Almond Board of California

Rotary Roaster Validation Guidelines for Industry

Introduction:

The heating of almonds in rotary roasters is complex. While there is some convection heating, there is conduction heating via the metal drum and in some cases radiant heat from burners located within the drum. The actual mechanisms of microbial destruction for such processes are not well understood and difficult to define. In order to assist the Industry in validation of rotary roasters, the Almond Board of California sponsored a research project to better understand the impact of roaster conditions on Microbial destruction. The goal was to develop a better understanding of how rotary roaster parameters such as burner temperature, roast time, incoming nut temperature, exhaust flume setting, air flow, etc. might influence the ability to obtain a consistent log reduction. In addition, the ABC wished to establish a validation guideline in order to give the industry better insight into what is required for approval of rotary roasters by the ABC Technical Expert Review Panel.

Background:

Validation of any technology used to treat almonds requires a minimum 4-log destruction of Salmonella bacteria. In most processes, there are definitive parameters that can be monitored to ensure that the process is consistent each time, and delivers an appropriate log-reduction. In the case of a continuous dry roaster, the parameters that are monitored are typically product throughput (residence time), roaster temperature, and possibly airflow. Such a process is well defined, with a know residence time of the product at a specified temperature within the roaster. In the case of a rotary roaster, the parameters are not typically as well defined. For instance, many rotary roasters do not have a specified time component assigned to the roast cycle. The roast cycle time in some cases in solely dependent on an end-point product temperature as measured by a probe located within the bed of rotating nuts. While the “product temperature” usually is measured by a thermocouple in the bed of almonds near the rotating drum, this is not a true measurement of product temperature—the temperature measured could be lower or higher than the true almond surface temperature and is affected by the temperature of the drum and the air within the bed of almonds. To complicate matters, the time it takes a batch of nuts to reach the desired end-point temperature may vary from one roast to the next – often times with differences in total roast time of many minutes. This can be attributed to a number of factors such as roaster initial temperature, air flow (damper setting) within the roaster, flame setting, or incoming nut temperature. As such, it can be difficult to ensure reproducibility and subsequently consistent log destruction of microorganisms. Therefore, in order to ensure that variations in roasting conditions still result in an appropriate log kill, it is required that multiple roast conditions be tested, and/or addition of control modifications such as measurement of burner output temperatures and roast times be incorporated into the roaster program.

Accepted Test Microorganism:

Enterococcus faecium NRRL B-2354 (Pediococcus) is a surrogate for SE PT 30 for dry heat conditions and can be used for validation of rotary roasters.

Suggested Validation Approach:

The unique nature of Rotary Roasters requires that validation be achieved through microbial challenge testing using *Enterococcus faecium* NRRL B-2354 or other approved surrogate.

A. Objectives of Validation Testing

1. Identify specific controllable operating conditions (operating parameters) in addition to end point temperature which will ensure that a minimum 4-log reduction of SE PT 30 is obtained for each cycle.
2. Collect enough information and data to demonstrate ability of roaster to deliver a consistent log reduction under identified operating parameters above, given variable factors as described below.

B. Validation testing should be designed to address at a minimum the items listed below. For the parameters with adjustable settings, sufficient number of trials at a minimum of three variations will be conducted to identify critical limits for each parameter.

1. <u>End Point Temperature:</u> Typically end point temperature is the defining factor of the process for a rotary roaster. Test data should show the impact of different end point temperatures on log-reduction of the test microorganism, and time to reach that temperature. In addition, end point temperature should be correlated with roast time, burner temperatures, damper setting, nut temperature, roaster temperature, and other variables to better understand the inter-relationships and impact on microbial destruction.
2. <u>Burner (Heater Setting):</u> Many rotary roasters have an adjustable heater set point. Altering the set point affects the time it takes to reach an end point temperature, and can affect log kill during the roast cycle. For each rotary roaster studies must be conducted to determine the impact of heater setting on actual heater output (roaster) temperature, and time to reach end point temperature. Such studies must take into consideration “worst case” scenarios. For instance in the case of a gas fired roaster, validation testing should take into consideration the possibility of a reduced gas flow, or lower intensity burner output.
3. <u>Burner Temperature:</u> It would be ideal from a control standpoint to know the precise burner temperature during a roast cycle. However, due to the nature of the rotary

roaster process, burner temperature continues to rise during the roast until the temperature of the nuts reach the desired end point temperature. When the end point is reached, the burner temperature is typically several hundred degrees Fahrenheit or more. In addition, from studies conducted it is apparent that the burner temperature at the end of a roast may be quite different from one cycle to the next. As such, it is difficult to use burner temperature as a precise control point to ensure that a minimum log reduction is achieved. However, burner temperature can be useful in providing assurance that the roaster is working properly. In addition, correlations can be made and possibly minimum burner temperature points established to better define and control a process for a specific log reduction. Studies should be conducted to better understand the impact of burner temperature on log reduction.

