University of Massachusetts Amherst

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

This slide was modified based on content sourced by:

Retail HACCP Validation and Verification

Chapman, B., Seymour, N., Bryant, V. Handling Fermentation at Retail. Short Course, NC State University. December 2019.

FOOD FERMENTATION & FOOD SAFETY CONTROLS

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

This slide was modified based on content sourced by:

Retail HACCP Validation and Verification

Chapman, B., Seymour, N., Bryant, V. Handling Fermentation at Retail. Short Course, NC State University. December 2019.

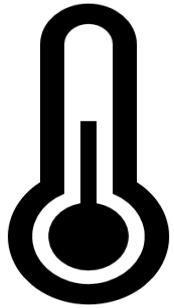
Common Retail Fermentations

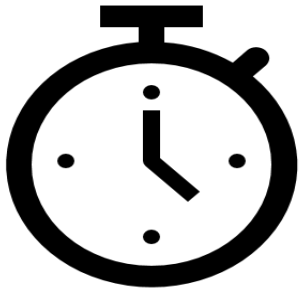
- Dairy – yogurt, crème fraiche
- Plant foods – sauerkraut, kimchi, miso, stinky tofu, vinegars, tempeh
- Meat – sausages, salami, etc.
- Beverages – kombucha

Fermentation Factors For Food Safety

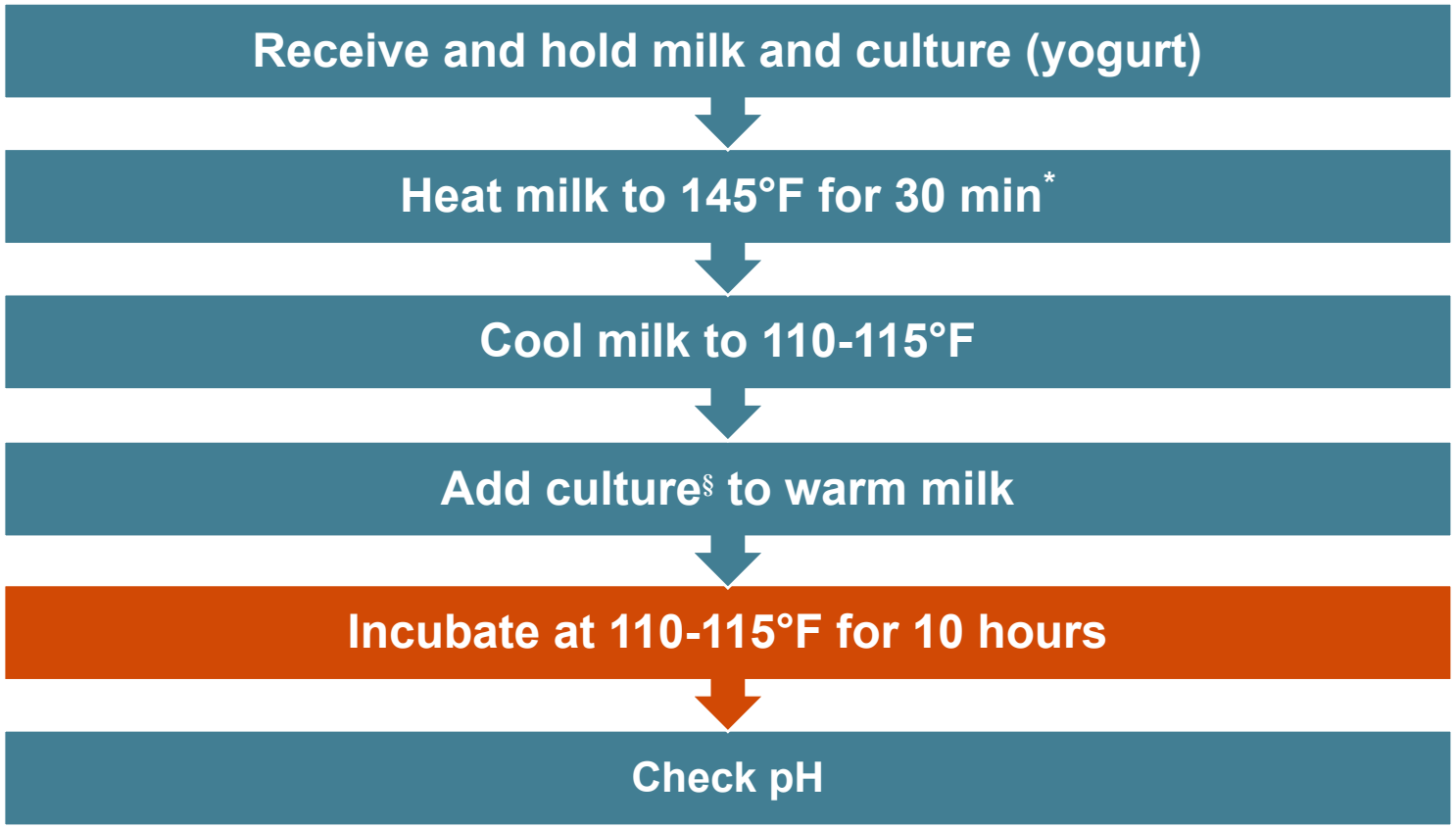
Dependent factors that influence pH

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





Example – Milk Fermentation for Yogurt



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

This slide was modified based on content sourced by:

Retail HACCP Validation and Verification

Chapman, B., Seymour, N., Bryant, V. Handling Fermentation at Retail. Short Course, NC State University. December 2019.

