Postharvest Heat Treatment Update

Dan Guyer
Biosystems and Ag. Engineering
Michigan State University


Submersible conveyor
Natural convection dryer section
Hot water bath
Cooling water bath
Pump for inducing current

Agenda

- Where we were (Summer 2018)
- Where we are (over past 8 months)
- Where we are going next....
- Open discussion / knowledge sharing

Where we were (Summer 2018)

- Brown rot (*Gnomoniopsis castaneae)* found and emerging within Michigan
- Treat fresh chestnuts @ 120 degF for 20 minutes
- Michigan should progressively incorporate this treatment into their industry

Where we are (last 10 months)

- Design treatment process for Michigan chestnut handling situation (CGI).

- Integrate the challenge/opportunity into Biosystems Engineering Senior-level design class (academic year-long course/project). Ideal project for this discipline.

Objectives

- Design a heat treatment system for brown kernel rot that configures to CGI’s current receiving line that heats the center of chestnuts to 120°F for 20 minutes
- Verify that 120°F reduces incidence of brown kernel rot in chestnuts
- Ensure quality of the chestnut is maintained during treatment
- Ensure that different sized nuts are all heated to 120°F and that no nuts are overheated

Key Constraints

- Budget of $XX
- Continuous flow at minimum 4,000 lbs/hr (adjustable for increased flow or retention)
- Fit within existing line
- Not require additional labor to operate
- Comply with State and Federal Produce Regulation
    - USDA Sec. 112, Subsec E, K, and L
    - MIDARD Good Agricultural/Good Handling Practices

General project perspective– brief background

- Infection process of brown kernel rot is not completely understood
- Our focus is on a post-harvest treatment; “quick-fix / mitigate”
- Heat treatment is used by Mastrogregori in Italy and Route 9 Cooperative in Virginia
- Wells, 1980, Klinac, 1999, and Ruocco, 2016 recommend 50 °C (120 °F) for 20-45 minutes[11, 12, 13]
- ***However, literature is not available on the complete efficacy of heat treatment for fungi
- Validation studies to ensure this is an acceptable solution should be conducted

Validation Studies

- 650 colossal nuts (from site having chestnut brown rot) were divided into groups:
    - Control
    - 120°F treatment
    - 150°F treatment
- Only non-floaters were used
- Stored in 38 degF cooler Oct-Jan
- 50 nuts from each group opened at one month intervals

Validation Study Results

Table 1. Results of validation study

Group of Nuts	Number with Brown Kernel Rot	Comments
October		
Control	2	Very small signs of rot; not progressed
November		
Control	4	Very small signs of rot; not progressed
120°F Treatment	3	Very small signs of rot; not progressed
150°F Treatment	N/A	Nuts were killed by the heat
December		
Control	4	2 additional nuts had IKB
120°F Treatment	3	1 nut has IKB as well
150°F Treatment	N/A	Nuts were killed by the heat
January		
Control	4	Rotten nuts ID'd by Dr. Medina-Mora
120°F Treatment	3	Rotten nuts ID'd by Dr. Medina-Mora
150°F Treatment	N/A	Nuts were killed by the heat
Room Temp for 1 month (Jan)		
Control	23	Rotten nuts ID'd by Dr. Medina-Mora
120°F Treatment	5	Rotten nuts ID'd by Dr. Medina-Mora
150°F Treatment	5	Nuts were killed by the heat but some rot still ID'd

