation of dry roasting processes can be achieved through the following approaches: 1) Microbial challenge testing using E. faecium NRRL B-2354 for a wide range of applications; 2) Microbial challenge testing using *P. agglomerans* SPS2F1 at 250°F, 265°F and 280°F; 3) Thermal validation using an aluminum almond (or equivalent device) temperature measurement and SE PT 30 TDT data for processes utilizing temperatures from 250°F to 300°F; 4) For the processes utilizing temperatures beyond 300°F, validation testing may have to use SE PT 30 challenge testing until further recommendations are issued; and 5) Microbial challenge testing using microorganisms other than SE PT 30, *Enterococcus* or *Pantoea.* Note: In this instance a report on the thermal resistance of the surrogate must be included with the validation report for review and evaluation.

Objectives of Validation Testing:

- Identify the coldest spot or path for each roasting line
- Identify the worst case scenario parameters for each product
- Validate the lethality for the worst case scenario parameters using microbial challenge testing or thermal validation
- Identify a set of parameters for each product that will meet the minimum 4-log reduction criteria

Dry Roast Line Description to Include:

- Flow chart to illustrate configuration of each roasting line: continuous conveyor single or multiple stage roaster, rotary roaster, etc. The validation studies will need to cover each individual roasting line
- Heating and cooling mechanism: temperature control(s) and recording device(s); hot air dynamics; parameter compliance verification frequency
- Conveyor speed control or rotation revolution control, speed dial setting, calibration procedures
- Maximum throughput
- Raw product and roasted product segregation procedures
- Line sanitation procedures

Products Covered Under this Validation:

- List all products produced on the line to be validated
- List all products to be validated or covered by the same parameters
- List all parameters that may be used for each product
- Maximum throughput for each product that has been validated
- Worst case scenario parameters for each product: The worst case may include the shortest time at lowest temperature, the coldest raw almonds or coldest ambient temperature when the roaster is operating, the highest moisture of the raw almonds, the maximum throughput, etc.

Temperature Mapping of Roasting Lines:

- Thermocouple specifications: A data tracer or thermocouple may be used for roaster temperature mapping, it must have a minimum accuracy of +/- 1.0° and calibration of the device must be current. The diameter of the thermocouple tip should not be coarser than gauge 30. The recording interval of the temperature measured by the device should not be more than 5 seconds.
- Temperature profile collection: Temperature mapping should be conducted when the roasting line is operating under the worst-case scenario conditions identified in the section “Products covered under this validation”. Locations of measurement or monitoring need to be sufficient to have all representative spots of conveyor product bed covered, such as left, middle, right, top, center, and bottom of a bed.
- Replication of temperature profiling runs: For each set of parameters to be validated, a minimum of three (3) profiling runs must be conducted. The coldest spot or zone identified will be the focal point for microbial challenge testing or lethality calculation if a TDT thermal validation approach is taken.

Microbial Challenge Testing Using *E. faecium* NRRL B:2354

After evaluating the results of the research projects conducted by Silliker Research Center, Michigan State University, The National Food Laboratory, and Deibel Laboratories, Inc, the ABC/TERP identified *E. faecium* NRRL B-2354 as a surrogate for validation of almond thermal processes. This surrogate is applicable for use in validation studies of dry heat processes of almonds, such as dry roast, dry roast flavoring, brine and pre-wet dry roast, dry plasticizing, etc.; moist air processes such as steam plasticizing, ambient steam processes (FMC, Ventilex, Biosteam, etc.); and other alternative heating

treatments such as infrared, microwave and radio frequency heating of dry or pre-wet almonds. Please follow “Guidelines for Process Validation Using *E. faecium* NRRL B-2354” posted in ABC Action Plan Update web page in microbial challenge testing of dry roasting operations.

Microbial Challenge Testing Using *P. agglomerans* SPS2F1:

Research is underway on *P. agglomerans* to determine the best procedure for use in preparation of inocula, procedures for inoculation of almonds, handling of inoculated almonds, dry roast treatment of inoculated almonds, recovery and enumeration procedures for *P. agglomerans* from treated almonds, etc. Please contact ABC for the most up-to-date recommended procedures for using *P. agglomerans* in microbiological challenge testing of dry roasting operations.

