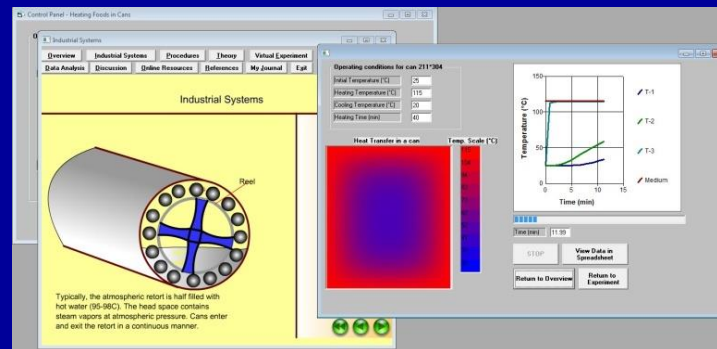


# Virtual Experiments in Food Processing for an Enhanced Education

Ferruh Erdođdu and R. Paul Singh



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# Significance

- Hands-on lab experiments are **the most effective tools** in teaching new concepts and testing novel hypothesis in engineering education.
- Students are typically organized around groups and follow the paradigm of spending **a long time** clustered around workbenches.

# Significance

- Due to the limited time
  - students receive an **uneven exposure time**,
  - it is **difficult to design** an experiment to examine the effects of various variables on the outcome, and
  - this leads to demonstrate only one set of processing condition for the given process.

# Significance

- With this traditional approach, we **might not achieve** a functional understanding of the effect of various input variables on the process performance.
- Personal observations indicate **that only a few active learners** actually perform the required tasks in a typical lab exercise.

# Significance

- This leaves many of the remaining students to only **observe or daydream**.
- In addition, many universities **cannot afford** to maintain up-to-date labs with the latest instrumentation.

# Objectives

- **to develop virtual labs for various food processing operations,**
- **to improve understanding of food processing principles, and**
- **to reduce the cost and time required for lab experiments.**

# Implementation

- Virtual labs were created using a computer **programming language** (*Microsoft Visual Basic*) to write the numerical simulation codes.
- The numerical codes were accompanied by
  - **Active-X programs** for extended graph abilities, visualization and spreadsheet abilities, and
  - **Animated picture technologies** to give the taste of an actual hands-on lab experiment.



# Implementation

- **The use of virtual labs involved the users to**
  - **interact by setting operation parameters,**
  - **observe changes and**
  - **record the data for further analysis.**
- **Use virtual labs in conjunction with lecture and lab experiments.**

# Comparison

- In a lab exercise, students run an actual process using a limited number of operating conditions and analyze the data
- In a **virtual lab** (in addition to a traditional lab):
  - Students generate their own set of additional data
  - Understand how industrial systems work
  - The output from the simulations is analyzed as if it were actual data (*like obtained from a hands-on lab experiment*)
  - Students can determine the effects of operating conditions on the results.

