ESTABLISHING FOOD SAFETY CONTROLS FOR FERMENTATION FOODS

AMANDA J. KINCHLA, UMASS AMHERST
Objectives

- Review the basics of fermentation
- Review of hazards
- Identify critical limits to control hazards
- Establishing monitoring and verification activities
- Demonstrate the use of a pH meter
Basic Fermentation Process

- Controlled growth of a microorganism that produces the desired byproduct that changes the food

- At retail, most fermentation is from *lactic acid bacteria*

- The creation of these products usually results in **acidification** via fermentation
Common Retail Fermentations

- Dairy – yogurt, crème fraîche
- Plant foods – sauerkraut, kimchi, miso, stinky tofu, vinegars, tempeh
- Meat – sausages, salami, etc.
- Beverages – kombucha
Fermentation Factors For Food Safety

Dependent factors that influence pH

- Culture type
- Incubation temperature
- Time of fermentation
- Food being fermented
Example – Milk Fermentation for Yogurt

1. Receive and hold milk and culture (yogurt)
2. Heat milk to 145°F for 30 min
3. Cool milk to 110-115°F
4. Add culture to warm milk
5. Incubate at 110-115°F for 10 hours
6. Check pH

Processing Notes:
- *Temp = PMO, 2019
- §Culture: can be direct LAB or fresh commercial sourced yogurt
Fermentation Hazards

“I put cabbage, carrots and onions in a jar and left it in the window”
Process Hazards

• TCS foods are being held outside of temperature control for over four hours

• Potential growth of pathogens of concern in various products

• Hazards are prevented by proper execution of the process and typically controlled by pH
Hazards associated with adding components or additives to food:

- *Staphylococcus aureus* and *Clostridium botulinum* may reproduce to high numbers and produce toxin if lactic acid fermenters do not rapidly produce a pH drop sufficient to inhibit growth of *Staph* or *C. bot*.

- *Mycotoxins* may grow when water activity or pH indicates the food product is non-potentially hazardous (i.e. sausages)

- Some organisms are acid resistant such as *Salmonella* and *E. coli*

- **AVOID Back Slop!** Some starter cultures saved from the previous batch may contain too low levels of lactic acid bacteria or contain other bacteria (back slop)
Controlling Hazards - Fermented Foods

1. Know the hazards associated with the food
2. Follow validated process
3. Monitor for proper selection for the microorganisms using acceptable starter cultures
4. Verify critical control points


https://media1.giphy.com/media/lRRjGTRIFwmQYFmmpU/giphy_s.gif
# 1. Know hazards of concern

<table>
<thead>
<tr>
<th>Product</th>
<th>Pathogen of concern</th>
<th>Selection / Starter</th>
<th>Incubation Time/ Temp</th>
<th>Target pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yogurt (1, 7, 8)</td>
<td><em>Staph A, L. mono, E.coli O157:H7</em></td>
<td>Pasteurized milk* / approved culture</td>
<td>Less than 24 hours / 105-115°F</td>
<td>Less than 4.6 within 24 hours and cooled to 45°F or less within 96 hours 10 hours</td>
</tr>
<tr>
<td>Sauerkraut (6, 9)</td>
<td><em>Staph A, C. bot</em></td>
<td>• Salting of cabbage 2-3% by weight&lt;br&gt;• native ferment</td>
<td>21 days / ~70°F</td>
<td>Less than 4.2 (pH ≤ 5.0 within 24 hr and then to ≤ 4.2 within 48-72hr)</td>
</tr>
<tr>
<td>Kimchi (3, 5)</td>
<td><em>Staph A, L. mono, B. cereus</em></td>
<td>Salting of vegetables / native ferment</td>
<td>4-5 days / ~68°F</td>
<td>Less than 4.2</td>
</tr>
<tr>
<td>Sausages (2, 4)</td>
<td>STEC, Salmonella, Listeria, Staph A, etc</td>
<td>Curing salts / approved starter cultures</td>
<td>1200 degree hours / dry 17 days at 50°F</td>
<td>Less than 5.3 with aw less than 0.85</td>
</tr>
</tbody>
</table>

