Science You Can Eat!
Food Science

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Goals for today

- Go team!
  - Educate you about food science so you can coach your team!
  - Get you to the 'Google search' level
  - Learn how to make a salinometer
  - Demonstrate calibration of salinometer
- What's happening??
  - Event structure
- **Ask questions at any point!**

What are examples of fermented foods?


McILHENNY CO.
TABASCO
BRAND
PEPPER SAUCE


HEINZ
APPLE CIDER
VINEGAR


KIKKOMAN
Soy Sauce


BUBBIES
KOSHER DILL PICKLES
NET CONTENTS 33 FL. OZ. (1.03 QT) 976 mL

Are fermented foods healthy?

- Prebiotic production through enzymatic carbohydrate breakdown during fermentation
- Ease of digestion
  - Lactose intolerance
  - Protein and carbohydrate breakdown
- Probiotic consumption
- Improved gut microbiome benefits immune system

All fermented foods are pickled, but not all pickles are fermented!

Fermentation vs. Pickling

- Focus of Division B Food: Fermentation & Pickling

	Fermentation	Pickling
Process	Controlled microbial growth	Direct acid addition
Flavor	Complex	One dimensional
Speed	Slow	Fast
Preserving liquid	Lactic acid and salt solution (brine)	Vinegar
Storage	Refrigeration	Shelf stable

Check out the pickles!

Thank you Mt. Olive Pickles!

Enzymes: Nature's Way of Fighting Uphill Battles

- Name ends in –ase; beginning of the word is substrate
  - Lactase – enzyme that breaks down lactose
- Proteins
- Functions based on shape recognition

Methods of Preservation

- Slow down or stop enzymatic bioprocesses in microbes
  - Decrease pH – increase acidity
  - Decrease water availability – decrease water activity
  - Thermal processes
  - Increase solution ionic strength

Method of Preservation: Decreasing pH

Direct addition of acid = pickling

Fermentation

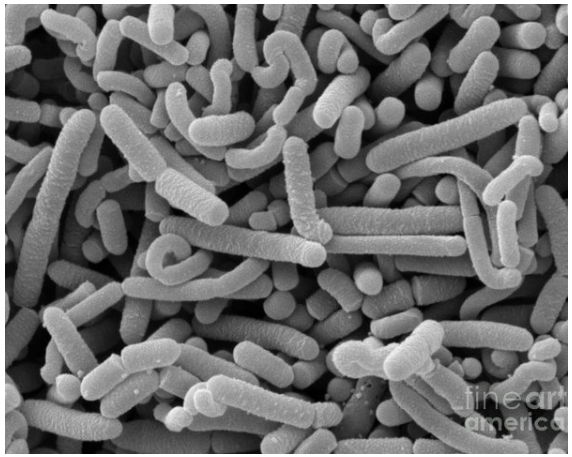
In a Pickle:
Acidification / Pickling

- Addition of acid, typically vinegar
- <pH 4.6 prevents growth of pathogens
- Main organism of concern *clostridium botulinum*
- Examples
  - Beets
  - Cucumbers
  - Eggs

Fermentation

- Studied by zymologist
- Desired microorganisms produce an acid that inhibits other bacteria from being able to grow.
- Often started in a brine (salt) solution using naturally present bacteria.
- Types of foods fermented
  - Vegetables – pickles, sauerkraut, kimchi, soybeans (tempeh, miso, Nattō, soy sauce), chocolate, coffee, tea (Kombucha), peppers (giardiniera)
  - Meats – salami
  - Milk – yogurt, cheeses, Kefir, crème fraîche
  - Breads – sourdough
  - Fruits – apple cider, wine
  - Fish – fish sauce