Fermentation Hazards

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

This slide was modified based on content sourced by:
Retail HACCP Validation and Verification
Chapman, B., Seymour, N., Bryant, V. Handling Fermentation at Retail. Short Course, NC State University. December 2019.

Hazards associated with adding components or additives to food:

Image Source: reddit

- ***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 ***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)

This slide was modified based on content sourced by:
Retail HACCP Validation and Verification
Chapman, B., Seymour, N., Bryant, V. Handling Fermentation at Retail. Short Course, NC State University. December 2019.

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/lRRjGTRlFwmQYFmmpU/giphy_s.gif

This slide was modified based on content sourced by:

Retail HACCP Validation and Verification

Chapman, B., Seymour, N., Bryant, V. Handling Fermentation at Retail. Short Course, NC State University. December 2019.

1. Know hazards of concern

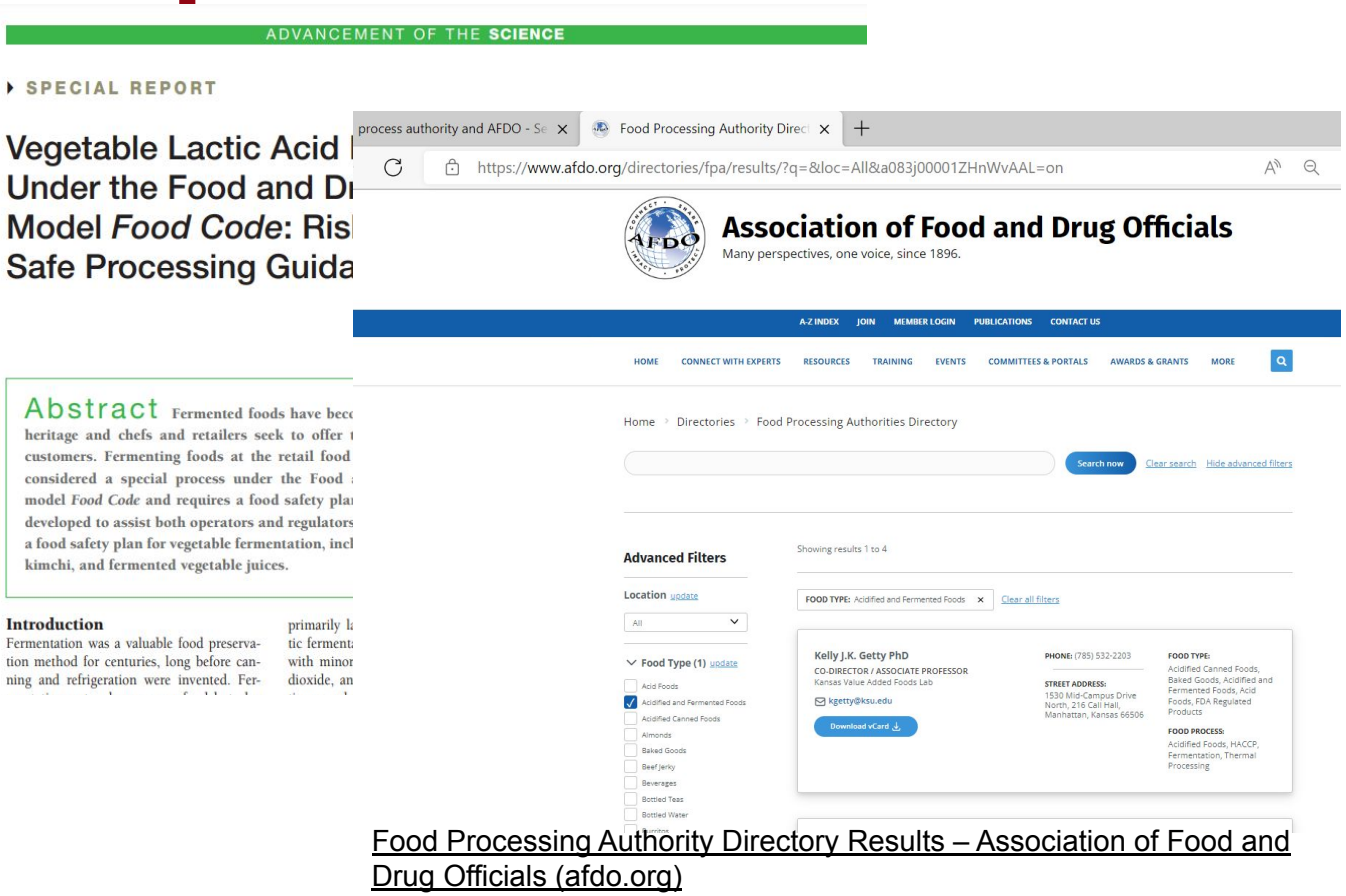
Product	Pathogen of concern	Selection / Starter	Incubation Time/ Temp	Target pH
Yogurt (1, 7, 8)	*Staph A, L. mono, E.coli O157:H7*	Pasteurized milk* / *approved* culture	Less than 24 hours / 105-115°F	Less than 4.6 within 24 hours *and* cooled to 45F or less within 96 hours 10 hours
Sauerkraut (6, 9)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