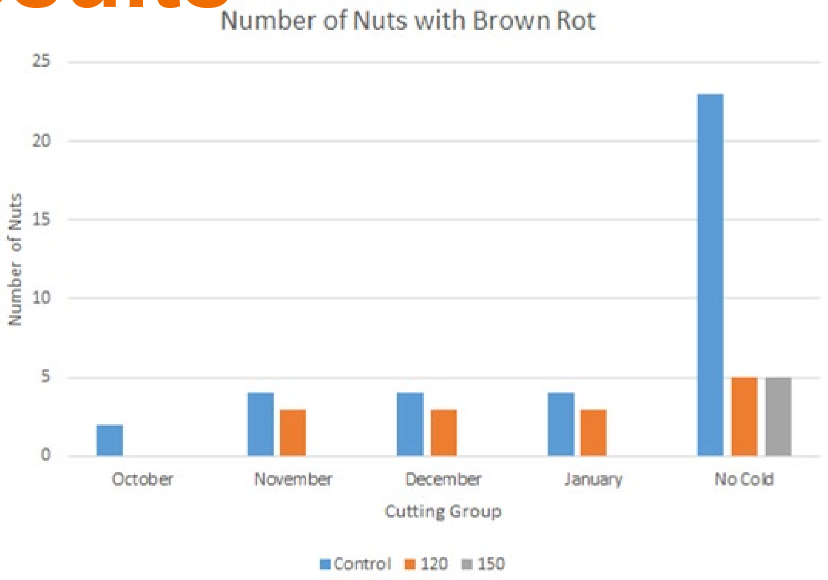


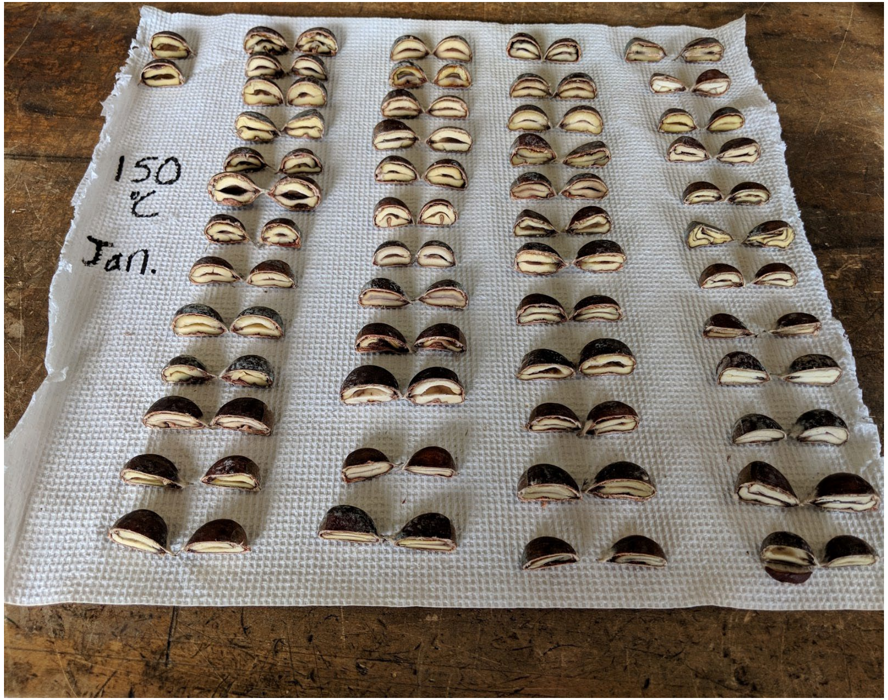
Figure 1. Number of nuts with brown rot; each cutting group consisted of 50 nuts; 'No Cold' indicates each group of nuts was left at room temperature (~68F) for approximately 18 days before cutting after being in cold storage for 3 months.

