## FS 432 Learning Outcomes

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Assessment tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Explain the mechanisms of spoilage and deterioration of foods and raw materials: microbial, chemical, physical, biochemical, etc. (Bloom II-III)</td>
<td>Exams, assignments</td>
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<tr>
<td>2. Explain the basic principles of food preservation processes: heating, chilling, freezing, control of water activity, acidification, chemical preservatives, packaging, etc. (Bloom II-III)</td>
<td>Exams, assignments</td>
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<tr>
<td>3. Explain the range of processing operations used for food preservation including thermal processing, chilling and freezing, dehydration, irradiation, nonthermal methods, etc. (Bloom II-III)</td>
<td>Exams, assignments</td>
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<td>4. Explain the properties and uses of various packaging materials for preserving foods (Bloom II-III)</td>
<td>Exams, assignments</td>
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<td>5. Explain the sources and variability of raw food material and the impact on food processing operations (Bloom II-III)</td>
<td>Exams, assignments</td>
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<td>6. Relate food quality (texture, sensory, structure/appearance, etc.) to the chemical composition, processing and storage conditions (Bloom II-III)</td>
<td>Exams, assignments</td>
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<td>7. Explain the effects of processing steps on nutritional quality, including bioactive components, of foods (Bloom II-III)</td>
<td>Exams, assignments</td>
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<td>8. Explain effects of processing and storage conditions on shelf life of foods (Bloom II-III)</td>
<td>Exams, assignments</td>
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<td>9. Distinguish between preservation methods appropriate for “natural” foods (Bloom III-V)</td>
<td>Exams, assignments</td>
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<td>10. Analyze, interpret and explain complex phenomena (e.g., literature data) in context of preservation principles (Bloom III-IV)</td>
<td>Exams, assignments</td>
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<td>11. Compile a literature review on a new topic related to preservation principles and analyze results of specific literature work in that area (Bloom III-IV)</td>
<td>Exams, assignments</td>
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<td>12. Compare and contrast preservation methods for foods (Bloom V-VI)</td>
<td>Exams, assignments</td>
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<td>13. Communicate clearly and effectively</td>
<td>Assignments</td>
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Bloom’s (revised) Taxonomy

I. **Remembering.** Remember or recall information.
   
   **Key words:** Arrange, define, describe, label, list, memorize, recognize, relate, reproduce, select, state
   
   **Assessment:** Multiple-choice test, recount facts or statistics, recall a process, rules, definitions; quote law or procedure; etc.

II. **Understand.** Understanding and explaining the meaning of information to change the form of communication, translate, restate what has been read or heard, see connections or relationships among parts of a communication, draw conclusions, see consequences from information.
   
   **Key words:** Explain, reiterate, reword, critique, classify, summarize, illustrate, translate, review, report, discuss, re-write, estimate, interpret, theorize, paraphrase, reference, example
   
   **Assessment:** Explain or interpret meaning from a given scenario or statement, suggest treatment, reaction or solution to given problem, create examples or metaphors, etc.

III. **Application.** Using abstracts in concrete situations. Can use ideas and concepts to solve problems, particularly in situations different from which they were learned. Use knowledge in response to real circumstances.
   
   **Key words:** Use, apply, discover, manage, execute, solve, produce, implement, construct, change, prepare, conduct, perform, react, respond, role-play
   
   **Assessment:** Put a theory into practical effect, demonstrate, solve a problem, manage an activity, etc.

IV. **Analysis.** Breaking down a whole concept into component parts. Differentiate among facts, opinions, assumptions, hypotheses, and conclusions. Finding interrelationships among component ideas. Identification of logical errors. Interpret elements, organizational principles, structure, construction, internal relationships; quality, reliability of individual components.
   
   **Key words:** Analyze, break down, catalogue, compare, quantify, measure, test, examine, experiment, relate, graph, diagram, plot, extrapolate, value, divide
   
   **Assessment:** Identify constituent parts and functions of a process or concept, or de-construct a methodology or process, making qualitative assessment of elements, relationships, values and effects; measure requirements or needs.

V. **Evaluate.** Assess effectiveness of whole concepts, in relation to values, outputs, efficacy, viability; critical thinking, strategic comparison and review; judgment relating to external criteria
   
   **Key words:** Review, justify, assess, present a case for, defend, report on, investigate, direct, appraise, argue, project-manage
   
   **Assessment:** Review strategic options or plans in terms of efficacy, return on investment or cost-effectiveness, practicability; assess sustainability; perform a SWOT analysis in relation to alternatives; produce a financial justification for a proposition or venture, calculate the effects of a plan or strategy; perform a detailed risk analysis with recommendations and justifications; etc.