NOTE: * Indicates the need for a certified pasteurizer

This slide was modified based on content sourced by:
Retail HACCP Validation and Verification
Chapman, B., Seymour, N., Bryant, V. Handling Fermentation at Retail. Short Course, NC State University. December 2019.

2. Follow validated process

- Scientific literature
- Validated recipes
- Process authority
- Challenge study



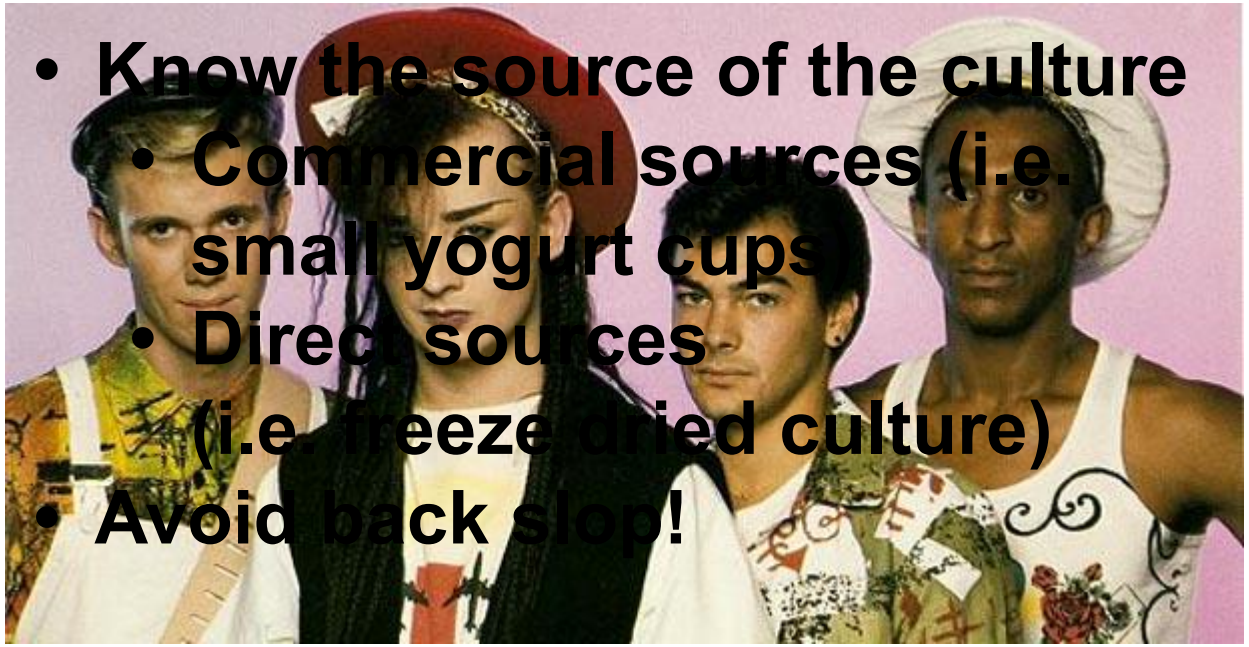
Food Processing Authority Directory Results – Association of Food and Drug Officials (afdo.org)

This slide was modified based on content sourced by:

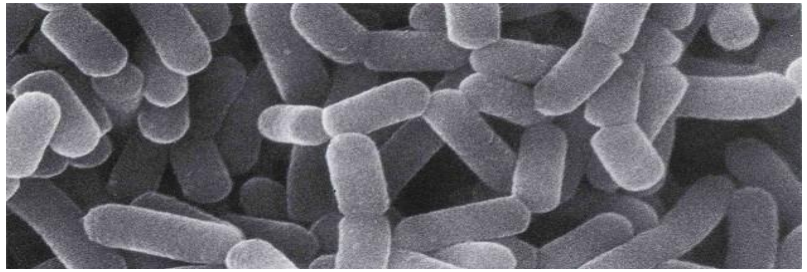
Retail HACCP Validation and Verification