**NOTE:** * Indicates the need for a certified pasteurizer

This slide was modified based on content sourced by:
2. Follow validated process

- Scientific literature
- Validated recipes
- Process authority
- Challenge study
3. Monitor for proper selection for the microorganisms using acceptable starter cultures

- Know the source of the culture
- Commercial sources (i.e. small yogurt cups)
- Direct sources (i.e. freeze-dried culture)
- Avoid back slop!
3. Monitor

Ensure the system is working

<table>
<thead>
<tr>
<th>Batch #</th>
<th>Initials</th>
<th>pH Meter Calibration</th>
<th>Batch pH</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Initial Read</td>
<td>Calibrated Read</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>START</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAY 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>END</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***Please NOTE***
The pH meter MUST be calibrated prior to each pH reading. See pH Calibration instructions in this notebook.
# Example of a log monitoring pH

<table>
<thead>
<tr>
<th>Date</th>
<th>Batch type and Batch number</th>
<th>Time</th>
<th>pH Reading</th>
<th>Operator Name</th>
<th>Initials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Operational Notes:** Follow the SOP titled, “Operating the pH Meter using the Hanna Portable pH unit”. BE SURE TO CALIBRATE the pH unit BEFORE monitoring.

**Record was verified by:**
- **Name:**
- **Date:**
- **Initials:**
- **Notes:**
Example of calibration log for pH
4. Verify critical control points

- SOP describing the critical limit to measure and record safe levels of acidity on a pH log
- A detailed pH measurement and calibration SOP
- A detailed SOP of incubation (i.e. time, temp and/or salinity)
Processors Must Demonstrate Control

- Proper documentation to demonstrate:
  - The process they are using can support the validated process they reference
  - They are using calibrated tools – time clocks, thermometers & pH meters
  - Established SOP’s for the process and monitoring activities
  - Established monitoring records that comply with the critical limit
  - Corrective actions
  - Training records

Raise the hand of the person beside you, if you’re a control freak

This Photo by Unknown Author is licensed under CC BY
Example. Controlling Hazards – Fermented Vegetables

1. Know the food/foods being fermented and common hazards associated
   *Clostridium Botulinum, Staphylococcus aureus*

2. Follow a validated recipe
   50–70 °F related to the science for efficient fermentation

3. Selection and starter
   Natural or added LAB

4. Monitor and Verify
   Ferment juices at ambient temperature to a pH of ≤5 within 24 hr and then continue to ≤4.2 within 48–72 hr for ambient storage
Fermentation influenced by many factors!

Fermentation factors for food safety:

- Culture type
- Incubation temperature
- Time of fermentation
- Food being fermented

Figure. The pH over time in relation to the change of sodium concentration.

Effect of Temperature and Salt Concentration on Kimchi Fermentation

Tae-Ick Mheen and Tai-Wan Kwon
Department of Biological Science and Engineering,
Korea Advanced Institute of Science & Technology, Seoul

Fig. 2. Changes of total acid and pH during Kimchi fermentation at various temperatures (3.0% salt)

- Total acid
- pH
- ●  20°C
- ▲  15°C
- ■  10°C
Remember! Fermentation Factors For Food Safety

Dependent factors that influence pH

§ Culture type
§ Incubation temperature
§ Time of fermentation
§ Food being fermented
• Low pH means that the cell utilizes more energy to maintain a pH near neutral intracellular it has less energy to grow or produce toxins
• pH ranges in between 0 to 14, where 7 is neutral below is acid and above is alkaline
• Foods: Acidic >4.6 vs. Low acid’ < 4.6
**Definition:** The logarithm of the reciprocal of the hydrogen ion concentration of a solution

\[ \text{pH} = - \log [H^+] \]

pH units represent a 10-fold change in hydrogen ion concentration

**Problem**

- Beer has a pH = 4, \([H^+] = ?\)
  - \(\text{pH} = - \log [H^+]\)
  - \(4 = - \log [H^+]\)
  - \([H^+] = 10^{-4} \text{ mol/L}\)
pH Meter

The pH meter measures the difference in electrical potential between a pH electrode and a reference electrode.
Your measurement is only as good as the tool that you used to take the measurement.
Acceptable pH meters

Accuracy with at least ±0.01 pH

Accuracy
Not recommended for pH meters. Accuracy with ±0.1 pH.