Validation Study Pictures

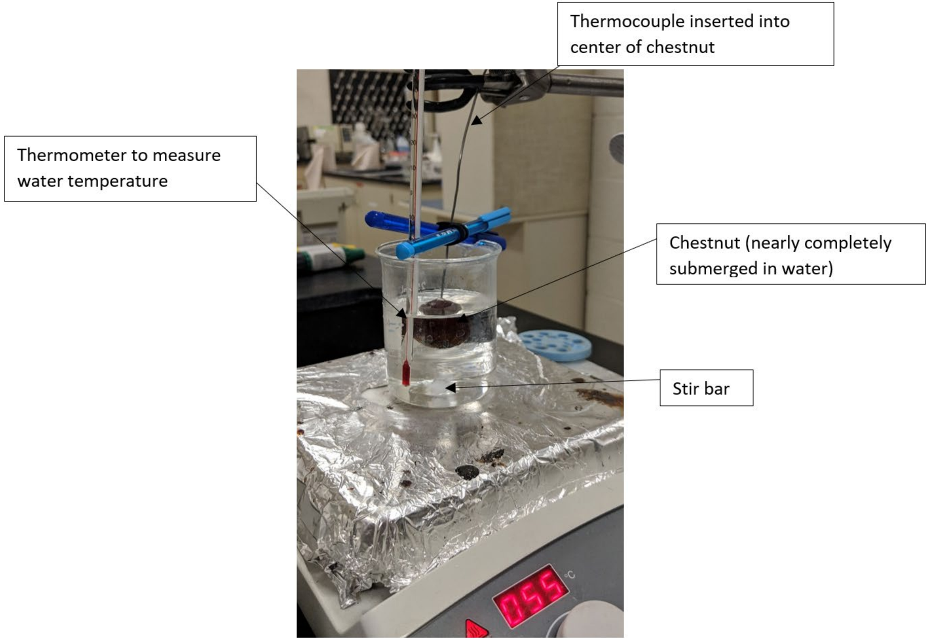
Room temp control

Room temp 120°F treatment

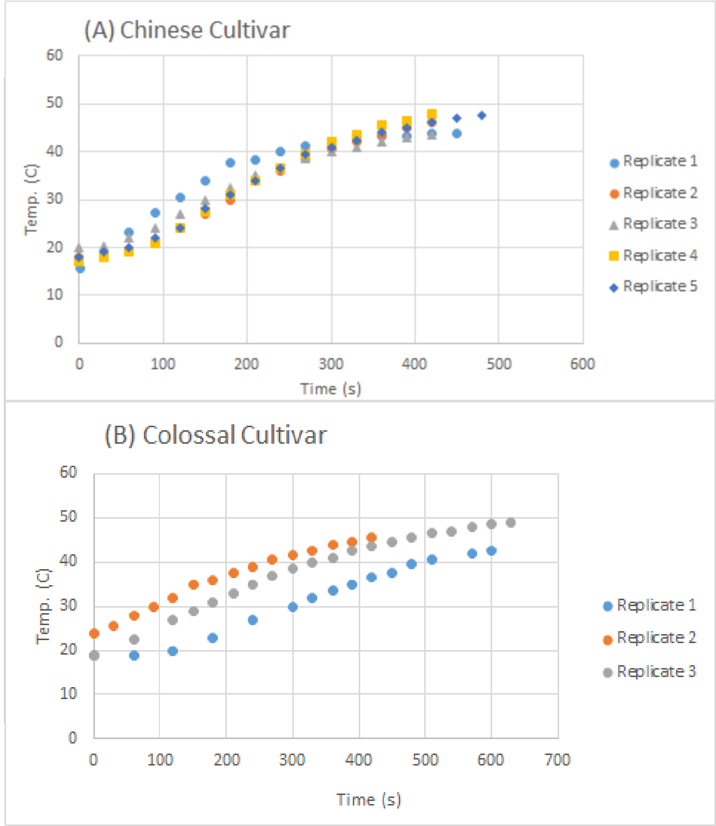
150 degF treatments after 1 mth



Heat Transfer through chestnut



Heat transfer validation study setup



Recommendation from Decision Matrix

Hot Water Bath: Blancher

- Initial design requested by CGI
- Highest scoring alternative in design matrix
- Maintains fresh nut quality
- Initial research shows these systems fit CGI's budget

Decision Matrix	Importance	Hot water bath	Hot water bath (trommel)	IR Heating	Conveyor steam blancher	Convection oven
Maintenance	5	7	6	7	2	4
Worker Safety	10	8	6	8	2	6
Ease of Integration	10	8	7	4	3	5
Environmental Impact	10	5	5	8	4	7
Eveness of Heating	20	7	8	5	6	7
Captial Cost	20	5	4	7	3	7
Impact on Nut Quality	25	8	7	7	5	1
Total	100	148	143	146	125	137
Weights are applied 1-10 with 10 being the highest score and 1 being the lowest						

Design Alternatives: Fruit and vegetable blancher

- Fruit and vegetable blanchers are commonly used.
- Different types exists that use hot water or steam and are rotary or straight conveyors
- Blanching is done at a higher temperature than we want, but operating temperature can be adjusted

A.K. Robins model AK60-9; 9 feet long, 5 foot diameter. Sold by Alard Equipment for $32,500 in used-rebuilt condition.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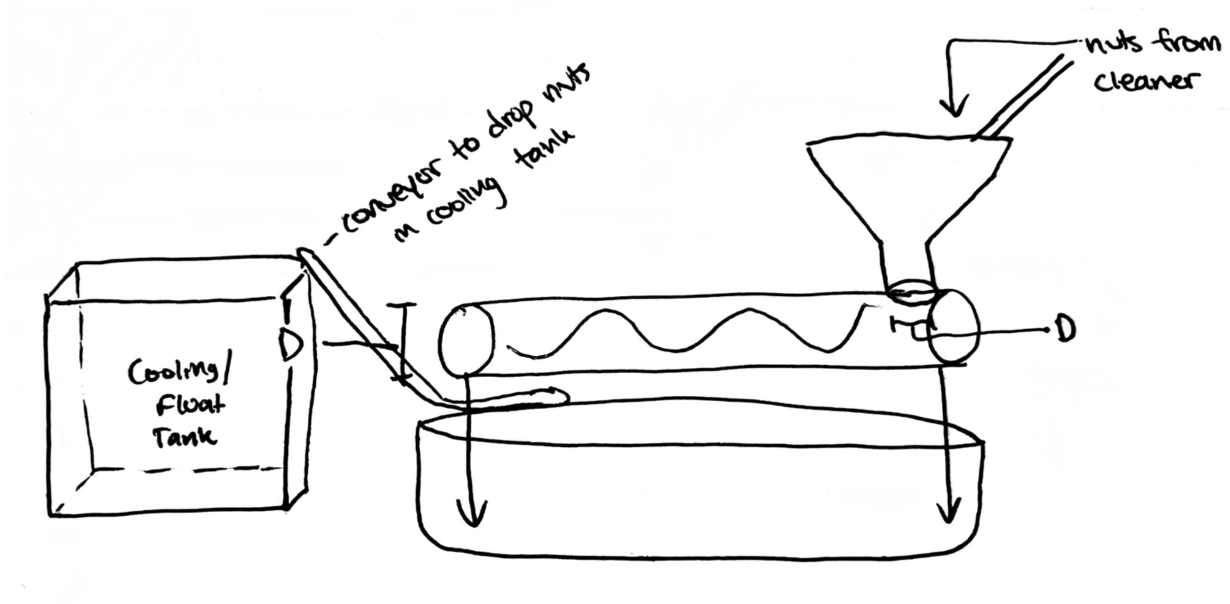
7831
CFM Worldwide
Pre-owned Food Equipment


CFM Worldwide
Pre-owned Food Equipment

Continuous conveyor

Design Alternatives: Build a blancher



What have we learned?!