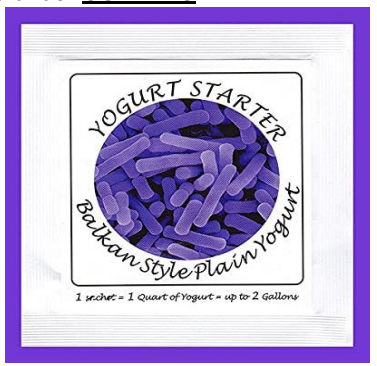
Chapman, B., Seymour, N., Bryant, V. Handling Fermentation at Retail. Short Course, NC State University. December 2019.

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!





https://www.amazon.com/Yogurt-Starter-Cultures-Freeze-dried-Culture/dp/B01BO47O88?th=1

3. Monitor

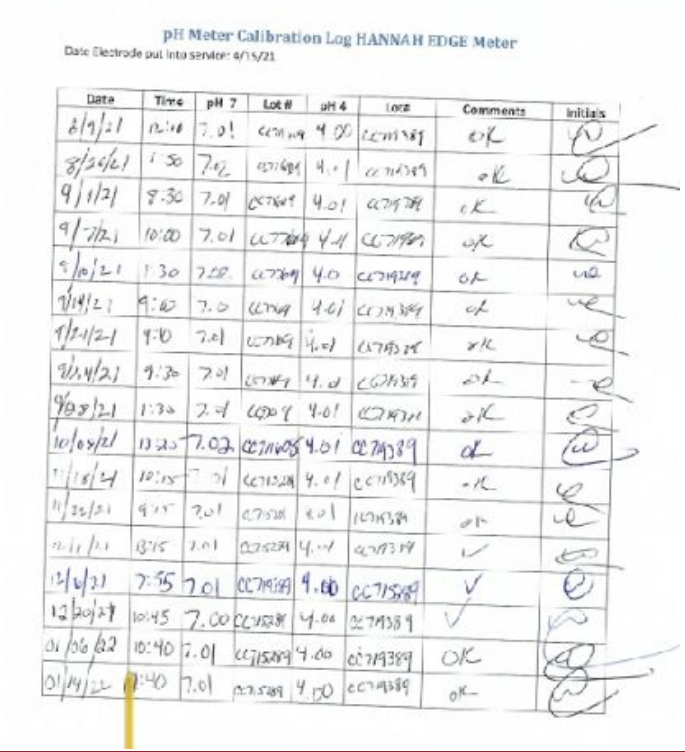
Ensure the system is working

Batch # **NOTE* Batch # = (Date Started + Bucket #) Ex: 11/26/15-2*					******Please NOTE****** The pH meter MUST be calibrated prior to each pH reading. See pH Calibration Instructions in this notebook.
Date	**Initials**	**pH Meter Calibration**		**Batch pH**	**Notes** *Corrective actions? Abnormal observations? Protocol deviations?*
		Initial Read	**Calibrated Read**		
START					
DAY 3					
END					

Example of a log monitoring pH

Date	Batch type and Batch number	Time	pH Reading	Operator Name	Initials
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



pH Meter Calibration Log HANNAH EDGE Meter

Date Electrode put into service: 6/15/21

Date	Time	pH 7	Lot #	pH 4	Lot #	Comments	Initials
8/9/21	12:10	7.01	CC71489	4.01	CC71389	OK	
8/26/21	1:30	7.02	CC71684	4.01	CC71389	OK	
9/1/21	8:30	7.01	CC71684	4.01	CC71389	OK	
9/7/21	10:00	7.01	CC71684	4.01	CC71389	OK	
9/10/21	1:30	7.00	CC71684	4.01	CC71389	OK	
9/14/21	9:10	7.01	CC71684	4.01	CC71389	OK	
9/21/21	9:10	7.01	CC71684	4.01	CC71389	OK	
9/24/21	9:30	7.01	CC71684	4.01	CC71389	OK	
9/28/21	1:30	7.01	CC71684	4.01	CC71389	OK	
10/05/21	13:20	7.02	CC71684	4.01	CC71389	OK	
11/16/21	10:15	7.01	CC71538	4.01	CC71389	OK	
11/30/21	9:15	7.01	CC71538	4.01	CC71389	OK	
12/1/21	8:15	7.01	CC71538	4.01	CC71389	OK	
12/6/21	7:55	7.01	CC71538	4.00	CC71389	OK	
12/20/21	10:45	7.00	CC71538	4.00	CC71389	OK	
01/06/22	10:40	7.01	CC71538	4.00	CC71389	OK	
01/14/22	10:40	7.01	CC71538	4.00	CC71389	OK	

