

Student Instructions for Simulation Module
(Intended for use by Undergraduate or Graduate Food Science students)

Module Title:

Thermal Processing: How Microbial, Food, and Process Factors Influence Microbiological Safety

Module Goal:

Learn the impact of processing conditions on food safety by demonstrating changes in populations of potential pathogens as food is processed.

Module Learning Outcomes:

1. Understand how food composition, can shape, and heating/cooling time affects safety
2. Determine the process required to accomplish commercial sterility ($F_0 = 35$ min) of a pathogen of concern in a given food
3. Assess how two processes can be equivalent in terms of the same level of inactivation

Module Specific Goal

To validate a thermal process by checking whether the concentration of *C. botulinum* meets the safety standards after a sterilization process

Module Background and Problem Details

Clostridium botulinum is of particular concern in canned products. It is a spore former and is one of the most heat resistant bacteria.

In 2007, fourteen people in seven states contracted botulism poisoning from Castleberry's chili products. An FDA investigation later revealed that the problem arose from the use of canners which "had broken alarms, a leaky valve and an inaccurate temperature device." Using the simulation program we can quickly see the time required for a safe process, how the size of the container affects the process, and the heating time should be compensated if the temperature of the canner is lower than intended.



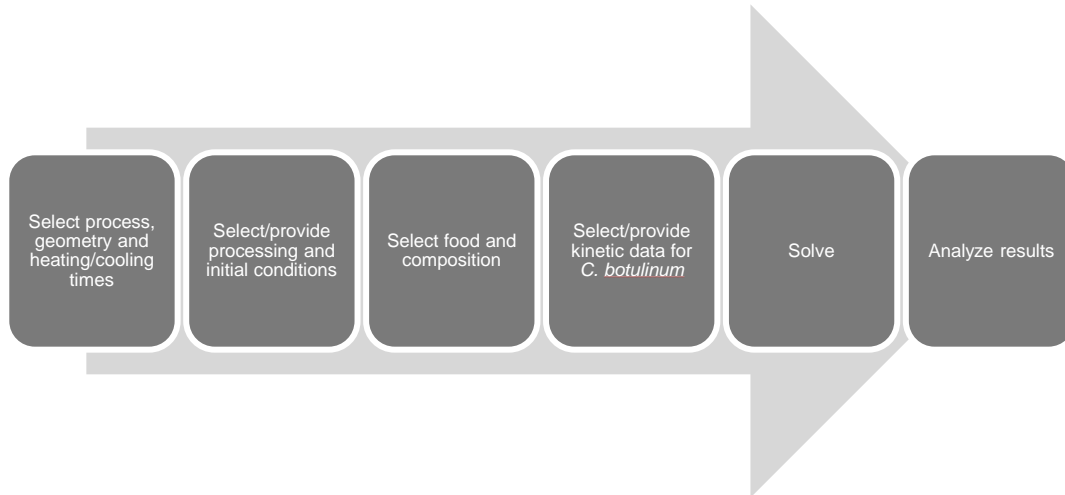
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A can has the following dimensions: diameter 8 cm and height 8 cm. It is being heated equally from all sides by steam or hot water at 130°C (266°F). The initial can temperature is 60°C (140°F) and the cooling water temperature is 20°C (68°F).

What You Need to Find

1. What is the minimum duration of heating/cooling needed to achieve the desired F_0 of 35 min for **Campbell's mushroom gravy** (under food group: **soups and sauces**) and **CAMPBELL'S CHUNKY SOUPS, BARBEQUE SEASONED BURGER SOUP** (under food group: **soups and sauces**) for steam versus water heating. The process also requires the maximum can temperature is below 38°C (100°F) after cooling. Therefore, you should have four solutions. This will require trial and error, assume in range of 80-110 minutes for heating and 40-80 minutes for cooling?
2. For steam heating of **Campbell's mushroom gravy**, if the height is decreased in half but the volume is constant, what is the new heating/cooling time requirements?
3. For steam heating of **Campbell's mushroom gravy**, if the retort temperature decreased by 2°C, what is the new heating/cooling time requirements (use part 1 can dimensions)?