VI. **Create.** Develop new unique structures, systems, models, approaches, ideas; creative thinking, operations.
   
   **Key words:** Develop, plan, build, create, design, organize, revise, formulate, propose, establish, assemble, integrate, re-arrange, modify
Assessment: Develop plans or procedures, design solutions, integrate methods, resources, ideas, parts; create teams or new approaches, write protocols & contingencies

FS 432 Specific Learning Outcomes:

**Processing and preservation**

- Explain why foods are processed
- Explain what causes foods to go bad
- List what methods are used to preserve foods.

**Shelf life/Raw Material Variability**

- Describe the factors that influence shelf life.
- Explain the process for measuring shelf life and generating shelf life kinetic data.
- Explain the derivation of kinetic models used to calculate shelf life and the physical meaning of each parameter.
- Using kinetic models, solve for end of shelf life for food products under different storage conditions when given kinetic parameters.
- Compare shelf of different foods at different storage conditions and relate results to kinetic parameters.
- Given rate of change data during shelf life, determine 1st order reaction kinetic parameters.
- Explain sources of variability in food raw materials.
- Describe methods used by food manufacturers to account for raw material variability to retain consistent product quality.

**Post-Harvest**

- Explain the mechanisms of post harvest/slaughter changes in plant and animal products.
- Describe how post-harvest/slaughter chemical and physical changes contribute to product variation.
- Explain how process and shelf life conditions contribute to specific plant and animal product quality factors.

**Thermal Processing**

- Compare and contrast the different types of commercial heating processes used to treat both liquid and solid foods. Explain the purpose of each of these heating processes.
- Describe the effects that intrinsic and extrinsic parameters, for example pH, aw, and heat transfer characteristics, have on selecting the type of heat treatment used on a food product, as well as have on choosing the specific heat treatment conditions.
- Describe and explain chemical and physical changes that take place during thermal processing.
• Describe and explain use of equipment involved in thermal processing (For example, discuss both batch and HTST pasteurization, as well as aseptic processing; also discuss retorts, how they function, and the different types of them).

• Discuss the thermal processing of various example products where a choice must be made in terms of which heating process, which equipment, and what specific conditions must be used to insure a safe but nutritious product. For example, consider blanching as a pre-freezing and as a pre-retorting technique; consider pasteurization of milk and beer; sterilization of acid and low acid foods.

• Describe and explain the derivation of the basic TDT parameters (D, TDT, z) and how each is used to design a thermal process that results in a safe product with suitable organoleptic and nutritional quality.

• Using the standard method, TDT parameters, and heat penetration data develop a heating process specific to a given food.

• Apply the standard method and TDT parameters to compare retention of quality and nutrition factors to total destruction of microbes during a specific heating process.

Refrigeration

• Explain the benefits of chilling and refrigerated storage and the optimal storage temperature for different foods.

• Explain the effects of chilling rate on product quality.

• Calculate the refrigeration requirements for chilling and cold storage.

• Describe the effects of storage parameters (temperature, RH, air velocity and air composition) on refrigerated storage of various foods.

• Explain the basic principles of a mechanical refrigeration system for providing cooling.

• Explain the changes that occur during refrigerated storage that can lead to end of shelf life and provide in-depth examples of each.

• Estimate the shelf life of a refrigerated food using appropriate kinetic models.

• Compare and contrast shelf life of refrigerated foods based on different spoilage mechanisms with different kinetic parameters for the shelf life model.

• Identify and describe the effects of intrinsic and extrinsic parameters that affect microbial growth, chemical reactions, biochemical processes, physical changes and nutritional changes that take place during refrigerated storage of foods.

• Determine shelf life of a food and compare for different foods given kinetic parameters for a simple shelf life model.

Freezing

• Explain the benefits of freezing and frozen storage of foods.

• Describe and explain the importance of the typical steps in freezing and subsequent freezer storage and distribution of various liquid and solid foods.
• Describe the effects of parameters during freezing (rate, etc.) and storage (temperature, temperature fluctuations, RH, etc.) of various frozen foods.
• Describe the important processes (freezing point depression, subcooling, nucleation, growth and recrystallization) involved in freezing foods and the effects of different extrinsic and intrinsic parameters on freezing of foods.
• Apply the phase/state diagram for various foods to freezing and freezer storage, with special attention to areas of equilibrium and nonequilibrium.
• Compare and contrast the effects of freezing rates on product quality in frozen foods with special attention on intracellular and extracellular processes.
• Calculate percent of water frozen (and unfrozen water) into ice at equilibrium from state diagram.
• Calculate, compare and contrast freezing time under different conditions using Plank’s equation.
• Compare and contrast different freezing technologies in terms of process characteristics and quality changes during freezing of different foods.
• Describe and distinguish effects of freezing and freezing rate on quality of frozen foods in general, but particularly with regard to intracellular and extracellular ice formation.
• Describe the physical and chemical changes that occur during frozen storage, summarize the effects of conditions on storage of frozen foods and use the reaction kinetic model for predicting shelf life of foods.
• Compile a literature review on a topic of interest in freezing of foods and evaluate results of a research study related to that topic.