PRODUCT (S):	Sauerkraut, Kimchi and Fermented Cucumber Pickles		
PLANT NAME:	The Stone Belly Restaurant	ISSUE DATE	April 23, 2021
ADDRESS:	123 Gut Road, Belchertown, MA	SUPERSEDES	May 1, 2018

pH Calibration Log

Method: Follow the SOP titled, "Calibration Method for HANNA PORTABLE PH METER HI 8424"

Date	Time	Person Calibrating	pH reading for 4.01 buffer	Calibrated Value	pH reading for 7.01 buffer	Calibrated Value

Verified by:

Date of Review:

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**

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

This slide was modified based on content sourced by:

Retail HACCP Validation and Verification

Chapman, B., Seymour, N., Bryant, V. Handling Fermentation at Retail. Short Course, NC State University. December 2019.

Fermentation influenced by many factors!

Fermentation factors for food safety:

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

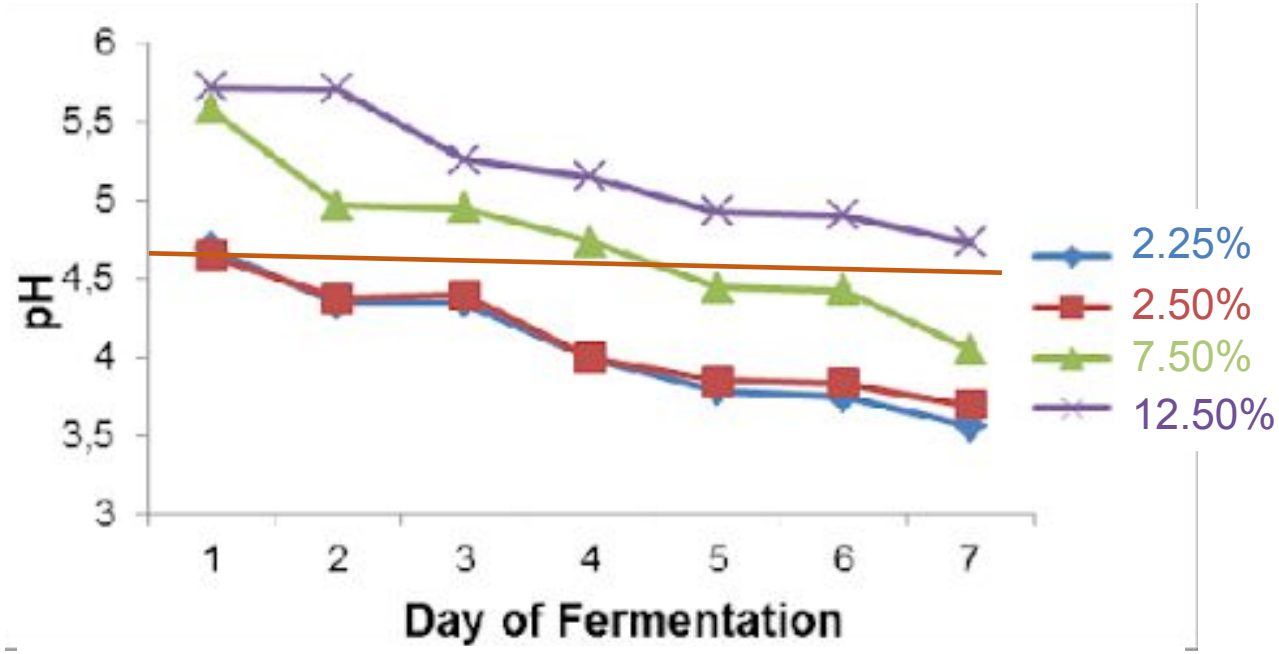


Figure. The pH over time in relation to the change of sodium concentration.

Fadhil, R., Hayati, R. Agustina, R. Quality Characteristics of Sauerkraut from Cabbage (Brassica oleracea)during Fermentation and Variation of Salt Concentration. International Journal of Scientific & Technological Research. Vol. 8 (10) October 2019.

KOREAN J. FOOD SCI. TECHNOL.
Vol. 16, No. 4 (1984)