Thermal Validation Using TDT Data:

- TERP has issued recommendations on thermal validation using SE PT 30 TDT data. However, these recommendations only apply to temperatures from 250 to 300°F. Extrapolation beyond 300°F is not applicable.
- Temperature data collection must follow the procedures outlined in the section on “Temperature Mapping of Roast Line”. The temperature profiles for thermal calculations must be collected by a thermocouple of gauge 30 attached to an aluminum almond (FMC FoodTech Invention, for availability of aluminum almonds, please contact FMC FoodTech, Madera, CA 93639 at 1-559-661-3193 or 1-559-661-3121) or equivalent temperature monitoring procedure. The thermocouple will need to be inserted into the center of an aluminum almond that is a replica of a Nonpareil almond kernel of size 28.
- A sufficient number of runs must be conducted to thoroughly evaluate heat distribution of the entire roasting line.
- The coldest temperature and shortest time profile collected from all spots and runs will be used for lethality determinations. However, the ranges and variations of temperatures and times from all runs will be reported.
- All temperature profiles will be submitted on CD or electronic format with the report.

Microbial Challenge Testing Using SE PT 30:

- For dry roasting processes utilizing temperatures above 300°F, ABC does not have recommendations at this time. As new research results become available, updated recommendations will be issued.
- If a handler or manufacturer chooses to conduct microbial challenge testing using a pathogen, it is suggested that SE PT 30 (ATCC, BAA-1045) be used. If any other pathogenic microorganisms are used in a validation study, a study must be conducted to show the heat resistance of the microorganism(s) used in comparison with SE PT 30. A report providing information on the heat resistance of the test microorganisms must be included with the validation report that is submitted to ABC for review and evaluation.
- Heat resistance confirmation tests must be conducted for the SE PT 30 inoculated almonds before they can be used for validation testing of dry roasting processes. The microbiological procedures described by Dr. Harris (UC Davis) (*ABC Supporting Document DOC001*) should be followed. The confirmation test must be carried out at a minimum of 4 heat exposures in duplicate at either 250, 265, 280, or 295°F in a Fisher Scientific hot air oven 851F. If the test generates a D value of at least 25 minutes at 250°F, 12.5 minutes at 265°F, 5.75 minutes at 280°F, or 3.0 minutes at 295°F, the inoculated almonds can be used for validation runs of dry roasting processes.

Microbial Challenge Testing Using Other Microorganisms:

- A handler or manufacturer may use other microorganisms to conduct validation studies.
- There must be sufficient data to determine the basis for using the organism. For example, the dry heat resistance data on the organism must be comparable to the dry heat resistance of SE PT30 under comparable conditions. Studies comparing the heat resistances of the surrogate and SE PT 30 must be conducted at appropriate temperatures, with the appropriate almonds with moisture information and heating information, and include heat distribution, heating data using an aluminum almond or other appropriate temperature monitoring procedures, as well as appropriate microbiological techniques for preparation of inocula, procedures for inoculation of almonds, handling of inoculated almonds, dry roast treatment of inoculated almonds, recovery and enumeration procedures from treated almonds, etc.
- Heat resistance confirmation studies must be conducted for the inoculated almonds. The microorganism on the inoculated almonds must demonstrate a resistance equivalent to what was observed for SE PT 30 in TDT studies before the inoculated almonds can be used for validation testing in dry roasting operations.
- A handler or manufacturer should submit their data on the heat resistances of surrogate microorganisms to ABC for review and evaluation before they proceed to validate processes using these microorganism(s).

Validation Report:

For each process or product that has been validated, the process authority must submit a written report to ABC for review and evaluation. The validation report, at a minimum, should include detailed information on the following:

- Handler or manufacturer information:
  - Contact information
  - Background information
  - General information about almond usage and handling
- Production line(s) validated:
  - General description of the production line: continuous conveyor or rotary, single or multiple zones, hot air entrance or circulation diagram
  - Temperature control(s) and monitoring device(s)
  - Procedure(s) or device(s) used for identifying process deviations
- Product(s) validated:
  - Products covered by the parameter set that has been validated
- Validation methodology
  - Thermal validation method
    - TDT data used
    - If not ABC TDT data, a detailed research report should be included demonstrating the validity of the TDT data used
    - Temperature data acquisition procedure; replication of data collections; raw temperature profiles
    - Cold spot or zone identification
  - Microbial challenge method
    - Detailed procedure covering all aspects
    - A detailed discussion and supporting data are needed to substantiate the microbiological procedures used in the validation studies

- If microorganisms other than *Pantoea* or SE PT 30 are used in the validation study, a detailed report must be submitted on resistance comparisons of SE PT 30 and the microorganisms used in the study.

- Results summary
- Handling procedures for products produced during process deviations
- Date(s) validation conducted
- Product(s) containing almonds not validated or not achieving a 4-log reduction
- Conclusions and recommendations
- Process authority: contact information; ABC approval # and date