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Fermentation

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Outline:

- What is fermentation
  - Wild ferment vs. using a starter culture
- FATTOM
- Different fermentation processes and food safety concerns
- Biogenic amines
- Examples of fermentation processes

Fermentation

What is Fermentation

- “Ferments are the creative space between fresh and rotten food, where most of human culture’s most prized delicacies and culinary achievements exist”. (Katz. S, The art of fermentation: 2012)
- A metabolic process where microorganisms’ organisms convert carbohydrates, such as starch or sugars, into alcohol, acids and other by-products.
- Preserves foods that would otherwise spoil and increases the shelf-life.
- Fermentation can be:
  - Wild (a natural process where microorganisms can be naturally occurring on the surface of food) or
  - Cultured (microorganisms deliberately added to the food)

Wild Fermentation

- Naturally occurring fermentations.
- The result of microorganisms already present on the food substrate, or on the equipment and utensils that contact the food substrate.
- Commonly occur with the aid of added salt (e.g. kimchi) or can also occur spontaneously (e.g. fermented lemons)
- Food safety concerns with wild fermentation:
  - Situations where there are possible low number of wild microorganisms present for fermentation
  - Poor conditions for the fermentation, e.g., (temperature is too high or too low, pH is not lowered fast enough to prevent growth of pathogenic organisms)

Fermentations using starter culture

- Desirable microbial agents are added to initiate fermentation.
- Using starter culture can shorten the fermentation time and may lead to reduction in the likelihood of growth of pathogenic microorganisms and mold.
- Example of microbial agents added:
  - Lactic Acid Bacteria (LAB)
  - Yeast (e.g. *Saccharomyces cerevisiae)*
  - SCOBY
  - Kefir grains
- Backslopping (addition of a small amount of a previously fermented batch to the raw food e.g. sourdough bread), is another

How Does Fermentation Preserves and Increases The Shelf-life of Food

FATTOM

- Food
- Acidity
- Time
- Temperature
- Oxygen
- Moisture

Different Fermentation Processes

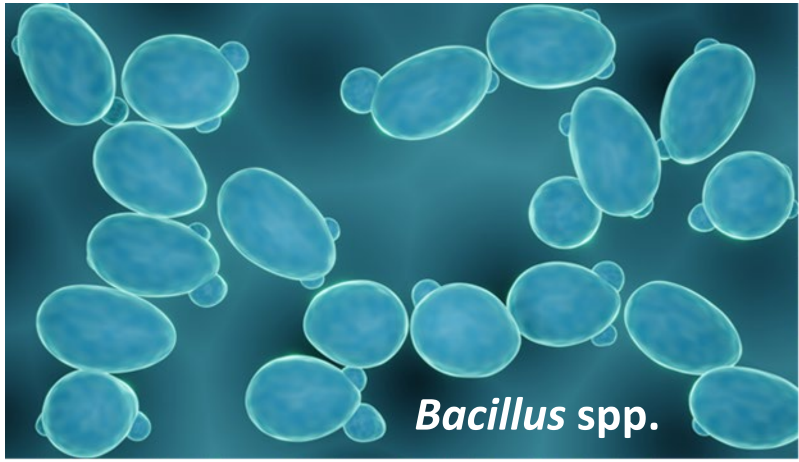
- Acidic fermentation
  - Lactic acid fermentation: Lactobacilli bacteria (LAB) → sugar→ lactic acid
  - Acetic acid fermentation: Acetobacter bacteria → alcohol → acetic acid
- Alkaline fermentation
  - Bacillus or Fungi (e.g. Geotrichum)→ Protein → ammonia
- Ethanol fermentation/alcohol fermentation
  - Yeast→ sugar and carbohydrates→ alcohol + carbon dioxide
- Symbiotic culture of bacteria and yeast/SCOBY based and combined fermentations (more than one type of starter microorganisms are used)
  - symbiotic culture (e.g. bacteria and yeast)→ sugar→ alcohol + acetic acid

Common Features of LAB Fermentation

- Low pH (pH < 4.6)
- Involve lactic acid bacteria, i.e., produce lactic acid, some produce other acids (acetic, malic, etc.)
- Need source of sugar
- Some produce CO_2
- Don't need oxygen
- Sensitive to temperatures (e.g. optimal LAB fermentation temperature is 20°C to 25°C)

Combination of low pH and competitive microflora contributes to the safety of the LAB fermented food.

Common Features of Alkaline Fermentation



- Also referred to as high alkalinity curing.
- Results in a product with high pH (above 7).
- Starter culture most often includes Bacillus spp. and/or fungi (e.g. Geotrichum candidum).
- Processing can include a soaking step (food safety actions include acidification of water or soaking under refrigeration).
- Foods produced with alkaline fermentation or alkaline processing may still require other intrinsic and extrinsic factors (i.e., water activity and refrigeration) to assure safety.