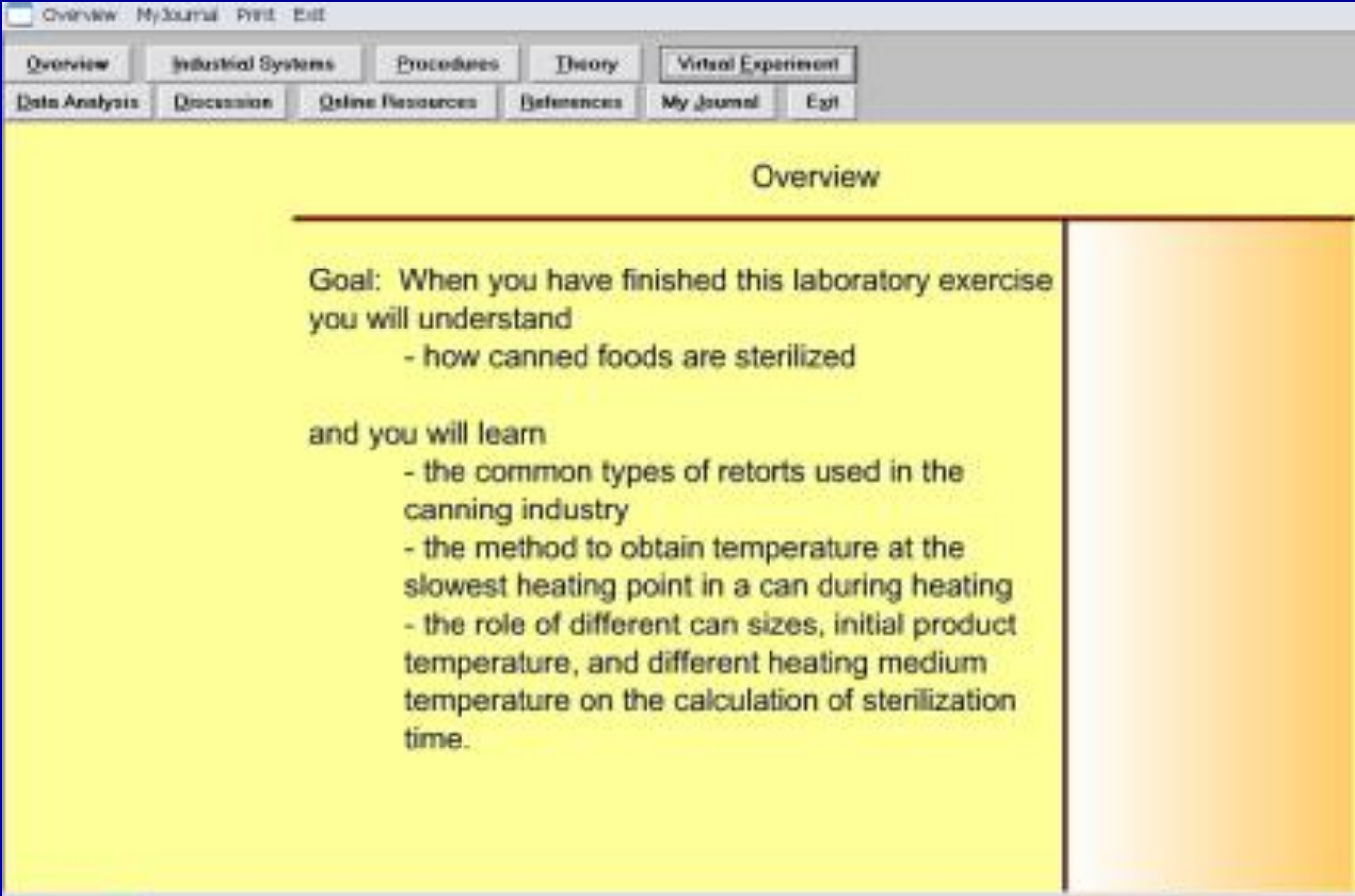
# Virtual experiments in food processing – 27 experiments

- Fluid flow
- Heat transfer fundamentals
- Mass transfer operations
- Food processing operations
- Food storage and transport

# Navigation bar used in each experiment



# Overview of a virtual lab exercise



The screenshot shows a web application interface for a virtual lab exercise. At the top, there is a menu bar with the following items: Overview, Industrial Systems, Procedures, Theory, Virtual Experiment, Data Analysis, Discussion, Online Resources, References, My Journal, and Exit. The main content area is titled "Overview" and contains the following text:

Goal: When you have finished this laboratory exercise you will understand

- how canned foods are sterilized

and you will learn

- the common types of retorts used in the canning industry
- the method to obtain temperature at the slowest heating point in a can during heating
- the role of different can sizes, initial product temperature, and different heating medium temperature on the calculation of sterilization time.

# Industrial applications relevant to each exercise


Overview MyJournal Print Exit

Overview Industrial Systems Procedures Theory Virtual Experiment  
Data Analysis Discussion Online Resources References My Journal Exit


## Industrial Systems

In the food canning industry, both batch and continuous retorts are used. Retorts operate under atmospheric or higher pressures depending upon the process requirements.