This Photo by Unknown Author is licensed under CC BY.
pH and Sample Temperature

- pH is *temperature dependent*
- Every solution will undergo a change in temperature in their pH value through changes in temperature
- To achieve highest accuracy, calibrate and measure at the same temperature.

<table>
<thead>
<tr>
<th>T (°C)</th>
<th>K_W (mol^2 dm^-6)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.114 x 10^{14}</td>
<td>7.47</td>
</tr>
<tr>
<td>25</td>
<td>1.008 x 10^{14}</td>
<td>7.00</td>
</tr>
<tr>
<td>50</td>
<td>5.476 x 10^{14}</td>
<td>6.63</td>
</tr>
<tr>
<td>100</td>
<td>51.3 x 10^{14}</td>
<td>6.14</td>
</tr>
</tbody>
</table>

pH Meter Calibration

Before calibration or usage:

• Make sure the electrode is in good condition.
• pH meter calibration is necessary
• Regularly calibrating your pH meter will adjust your electrode based on any changes that may have occurred and ensures that your readings are accurate and repeatable.
PH METERS: DEMONSTRATION
References


2. FSIS, U. 2014. Safe Practices for Sausage Production The U.S. Department of Agriculture (USDA), Food Safety and Inspection Service (FSIS), and The Association of Food and Drug Officials (AFDO) In cooperation with the U.S. Food and Drug Administration (FDA).


7. PMO, 2019 https://www.fda.gov/media/140394/download: All yogurt products at all milkfat levels, cultured in the cup after filling (cup-set) and subsequently moved out of the culturing room when reaching a pH of 4.80 or below, and a pH of 4.6 or below within the following twenty-four (24) hours* and cooled to 7°C (45°F) or less within ninety-six (96) hours of being moved out of the culturing room**;


Fermented Sausages

- Fermented sausages are a class of chopped or ground meat products that have reached a pH of 5.3 (4.6-5.0 typical) because of the microbial fermentation of sugar.
- Fermented sausages have undergone a decrease in water activity during drying. The drying process removes 15-50% of moisture content.
- Fermented sausages may or may not be cooked (may or may not be shelf stable).

This slide was modified based on content sourced by:

This Photo by Unknown Author is licensed under CC BY-SA.
Fermented Sausages

• During the general production and aging process there are two major food safety issues are associated with the production of fermented sausages
  • **Pathogen inactivation**-the process designed to render pathogens such as bacteria, virus, or fungi non-infectious.
  • **Pathogen inhibition**-the process designed to limit the growth of pathogens such a bacteria, virus, or fungi to prevent foodborne illness.
• Hazards of concerns:
  • *Listeria, E.coli, Salmonella, Staph enterotoxin, Campylobacter, Shigella, Yersinia, Trichinella, C. botulinum*
Fermentation Specifics

- Number of visits will depend on type of fermentation
- Checking starter culture is essential
- Key steps in fermentation verification visit:
  - Mixing with starter
  - pH drop (meat: 1200 degree hours, yogurt/milk: 10 hours, other fermentation depends on literature)
- Final product
## Corrective Action

<table>
<thead>
<tr>
<th>Level of Non-compliance</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missed Critical Limit</td>
<td>Immediate correction, including discarding of food if justified, follow up within 10 days to ensure continuing compliance</td>
</tr>
<tr>
<td>Missed monitoring of critical limit</td>
<td>Immediate correction, have employees begin monitoring during visit, follow-up within 10 days to ensure continuing compliance</td>
</tr>
<tr>
<td>Other areas of non-compliance</td>
<td>Follow-up within 30 days to make sure either the plan has been changed or procedure has changed</td>
</tr>
</tbody>
</table>
How to Choose Corrective Action

• Written in the plan for CCPs

• Should follow the approved procedure

• Get disposal of unsafe food

• Monitoring corrective action will require follow-up