Fermentation

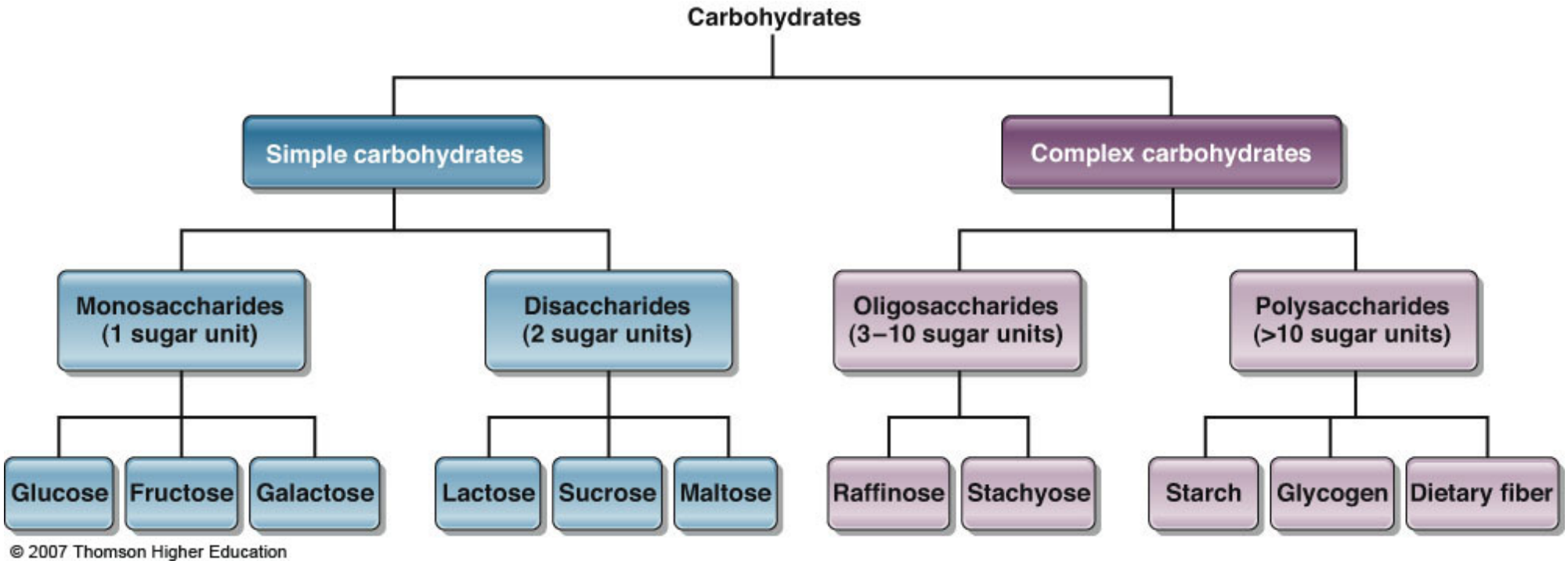


Lactobacillus bacteria
Lactic acid bacteria (LAB)

Carbohydrate in food

Lactic acid
Carbon dioxide
Ethanol

- Homolactic
  - Anaerobic
  - Produces lactic acid
- Heterolactic
  - Aerobic
  - Produces lactic acid, ethanol & carbon dioxide



Reducing vs. non-reducing sugars

Reducing sugars can reduce other compounds

All monosaccharides, lactose and maltose are reducing

Sucrose is not reducing

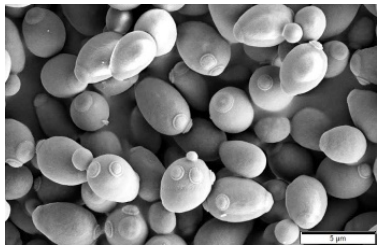
Fig. 5-6, p. 130

Fermentation Types

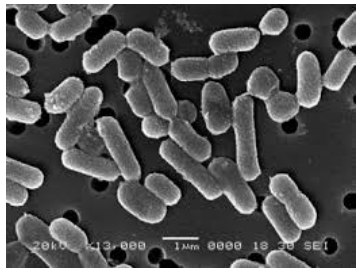
- Lactic acid fermentation
  - Pickles, sauerkraut, kimchi, yogurt, kefir
- Yeast fermentation
  - Anaerobic
  - Produces ethanol and carbon dioxide
  - Beer, wine, sourdough