### Batch Retort



In a batch retort, carts loaded with canned food are pushed into the retort. The retort lid is closed and steam is turned on. After a desired heating period, the steam is turned off, cooling water is introduced to cool the cans. The retort lid is opened and carts are pulled out of the retort.



# Photographs and diagrams how an exercise is conducted in a lab


Overview MyJournal Print: Exit

Overview Industrial Systems Procedures Theory Virtual Experiment

Data Analysis Discussions Online Resources References My Journal Exit

## Procedures


1) To install a thermocouple in the center of a can, a hole is punched in the lid of the can, and special fittings are used to prevent leakage of food during the heating process. The fittings are shown below.



Lid with a hole drilled in its center

Thermocouple

Nut and bolt



# Theoretical considerations

Overview MyJournal Print Edit


Overview Industrial Systems Procedures Theory Virtual Experiment  
Data Analysis Discussion Online Resources References My Journal Exit

## Theory

The heating and cooling curves are described by the following equations:

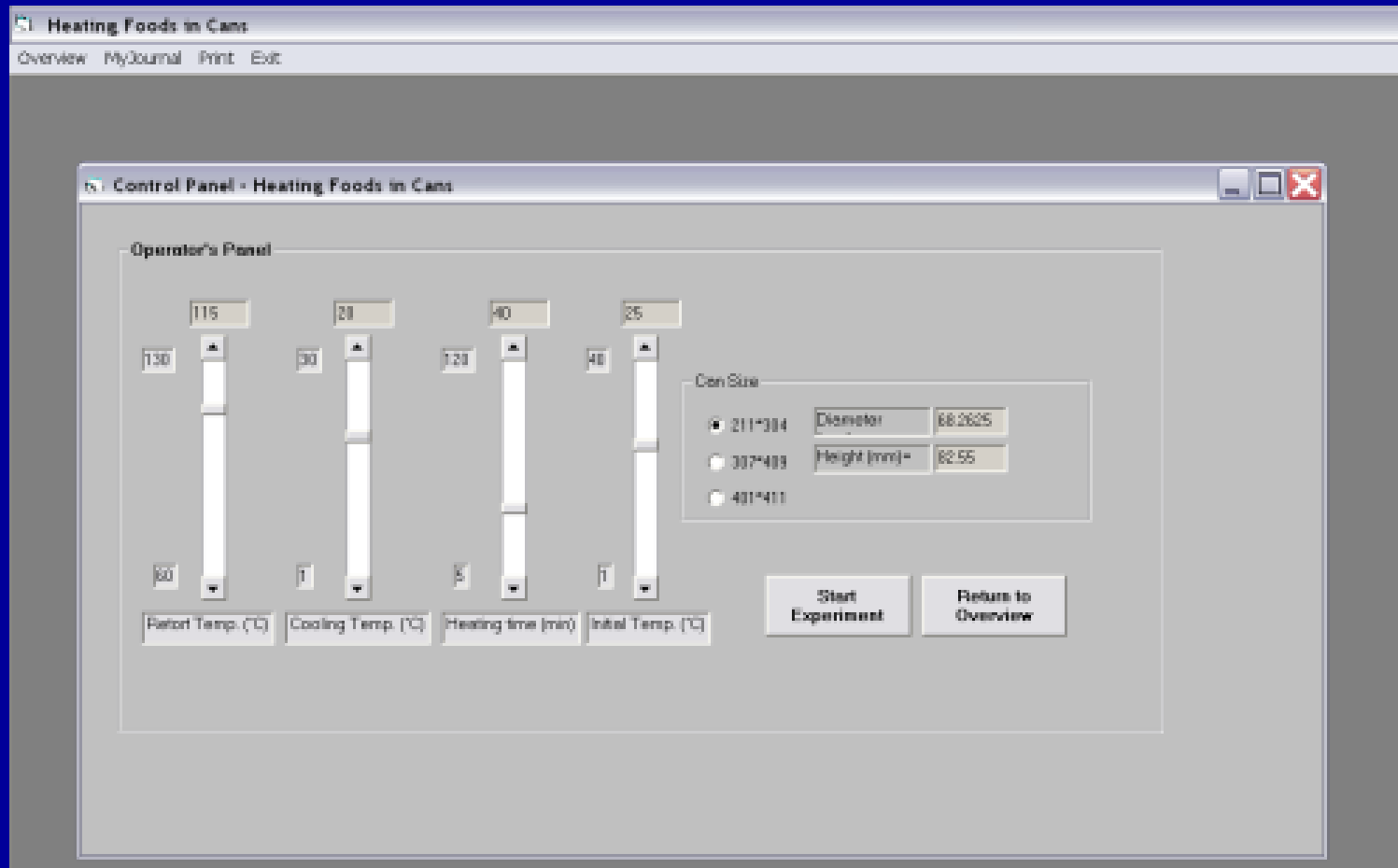
$$\log(T_m - T) = -\frac{1}{f_h} t + \log(T_m - T_{ph})$$
$$\log(T - T_w) = -\frac{1}{f_c} t + \log(T_{pk} - T_w) \text{ , respectively.}$$