**Nonthermal**

- List alternative (nonthermal) processing methods for food preservation.
- Describe and explain the sources of ionizing radiation with their pros and cons.
- Describe and explain the mechanisms of action of ionizing radiation on various foods.
- Describe the effects of ionizing radiation on the chemical and physical properties of foods.
- Calculate irradiation dose needed for given lethality.
- Describe and explain high pressure processing for food preservation.

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**Packaging:**

- Describe and explain the role of food packaging in preserving food products.
- Discuss how changes in packaging materials have affected food storage, distribution and use occasions.
- Explain how specific packaging materials and structures are selected for a given food product.
- Describe the different types of packaging materials, how each can be used and the
manufacturing processes used to form specific package structures.

• Describe and explain important physical characteristics of both rigid and flexible packaging materials. What are the advantages that compound packages, for example, laminates or coated packages offer the food industry?

• Discuss the elements of mass flow of gasses through polymer based packages and how packaging material properties impact transmission through the films.

• Using transmission models and packaging parameters necessary for protection and stability of food during shelf life, select the appropriate packaging material and specifications for a given product use.

**pH and Antimicrobials:**

• Define a food additive

• Discuss the origin of “GRAS”, and how particular food additives qualify for addition to food as GRAS ingredients.

• Discuss the impact of pH and changes in pH on the quality (specific to appearance, texture, and flavor) and stability of food.

• Describe the mechanisms through which organic acids can inhibit or destroy microorganisms. Why are some acids more effective than others and what can impact effectiveness? Explain why organic acids are more effective than mineral or strong acids.

• Discuss the origin of antimicrobials like nicin and how they might replace compounds like nitrites in certain foods.

**Evaporation:**

• Identify common applications and uses for evaporation in food preservation.

• Explain boiling point elevation in foods.

• Describe the primary elements of an evaporator

• Explain the purpose of each component of an evaporator.

• Explain the major reactions/processes that occur during evaporation that influence quality.

• Apply mass and energy balances to calculate steam requirement and steam economy in a single effect evaporator operating under vacuum conditions.

**Dehydration:**

• Identify the purposes for drying foods.

• Define water activity, relative vapor pressure and equilibrium relative humidity in the context of dehydration.

• Describe the limitations of the concept of water activity in dried foods.
• Describe the concept of molecular mobility for water molecules in dried foods. II
• Define the concept of glass transition in dried foods. I
• Describe the changes in foods as water content decreases. II
• Identify and label the different regions of a state diagram for drying and dried foods. I
• Identify the different components of a psychrometric chart. I
• Describe the importance of a psychrometric chart in drying and use it to help solve drying problems. II
• Summarize the different transport process important in drying. II
• Describe a typical drying curve and identify the different regions of drying. II
• Plot a drying curve based on experimental weight measurements. III
• Summarize the important transport steps dominant in each drying region. II
• Describe the differences between the first and second falling rate periods. II
• Calculate drying time and drying rate in constant rate period given product characteristics and external drying conditions. III
• Estimate the time for drying in the falling rate period from the diffusion equation. III
• Estimate the diffusion coefficient in the falling rate period from drying data. III
• Describe the effects of the internal and external factors on drying rate and time. II
• Differentiate the different regions of drying on experimental drying curves. IV
• Describe the chemical, physical and nutritional changes that occur during drying. II
• Identify the different types of driers used for foods and the types of foods dried in each. I
• Describe the different types of heating devices used in food dehydration. II
• Describe the general operating principles of different types of driers used for foods. II
• Describe the importance of glass transition to stickiness in spray drying. II
• Describe the transport processes that occur during spray drying. II
• Estimate the time of drying (both constant and falling rate) in spray drying. III
• Describe the operation of a freeze drier. II
• Summarize the physical changes in the different stages of freeze drying. II
• Describe the importance of the state diagram on freeze drying. II
• Compare the differences in quality of various dried foods. IV
• Compare, differentiate and explain research results (from literature articles) that study the effects of formulation and operating parameters on drying and dried product quality. IV

**Water Activity:**

• Given experimental data, construct moisture sorption isotherms for a given food products. III

  Explain how MSIs are determined experimentally.