Identification of organism

- Yeast-fungus
  - *Saccharomyces cerevisiae* (bread)
  - Aerobically or anaerobically



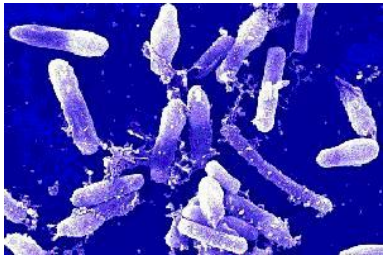
- **L**actic **A**cid **B**acteria (LAB)
  - Lactobacillus
    - Homolactic
    - Yogurt, souring vegetables, making sausage
  - Leuconostoc
    - Heterolactic
    - used to sour vegetables
  - Streptococcus *thermophiles*
    - Homolactic
    - Yogurt



Identification of organism

- Acetobactor, Acetic Acid Bacteria –
  - chocolate & vinegar

- Bacillus species
  - spore producing bacteria
  - chocolate



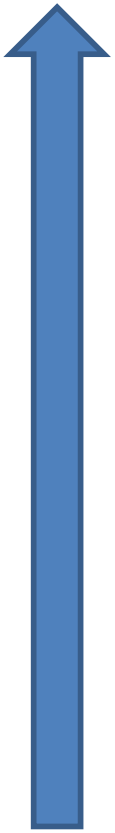
- Mold species
  - penicillium - Gorgonzola, blue cheese
  - rizopus species - Tempeh

Method of preservation: Controlling water activity

Water activity is the amount of water available for chemical reactions or microbial growth