where  $T_m$  is the heating medium temperature,  $T$  is temperature at any time,  $t$  is time,  $f_h$  is the heating rate parameter,  $T_{ph}$  is the pseudo initial temperature for heating curve,  $T_w$  is the cooling medium temperature,  $T_{pk}$  is the pseudo initial temperature for cooling curve,  $f_c$  is the cooling rate parameter.

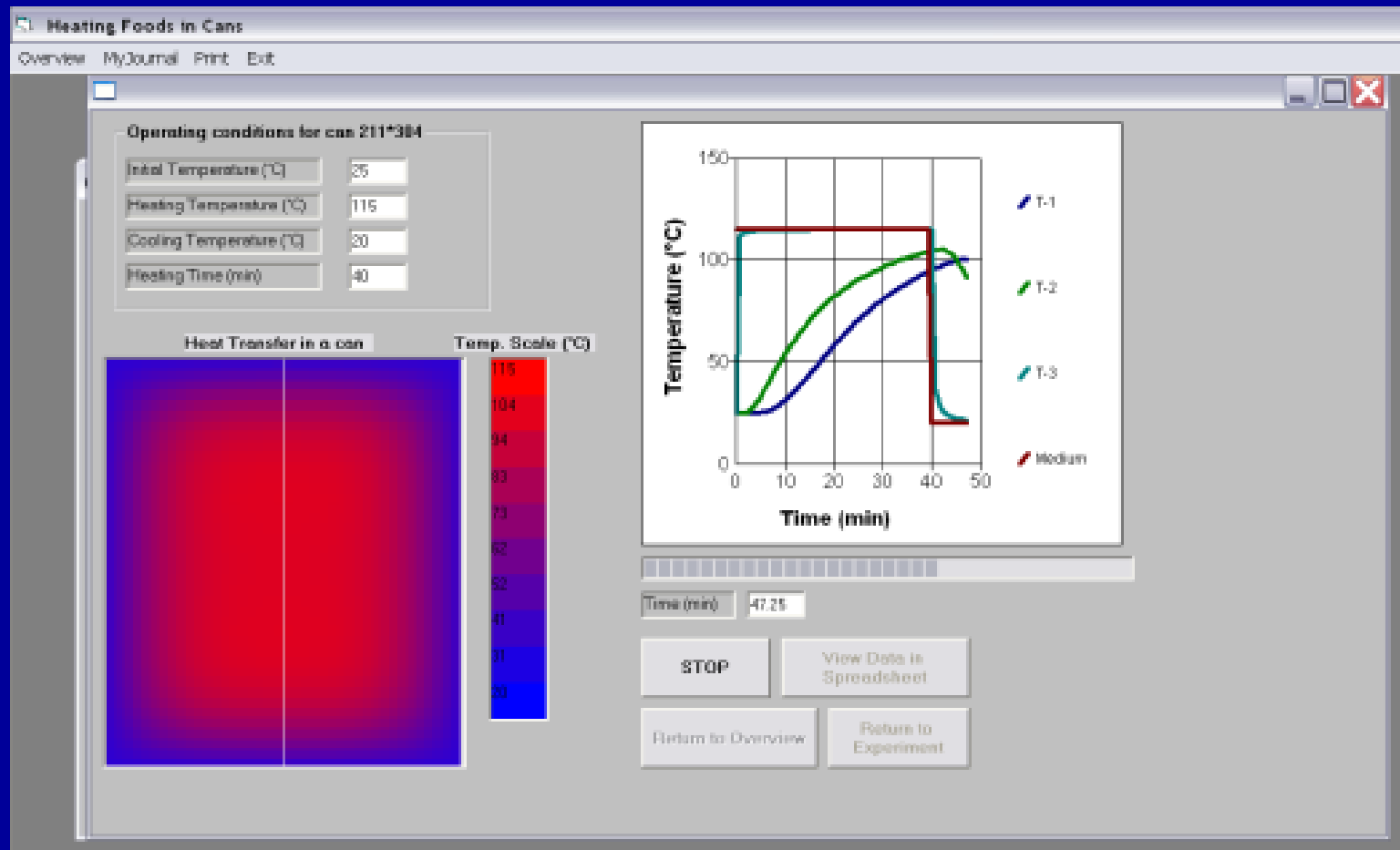




# Operator`s panel for users to select operating conditions



# The virtual experiment



# Description of how to analyze results

Hearing Foods in Cans - [Data Analysis]

Overview MyJournal Print Exit

Overview Industrial Systems Procedures Theory Virtual Experiment


Data Analysis Discussion Online Resources References My Journal Exit

## Analysis

To Calculate  $f_h$ :

- Prepare a new column on your spreadsheet for  $\log(T_m - T)$  where  $T_m$  is the retort temperature, and  $T$  is the variable temperature at a given location.

	A	B	C
1	211*304		
2	Retort Temperature (°C)	115	
3	Heating Time (min)	40	
4	Cooling Temperature (°C)	20	
5	Initial Temperature (°C)	25	
6		=log[115-25]	
7			
8	Time(s) T		log(T <sub>m</sub> -T)
9	0	25	1.95424
10	47.48	25	1.95424
11	95.494	25	1.95424



# Discussion questions

The screenshot shows a web application window titled "Heating Foods in Cans - [Discussion]". The window has a menu bar with "Overview", "My Journal", "Print", and "Exit". Below the menu bar is a navigation bar with buttons for "Overview", "Industrial Systems", "Procedures", "Theory", "Virtual Experiment", "Data Analysis", "Discussion", "Online Resources", "References", "My Journal", and "Exit". The "Discussion" button is highlighted. The main content area is yellow and contains the heading "Discussion" followed by three numbered questions. A vertical orange gradient bar is on the right side of the content area.

Heating Foods in Cans - [Discussion]

Overview My Journal Print Exit

Overview Industrial Systems Procedures Theory Virtual Experiment

Data Analysis Discussion Online Resources References My Journal Exit

## Discussion

1. In conduction heated foods, you determined the slowest heating point to be the geometric center of the can. Where do you expect this point to be located for a convection heating food such as canned tomato juice?
2. Discuss the effect of changing retort temperature on  $t_h$  at the geometric center of a can.
3. Does  $t_h$  vary by location in the can? Discuss.