4. Pre-Process Roaster Temperature (cold or warm start): As previously mentioned, the time to reach a desired end point temperature may vary from one roast to the next. One of the factors that can contribute to this is the temperature of the roaster itself prior to starting the cycle. For instance, a cold roaster will typically take longer to reach the desired end point temperature verses a roaster in which a cycle has recently been completed. Test should be conducted to determine the impact of roaster temperature prior to starting a cycle on log reduction of test microorganisms. Conversely to beginning a cycle on a "cold roaster," starting on a pre-warmed roaster could result in a shorter total roast time. As such, validation tests should also be conducted on cold, pre-warm and warm start to determine if roaster starting points affect the ability to reach a minimum 4-log reduction.
5. Initial Almond Temperature: Temperature of the almonds will have a direct impact on the time it takes to reach a desired end point temperature. Colder almonds will take longer to reach an end point temperature than almonds that are warmer. Validation studies should be conducted to determine the highest initial almond temperature by that a minimum 4-log reduction will be achieved at the same end point temperature.
6. Damper Exhaust Setting: The exhaust (damper) setting will directly affect the amount of heat generated and retained in the roaster drum during the cycle. When the damper is more open, there will be greater air flow and exhausting of gases during the roast cycle. This will result in a reduced temperature within the roaster. Validation testing should be conducted under various damper conditions to determine the impact on the ability to deliver a 4-log reduction.
7. Nut Moisture: The moisture of the nuts tested could have a direct impact on the log reduction delivered by the roast cycle. When nuts contain less moisture, there may be a negative impact on log reduction. As such, testing should take into consideration the incoming nut moisture content. Validation studies should be conducted on nuts of different moisture content to determine the lowest nut moisture content for critical parameter control.

8. <u>Product Loading:</u> The amount of product roasted during each cycle will affect the time it takes to reach the desired end point temperature. Batches containing fewer pounds will typically require less time than those containing a greater number of pounds. Testing should be conducted to address this and ensure that the appropriate log reduction is obtained for each desired batch size.
9. <u>Roast Time:</u> As previously mentioned the cycle for a rotary roaster is typically defined by the end point temperature set point. From a consistency, control and validation standpoint this is problematic. Dry heat microbial destruction typically requires exposure to temperature for a specific period of time. Roast cycle time should be closely measured for each variable tested. Careful review of the data should be made to determine an appropriate minimum roast cycle time to ensure a minimum 4-log reduction is reached. This factor should be monitored and controlled for each roast cycle. Because the time for each roast may vary, it might be necessary to stop a roast cycle prematurely at a defined time during validation testing in order to demonstrate a "worst case" scenario.

C. Microbiological Testing

1. Almonds utilized in validation testing should be inoculated and calibrated per the Almond Board of California protocol detailed in the document, *"Guidelines for Process Validation Using Enterococcus faecium NRRL B-2354"*
    i. Moisture content of the inoculated almonds and carrier almonds should be checked immediately prior to testing
    ii. Moisture of the batch to be roasted should also be checked pre and post roasting
        1. It is important to design the tests to ensure that batches of low and high moisture almonds are validated – **The purpose is to determine if moisture of the batch plays a role in the ability to achieve a minimum 4-log reduction and thus becomes a critical factor**
2. Special cages or packages should be used to contain inoculated almonds for testing in the roaster
    i. The Almond Board of California has custom designed and had fabricated a number of stainless steel cages as shown in figure 1 below
        1. Each cage which will hold up to 50 grams of inoculated almonds
        2. The cages are available for use

Figure 1. ABC Inoculated Almond Test Cage

   ii. Almond loading in cages should mimic free product movement in the roaster as closely as possible.
      1. Too few almonds in a cage will create artificial air spaces and may not be representative of true conditions and almonds packed too tightly in will inhibit rotation of the almonds and may negatively impact log-reduction.
         a. ABC has conducted testing with the cage loaded at 25-50 grams
            i. Testing should be conducted with an appropriate mass of almonds to mimic roaster conditions

3. Inoculated Sample Handling/Enumeration
   i. Test cages should be recovered at the completion of the roast cycle and almonds removed and placed into a sterile Whirl Pak bag or similar container.
      1. Inoculated almond samples should be immediately chilled in an ice water bath and stored at 38-40°F prior to enumeration
      2. Samples should be transported to a lab for enumeration within 24 hours after roasting
   ii. A minimum of triplicate samples will be taken from the unused inoculated samples at the testing site to serve as positive travel controls. The enumeration results of these travel control samples will be used for log reduction calculation.
   iii. Samples should be enumerated per the ABC protocol detailed in the document, "*Guidelines for Process Validation Using Enterococcus faecium NRRL B-2354*"

D. Reporting

1. A detailed description of the roaster should be provided including operating principles
    i. A description of the control system utilized and operating logs must be provided
    ii. A description of the heating unit must be provided
        1. Adequate details and test results should be provided to provide assurance that deviations in heater output are detectable, or that they do not affect the ability to achieve a minimum 4-log reduction
2. A list of critical parameters crucial in ensuring that a minimum 4-log process is achieved should be provided
    i. Critical factors may include, but are not limited to the following:
        1. Roaster end point temperature
        2. Roast cycle time
        3. Heater temperature
        4. Damper setting
        5. Batch weight
        6. Product moisture
        7. Incoming nut temperature
        8. Initial roaster temperature
    ii. Discussion should be provided, supporting that the identified critical factors are sufficient in ensuring reproducibility and consistency in delivering a minimum 4-log process.
3. A detailed table showing all test variables and micro challenge test dates and results should be presented in a report
4. A detailed description of the cooling system and process for prevention of post process contamination (Recontamination) must be provided – Specific areas which must be addressed are as follows:
    i. Segregation of raw and processed product with a description on how raw product being fed into the roaster is isolated from processed product
    ii. Air filtration system on cooling system to minimize introduction of contaminants
    iii. Conveying systems – cleaning, sanitation and prevention of recontamination
    iv. Finished product packaging
        1. The Process Authority must make a determination on whether adequate controls and Good Manufacturing Practices are in place to prevent post process contamination of the product
5. A description and example of process records and charts documenting that the critical parameters have been met must be provided
6. A one page summary sheet describing the Critical Parameters and deviation instructions must be provided (Please contact ABC for Summary Sheet template)