- Good temperature management of chestnuts will in itself suppress pathogen growth
- Brown rot accelerates with periods of warming
- Chestnuts are quite sensitive to overheating and doing so “kills” the chestnut and it’s natural defense mechanism against internal and external organisms….thus any process must have quite positive control of treatment duration for every chestnut.
- ….we also learned we have a lot more to learn!

Where we are going next…..

- Completion of student project (finalizing design, water heating component, cooling component, economic analysis, final report…)
- Partnering in submission of GREEEN and MDARD proposals
- Further investigation of treatment “modes” (other than hot water)
- Further verification and sensitivity analysis of heat protocol (time, temp, warming periods) with both:
  - Naturally occurring brown rot from field samples
  - Controlled inoculated samples
- Include weevil into study in parallel
- Specification/design options for Michigan for treatment.

Thank you….

- CGI
- Carmen Medina-Mora and Monique Sakalidis
- MCPC
- Professor Dennis Fulbright
- The “Rot Roasters” Senior Design Team!!!

The Rot Roasters: "Doin' the most for your chest

Rebecca Jones, Project Manager

Brigit Culkeen, Communications Manager

Matt Kay, Data/Research Manager

Brandon Dulaney, Editor

The Rot Roasters with members of the CGI team at the facility in Clarksville, MI

The Rot Roasters

Doin’ the Most for your Chestnut Roast

Design Optimization

- A volumetric flow rate of 2 ft^3/min was calculated based on CGI's desired throughput of 5000 lb/hr and the bulk density of chestnuts (41 lb/ft^3)
- Flow rate is related to flow speed by: Q=A*v, where Q is the volumetric flow rate, A is the cross-sectional area of the cylinder, and v is velocity of chestnuts
- Heat transfer calculations will be performed using the relationship: $Q=mc_p\Delta T$, where Q is heat required, m is mass of chestnuts, c_p is the specific heat of chestnuts, and ΔT is the change in temperature
- Optimization of the cylinder dimensions, velocity, and flow rate will be considered.

Economic Analysis

- Project budget from CGI is $75,000
- Look into different existing blanching systems (cost between $10,000 and $165,000 based on size and function)
- Also performing an economic analysis on the cost of parts to build a system from scratch
- An assumption will be made about the current losses of marketable product due to brown rot. This will be used to calculate payback period/benefits of the designed system and help CGI decide whether to invest

Summary and Conclusions

- We are designing a heat treatment system for CGI to treat brown kernel rot during post-harvest processing
- The system must fit within CGI's receiving line and budget and adhere to food safety standards
- Our validation study showed that the 120°F hot water treatment reduced the incidence of brown kernel rot in chestnuts
- The validation study also highlighted the importance of cold storage
- The recommended solution is a hot water bath; commercial systems as well as assembling a unique system are being considered

Next Steps

- Optimize system size and flow rate
- Integrate of system into current line
- Perform heat transfer analysis of the designed system
- Calculate payback period
- Compile recommendations for better handling/storage of nuts

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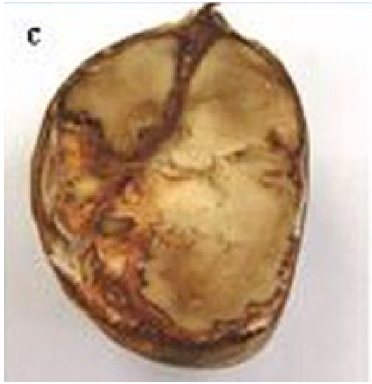
Michigan State University

Problem Statement

Design a heat treatment system that will help Chestnut Growers Incorporated manage post-harvest brown kernel rot, and configure to their current treatment line and throughput needs.

Project Background

- Client: Chestnut Growers Inc.
  - Handles about 200,000 pounds of chestnuts per season currently.
  - Increase capacity to handle 500,000 pounds a year and 5,000 pounds per hour
- Brown Rot - *Gnomoniopsis castaneae*[5]
  - Emerging chestnut rot pathogen[5]
  - Causes post-harvest degradation of produce[5]
  - Develops during storage[5]



Effects of rot on chestnuts[6]