# Links to industrial sites for more information

Heating Foods in Cans - [On-line Links]

Overview MyJournal Print Exit


Overview Industrial Systems Procedures Theory Virtual Experiment

Data Analysis Discussion Online Resources References My Journal Exit

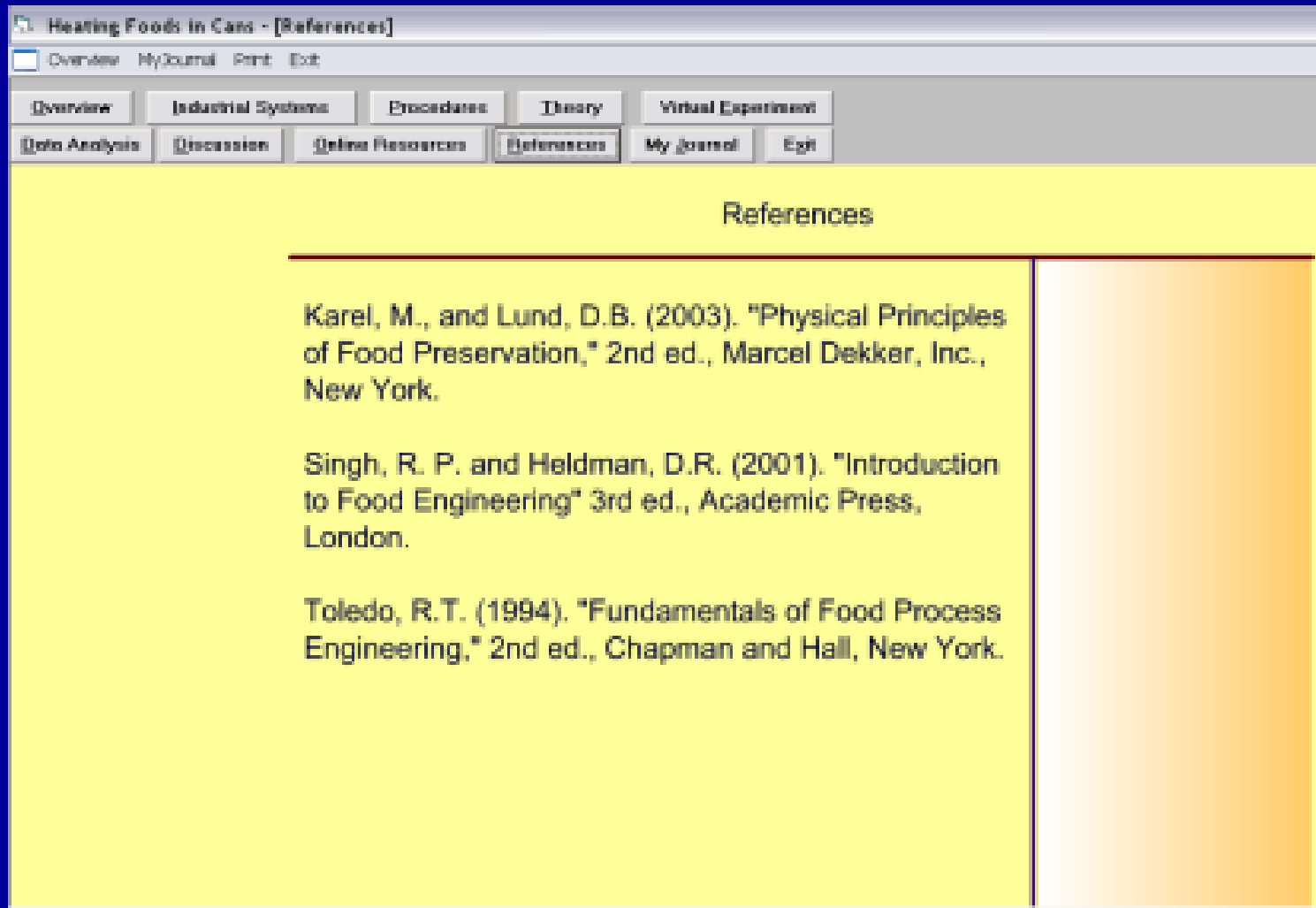
## Online Links

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- Alard Equipment Corporation
- Allpax
- ECKLUND
- FMC FoodTech
- Temco Incorporation
- Selas Corporation of America