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

김치발효에 미치는 온도 및 식염농도의 영향

민태익 · 권태완
한국과학기술원, 생물공학부

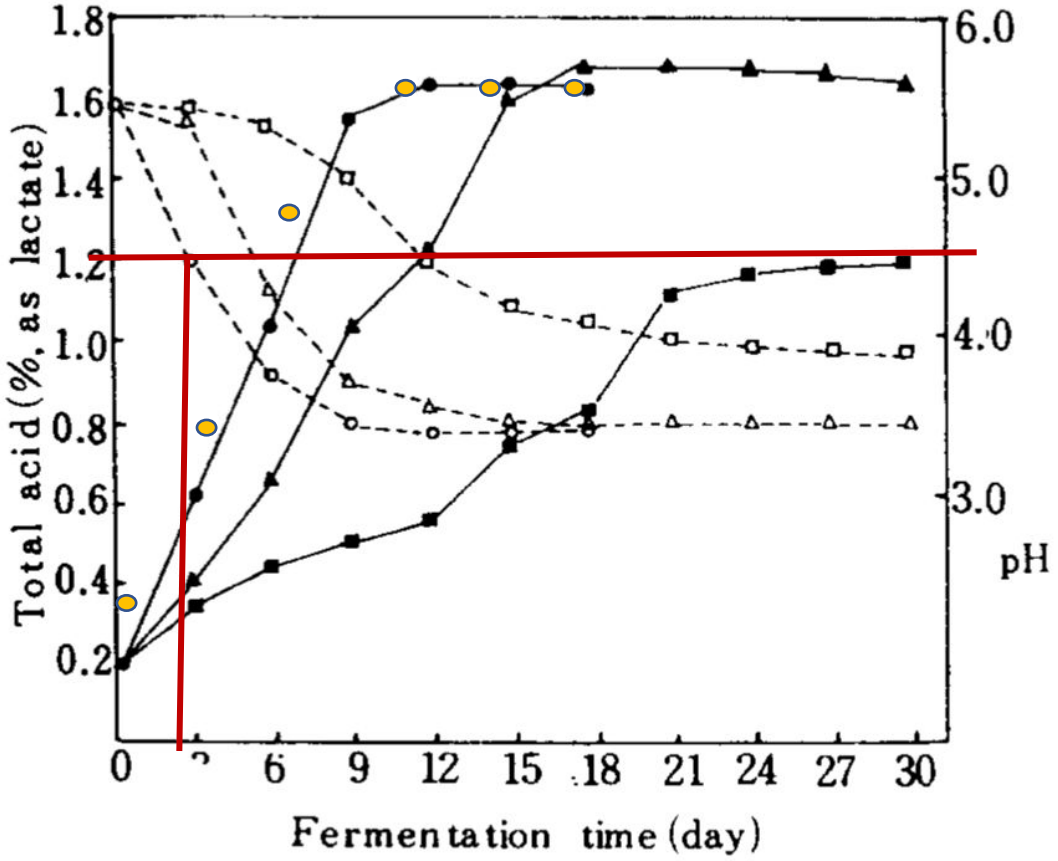


Fig. 2. Changes of total acid and pH during *Kimchi* fermentation at various temperatures (3.0% salt)

Total acid — pH
—●— 20℃ ···○···
—▲— 15℃ ···△···
—■— 10℃ ···□···

University of Massachusetts Amherst

This slide was modified based on content sourced by:

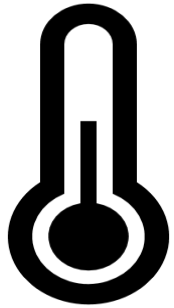
Retail HACCP Validation and Verification

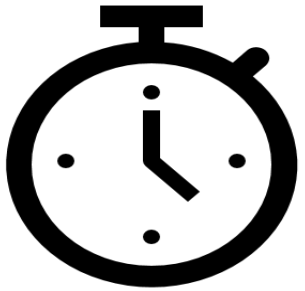
Chapman, B., Seymour, N., Bryant, V. Handling Fermentation at Retail. Short Course, NC State University. December 2019.

REMEMBER! Fermentation Factors For Food Safety

Dependent factors that influence pH

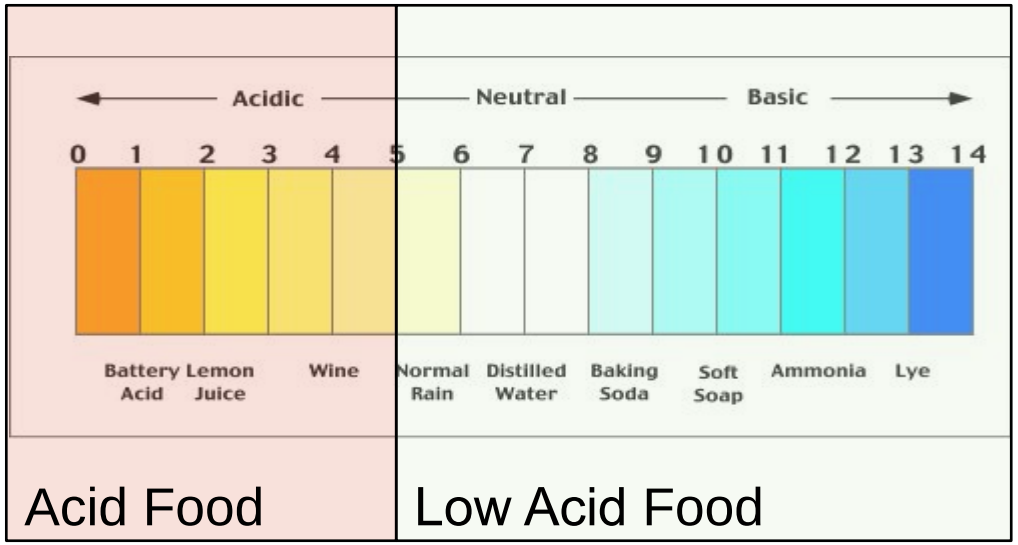
- **Culture type**
- **Incubation temperature**
- **Time of fermentation**
- **Food being fermented**