• Explain how changes in water activity affect chemical, physical, and biological stability of foods. II/III

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• Predict rates of change for specific product attributes (shelf life) as a function of Aw.
• Discuss how Aw combines with other preservation strategies to extend shelf life of different food products.
FS 432 Principles of Food Preservation, Spring Semester, 3 credits
Class/lecture: 3 hours/week; 9:30-10:45AM Biochem Room 1120
Prerequisites: FS 325, FS 410, FS 440, or Instructor Consent

Instructors:
Lead: Bradley Bolling, 115 Babcock, bwbolling@wisc.edu
Hans Zoerb, 203A Babcock, hzoerb@wisc.edu

Office Hours:
Feel free to see us at any time. We will make time for you whenever you need our assistance. If you have trouble finding us, email to set up an appointment. If you have questions about a specific topic, we recommend you speak to the instructor teaching that section.


Goals for this course:
As a result of participation in this course, students will:
• understand the physical, chemical and biological processes involved in conversion of raw materials into finished food products, including production, packaging, and storage/shelf life.
• understand the principles and processes that make food safe for consumption.
• know the modes of spoilage and deterioration of foods, and methods for their control.

Learning Outcomes:
We have a set of course level learning outcomes, see last pages. These are our overall goals for your learning in this class and we will assess your learning against these outcomes. However, each section has a set of more specific learning outcomes that will be handed out at the start of each section. These represent more specifically what we expect you will know and be able to do for each section and will be the basis for exams and assignments. Note that due to the broad nature of what we cover, we will not necessarily ask a question related to each and every outcome, but will pick and choose which ones to assess on the exam. You need to be prepared for all of them, however, since we can ask questions related to any of them.

Required Text:
None. Notes, articles and other information will be shared as needed. Pertinent information (slide sets, readings, assignments, etc.) will be posted on Learn@UW. Slides will only be posted after the class for which they are given. Note that the slides do not provide a complete set of what we expect you to learn since they simply provide a framework for our class presentations. You need to attend class to take notes to ensure you are exposed to all the material that will be covered on exams.

Various food processing and preservation books are available at Steenbock. We highly recommend you supplement our notes and readings by reviewing what others have written about food preservation.
Course format:
Lecture with demonstrations, discussions and in-class activities. Several assignments will be given throughout the semester.

Classroom Etiquette
To help promote a classroom conducive to learning, we aim to reduce distractions during class times (other than the learning exercises that we will periodically bring in). Please put away all computers, cell phones and newspapers at the start of each class period.

Exams:
Two exams will be scheduled throughout the semester (options for evening exams will be provided). They will be closed book with all equations provided.
Exams will be a combination of calculations and problems, explanation questions, thought questions, and what-if questions. We will model critical thinking questions periodically in class so you have some perspective (and practice) with this type of questioning. We will hand out example problems for the first exam so you are familiar with the way we ask questions (since these are not intended as study guides, we will not hand out example problems for subsequent exams). Classroom examples and homework assignments also provide practice for our type of exam questions.

Assessment format:
- Mid-term 1 (25%) on or around March 8
- Mid-term 2 (25%) on or around April 19
- Cumulative final exam (30%) May 9 (10:05-12:05 PM)
- Assignments and short papers (20%)

Course topics:
• Introduction
  - preservation and processing overview/mechanisms of food spoilage
  - shelf life principles and calculations/raw material variability
• Post-harvest/post-slaughter changes
• Principles of preservation/processing
  Thermal (heat) processing
  Low temperature processing and preservation
  Nonthermal processing methods
  Control of water – water activity
  Chemical preservation methods
• Packaging and food preservation
  - types of packages, vapor permeability, etc.
  - modified/controlled atmosphere storage
## Tentative Lecture Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Instructor</th>
<th>Assignment due</th>
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<tbody>
<tr>
<td>1/19 (T)</td>
<td>Intro/spoilage</td>
<td>BWB</td>
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<tr>
<td>1/21 (R)</td>
<td>Raw materials/shelf life</td>
<td>BWB</td>
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<tr>
<td>1/26</td>
<td>Post-harvest</td>
<td>HZ</td>
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<td>1/28</td>
<td>Post-slaughter</td>
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<td>2/2</td>
<td>Thermal process</td>
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<td>2/16</td>
<td>Refrigerated</td>
<td>BWB</td>
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<td>2/18</td>
<td>Freezing</td>
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<td>Water/aw</td>
<td>HZ</td>
<td>#2</td>
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<td>3/8</td>
<td>Exam 1</td>
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<td>3/10</td>
<td>Water/aw</td>
<td>HZ</td>
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<td>3/15</td>
<td>Evaporation</td>
<td>BWB</td>
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<td>3/17</td>
<td>Dehydration</td>
<td>BWB</td>
<td>#3</td>
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<td>3/22</td>
<td>Spring Break</td>
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<td>BWB</td>
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<td>pH, antimicrobials</td>
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<td>5/5</td>
<td>Natural foods</td>
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**Final Exam**  5/9 10:05-12:05