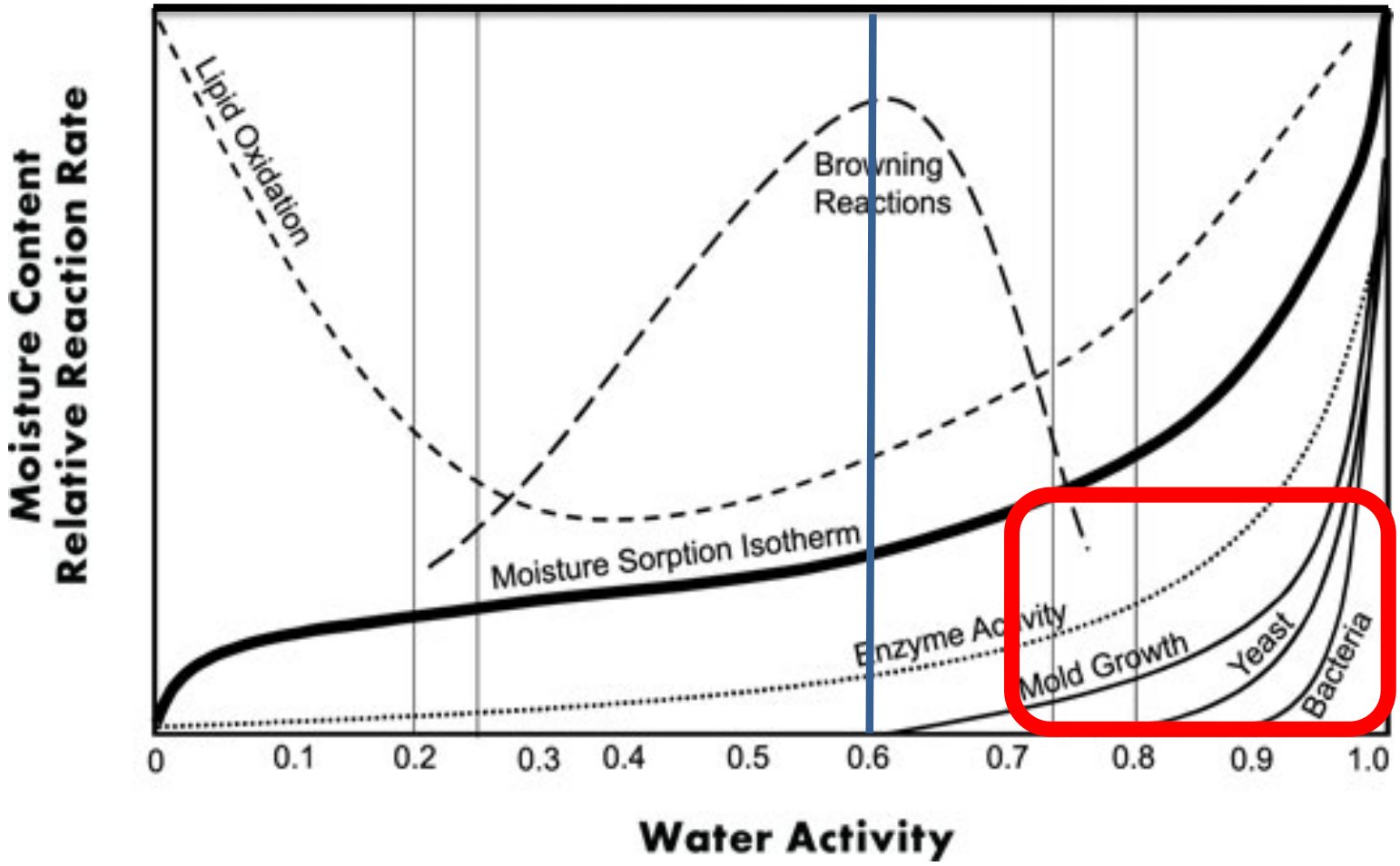
Water activity  Water content

Water activity range
0.0 - 1.0



Food	a_w
Milk	0.99
Fruits and vegetables	0.97-0.99
Meats	0.91
Fudge sauce	0.83
Salami	0.82
Jams and jellies	0.80
Soy sauce	0.80
Honey	0.75
Peanut butter	0.70
Crackers	0.30
Milk powder	>0.2

Microbial growth cut off



Water activity map (adapted from Labuza)

And now, the event and how it will work

TIPS

- Read the rules
- Check for NC clarifications (applies to Regionals and States)
- Bring a salinometer
- Bring one cheat sheet (8½” x 11”, both sides)
- Check safety requirements for goggles, clothing, and hair
- Bring a kit of allowed materials
- Read the rules again, especially safety regulations

Possible lab activities or questions

- Is it a reducing sugar?
  - Determined using Benedicts test
- What sugar is being fermented?
  - Shown an image of yeast growth with balloon inflation
  - Identify if fermented sugar is fructose, lactose, sucrose or sucralose
- Measure density of brines or moisture expressed from pickle
- Measure moisture content of pickle

How to make a Salinometer/Hydrometer for this event (and for Water Quality!)

- Keep it simple (10% of score just for bringing one in)
  - Distilled water
  - Any table salt at room temperature
  - Tube (straw, pipet)
  - Ballast/plug (modeling clay, sand, closed bottom, clip)
  - Calibrated for a 500mL beaker
    - Calibration information is optional but if used must be included in the 1 page (2 sides) of the cheat sheet
- Decide amount of ballast in 0% salinity water
- Take a sample kit today!

Calibrating your salinometer

- Make first mark at 0% or 1% (highest mark on straw)
- Only need to identify salt content from 1% to 10% ± 1% regionals, ± 0.5% state/nationals
- Make 2L 10% solution (10g salt/100mL solution)
- Use 500mL for calibrating at 10%
- Use the rest to make dilutions
  - Ex: dilute 500mL of the 10% solution + 500mL water to make a 5% solution
- Four solutions is adequate to calibrate (two is skimpy)
- Make calibration marks on device at liquid surface

Resources

- The National SO Website www.soinc.org
- Standard of identity: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?CFRPart=114&showFR=1
- Nutrition labeling laws in USA: https://en.wikipedia.org/wiki/Nutrition_facts_label
- Fermentation in food: https://en.wikipedia.org/wiki/Fermentation_in_food_processing
- Pickling: https://www.seriouseats.com/2017/08/preserving-pickle-cucumber-science-acidity.html
- Salinometer example: https://www.soinc.org/sites/default/files/uploaded_files/Making%20A%20Simple%20Salinometer12_0.pdf

THANK YOU!