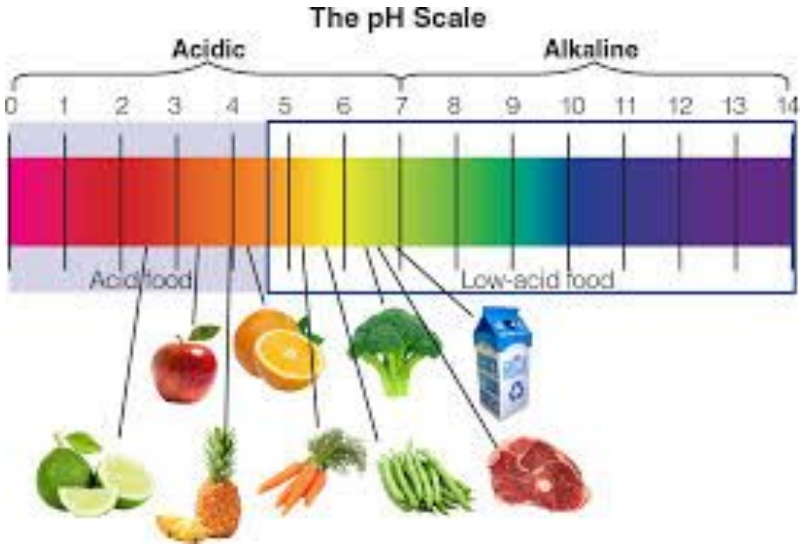




PH METERS: CONSIDERATIONS

pH





- 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

https://images.app.goo.gl/Uiae7EhdebGsKNMFA

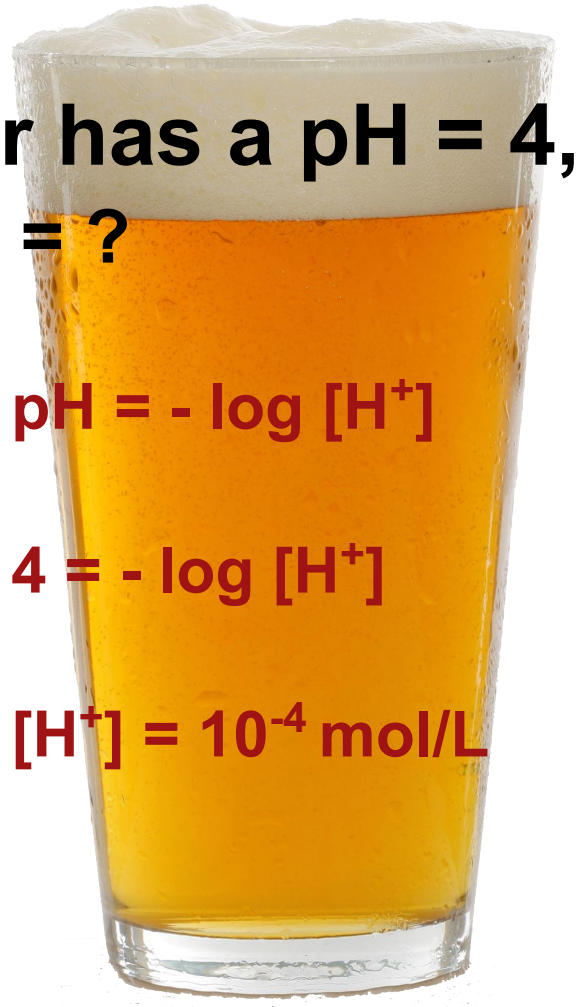
pH:
Problem

Definition: The logarithm of the reciprocal of the hydrogen ion concentration of a solution

pH = - log [H+]