Module Step by Step Procedure

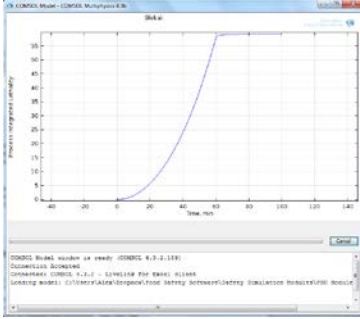


Model Set-up

Connecting to COMSOL

1. Double Click on "Can_retorting.xls"
2. Click cell A1 and click "open" on the COMSOL Ribbon
3. Select the file "Can_retort.mph" and click open
4. The following COMSOL GUI should pop-up (there might be a different image in the window), do not close this until you are completely finished:

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Selecting Process Parameters

Parameter	Expressions	Description
Prod_R		Product Radius, m
Prod_H		Product Height, m
Time_interval_rec		When times recorded, min
Total_heating_time		Total heating time, min
Total_cooling_time		Total cooling time, min
Elem		Element Quality, 1-course 5-finest

Name	Expressions	Description
Process	Steam	Conv. heat transfer coef, W m ⁻² K ⁻¹
T0		Initial temperature, C
T_retort		Retort temperature, C
T_cool		Cooling water temperature, C

Name	Expressions	Description
wt_Water		wt fraction of water
wt_Prot		wt fraction of protein
wt_Fat		wt fraction of fat
wt_Ash		wt fraction of ash
wt_Carb		wt fraction of carbohydrate
wt_Fiber		wt fraction of fiber

Name	Expressions	Description
D01		D0-value at Tref, minutes
D1		D-value, minutes
z1		z-value, C
Tref1		Tref, C

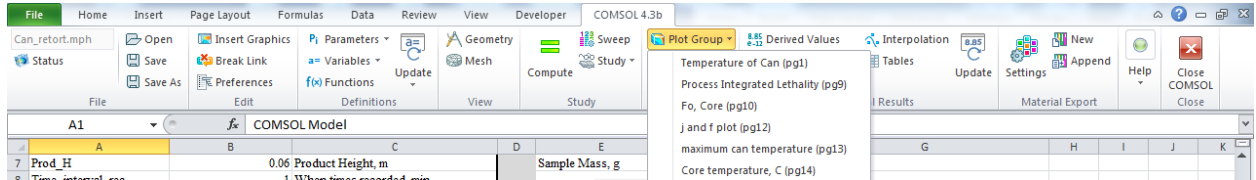
Parameter	Value
Can, ml	402.12
Sample Density, kg/m	1060.65
Sample Mass, g	426.51

5. In the Excel spreadsheet,
 - a. Enter can radius, height, time interval recorded, heating time, cooling time, and element quality (use 1 or 2).
 - b. Enter the type of process heating ('Steam' or 'Water', no quotes), initial temperature, temperature of retort and cooling water temperature
 - c. Select food group and food to be sterilized from dropdowns. Then click "Get Composition"
 - d. Select *C. botulinum* and "yes" for inactivation. Then click "Update Inactivation Kinetics"
 - e. On the COMSOL ribbon, Click the arrow under "Update" and click "update all"
 - f. Click Compute

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- g. When updating anything, you must click “update all” again before clicking “compute” again**

Results



- 6. If you would like any of the following plots, click “insert graphics” on the Comsol ribbon and an image is inserted into the EXCEL document**
- To see process integrated lethality, click on “Process Integrated lethality”
 - To see cold spot process lethality, click on “F_o, core”
 - To see max temperature in can vs time, click “maximum can temperature”
 - To see core temperature vs time, click “Core temperature”
 - To see $\log(T - T_{\text{retort}})/(T_0' - T_{\text{retort}})$ vs time, click “j and f plot”
- 7. To calculate j and f_h values:**
- Click cell “A40”
 - Click “point evaluation” on COMSOL ribbon
 - Select “point 2” and enter expression “logT” (no quotes)
 - Click “determine j and f_h” button
 - Before repeating this, please click 'Delete Data Below' Button.

Module Questions and Activities (Please turn in all relevant plots, neatly organized)

- What is the heating/cooling times for steam heating of **Campbell’s mushroom gravy**? What are the f and j_h values?
- What is the heating/cooling times for water heating of **Campbell’s mushroom gravy**? What are the f and j_h values?
- What is the heating/cooling times for steam heating of **CAMPBELL'S CHUNKY SOUPS, BARBEQUE SEASONED BURGER SOUP**? What are the f and j_h values?
- What is the heating/cooling times for water heating of **CAMPBELL'S CHUNKY SOUPS, BARBEQUE SEASONED BURGER SOUP**? What are the f and j_h values?
- What is the heating/cooling times for steam heating of **Campbell’s mushroom gravy** with half the original height but same volume? What are the f and j_h values?
- What is the heating/cooling times for steam heating of **Campbell’s mushroom gravy** with the retort temperature 2°C lower (128°C)? What are the f and j_h values?