# References to consult for writing a report



The screenshot shows a software window titled "Heating Foods in Cans - [References]". The window has a menu bar with "Overview", "MyJournal", "Print", and "Exit". Below the menu bar is a navigation pane with buttons for "Overview", "Industrial Systems", "Procedures", "Theory", "Virtual Experiment", "Data Analysis", "Discussion", "Online Resources", "References", "My Journal", and "Exit". The "References" button is highlighted. The main content area is titled "References" and contains a list of three references:

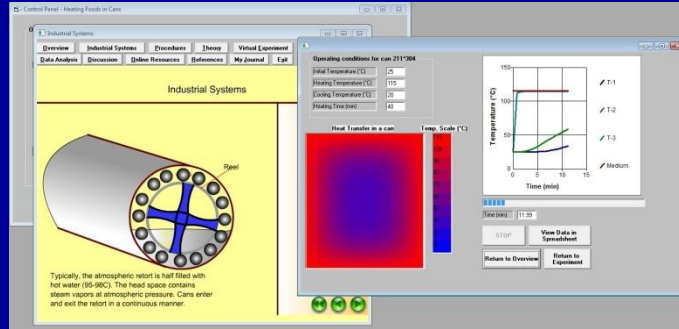
Karel, M., and Lund, D.B. (2003). "Physical Principles of Food Preservation," 2nd ed., Marcel Dekker, Inc., New York.

Singh, R. P. and Heldman, D.R. (2001). "Introduction to Food Engineering" 3rd ed., Academic Press, London.

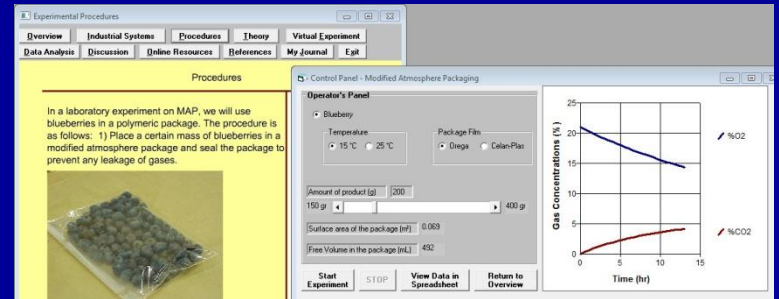
Toledo, R.T. (1994). "Fundamentals of Food Process Engineering," 2nd ed., Chapman and Hall, New York.

# Examples

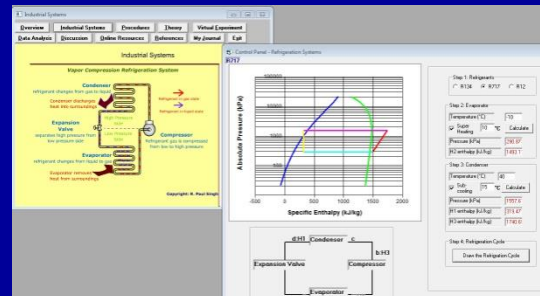
- Canning



- MAP  
(modified atmosphere packaging)



- Refrigeration cycle



# Use of virtual experiments in the universities

Virtual experiments have been routinely used in different universities for the past decade.

The following universities have introduced new courses/ laboratory exercises using the **Virtual Experiments** described in this webinar:



# Use of virtual experiments in the universities

- **University of California, Davis**
- **Ankara University**
- **Mersin University**
- **Ohio State University**
- **University of Illinois**
- **Oregon State University**

# **Use of virtual experiments in the universities**

- **Purdue University**
- **California State University, Pomona**
- **University of Newfoundland, Canada**
- **Iowa State University**

**In addition, instructors from (over) 30 countries have acquired the computer software from us to enhance their teaching.**

# Conclusions in summary

- Personal observations revealed that the virtual labs
  - led students get engaged more in the hands-on lab experiments,
  - encouraged the students to explore **what-if** scenarios,
  - eliminated the obstructive effect of not having the appropriate equipment to conduct various experiments, and
  - allowed students to develop higher level cognitive skills to analyze and evaluate processing parameters.



# Virtual Experiments in Food Processing

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