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- Wendy Cook, St. Timothy's School
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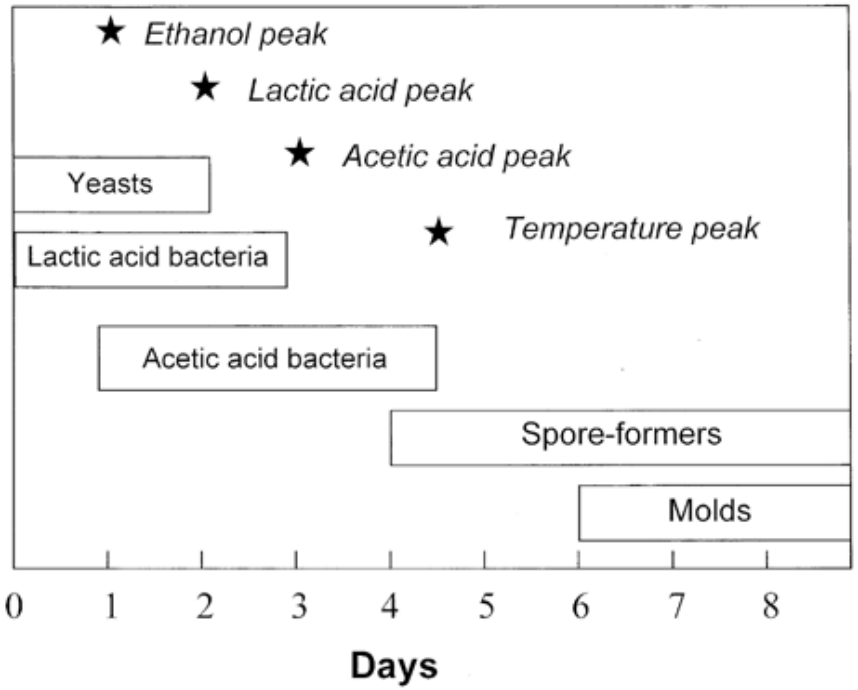
- Mt. Olive Pickles
  - Donating pickles and sponsoring SO!

Production of Chemical Feedstocks

Current Commercial Fermentation Processes Available for Feedstocks							
Alcohols & Ketones	Ethanol Butinol BDO Acetone	Organic Acids	Citric Lactic Succinic	Polymers	Xanthan PHA	Antibiotics	Beta-Lactam Tetracycline Clavulic Acid
Amino Acids	MSG Lysine Threonine Tryptophan	Biogas	Methane	Vitamins	Vitamin C Vitamin B2 Vitamin B12	Industrial Enzymes	Amylase Cellulase Lipase Prolease
Future Development based on Current Research							
Alkanes	Nonane Tetradecane	Olefins	Butadiene Isoprene Propene Farnesene		Amines		Histamine Tyramine
Dyes	Various(indigo)				Microbial Oils		Biodiesel

Making Chocolate



- Naturally present yeast and microbes ferment the pulp surrounding the seeds. Acid produced during fermentation starts to break down the seed coat.
- Yeast begin fermentation consuming sucrose and producing ethanol and acid in an oxygen-rich environment.
- When enough acid is present and oxygen is reduced, lactic acid bacteria begin to grow producing more acid.
- Finally, the beans are stirred to incorporate oxygen and allow acetic acid bacteria to grow, consuming ethanol and producing acetic acid.
- Acids and enzymes produced by the microbes breakdown proteins, carbohydrates and lipids to produce chocolate flavor when roasting.
- Beans are roasted or baked to kill all the microbes and prevent further fermentation and other organisms from growing.