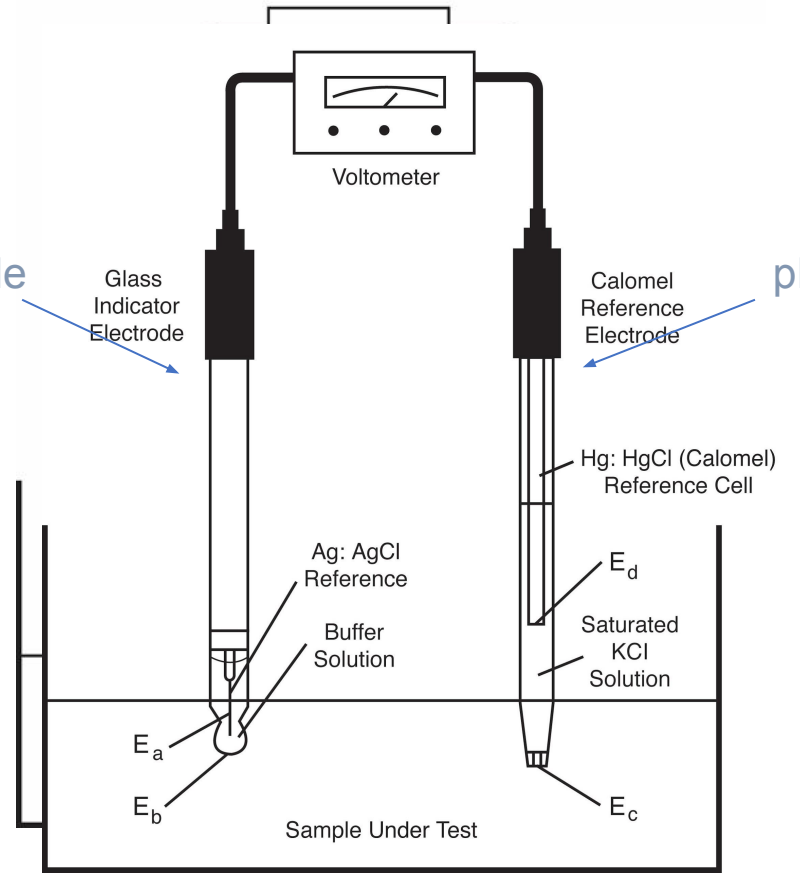
pH units represent a 10-fold change in hydrogen ion concentration

- **Beer has a pH = 4, $[H^+]$ = ?**
  - **pH = - log $[H^+]$**
  - **4 = - log $[H^+]$**
  - **$[H^+] = 10^{-4}$ mol/L**



http://pngimg.com/uploads/beer/beer_PNG2376.png

pH Meter



http://chem1.com/acad/webtext/acid2/acid2-images/tit-pHMeter.jpg

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

http://chem1.com/acad/webtext/acid2/acid2-images/tit-pHMeter.jpg

Accuracy with at least ±0.01 pH Accuracy

Not rec dec me

with

Accura

pH and Sample Temperature

T (°C)	K_W (mol^2 dm^6)	pH
0	0.114×10^{-14}	7.47
25	1.008×10^{-14}	7.00
50	5.476×10^{-14}	6.63
100	51.3×10^{-14}	6.14

- 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.

https://www.westlab.com/blog/2017/11/15/how-does-temperature-affect-ph

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

1. Attaie, R., P. J. Whalem, K. M. Shahani, and M. A. (Vic) AMER. 1987. Inhibition of Growth of Staphylococcus aureus during Production of Acidophilus Yogurt. J. Food Prot. 50:224–228.
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).
3. Kim, Y.-S., Z. Zheng, and D.-H. Shin. 2008. Growth Inhibitory Effects of Kimchi (Korean Traditional Fermented Vegetable Product) against Bacillis cereus, Listeria monocytogenes, and Staphylococcus aureus. J. Food Prot. 71:325–332.
4. Lücke, F. K. 2014. Quality improvement and fermentation control in meat products. Advances in Fermented Foods and Beverages: Improving Quality, Technologies and Health Benefits. Elsevier Ltd.
5. Mheen, T.-I., and T.-W. Kwon. 1984. Effect of Temperature and Salt Concentration on Kimchi Fermentation. Korean J. Food Sci. Technol. 16:443–450.
6. Pederson, C. S., and M. N. Albury. 1969. The Sauerkraut Fermentation.
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**;
8. Tamime & Deeth, 1980.
9. Acharya, S. Nummer, B.A. Vegetable lactic acid fermentations under the food and drug administration model food code: risk analysis and safe processing guide. Advancement of the Science. Vol. 84. No. 5. December 2021.
10. Fadhil, R., Hayati, R. Agustina, R. Quality Characteristics of Sauerkraut from Cabbage (Brassica oleracea)during Fermentation and Variation of Salt Concentration. International Journal of Scientific & Technological Research. Vol. 8 (10) October 2019.
11. Chapman, B., Seymour, N., Bryant, V. Handling Fermentation at Retail. Short Course, NC State University. December 2019.

QUESTIONS & ANSWERS

Amanda J. Kinchla

Kinchla@umass.edu

University of Massachusetts Amherst

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)

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 entertoxin, 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

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

This slide was modified based on content sourced by:
Retail HACCP Validation and Verification
Chapman, B., Seymour, N., Bryant, V. Handling Fermentation at Retail. Short Course, NC State University. December 2019.

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**