Food Safety Concerns

- The main concern with fermentation is from raw materials and fermentation failure
- Fermentation does not replace general food safety principles (i.e., food hygiene)
- Other areas of concern are:
  - Delayed/stunted fermentation
  - Insufficient salt
  - Poor sanitation and post ferment handling and process
  - Contamination by spoilage microorganisms (yeast and moulds, polysaccharide producers)

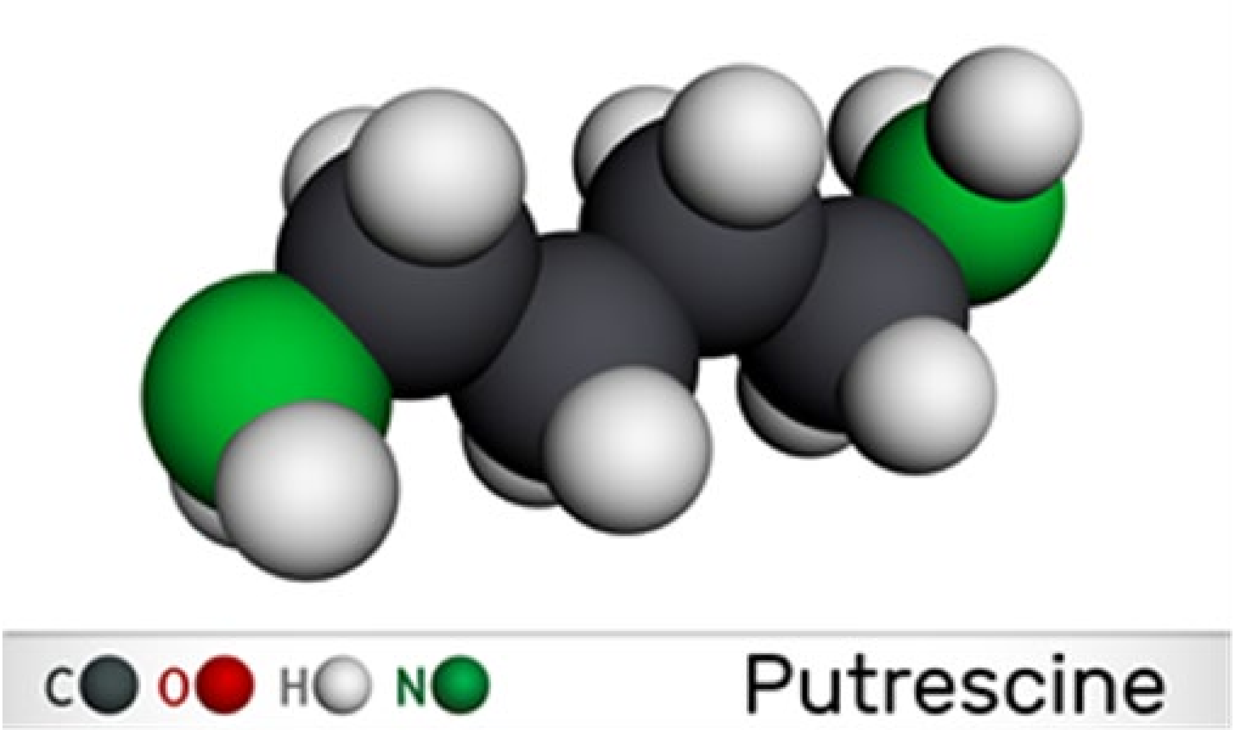
Pathogens/by-products of concern

- Biogenic amines
- Alcohol
- Moulds (mycotoxins)
- *Listeria monocytogenes*
- *Salmonella*
- *E. coli* O157:H7
- *Staphylococcus aureus*
- *Clostridium botulinum*

Biogenic Amines (BAs)

- BAs are organic, basic, nitrogenous compounds, mainly formed through decarboxylation of amino acids.
- The main BAs are histamine, tyramine, β-phenylethylamine, putrescine, cadaverine and spermidine
- Can be by-product of fermentation of soybean (natto, miso), dairy (cheese), vegetables (kimchi), meat (sausages), and fish (fish sauce, fesikh).
- There are no required testing of BAs in fermented food

- Consumption of large amount of BAs can result in:
  - Nausea
  - Respiratory distress
  - Hot flushing and sweating
  - Heart palpitations
  - Headache
  - Bright red rash
  - Burning sensations in the mouth
  - Alterations in blood pressure
  - Diarrhea
  - Hypertensive crises



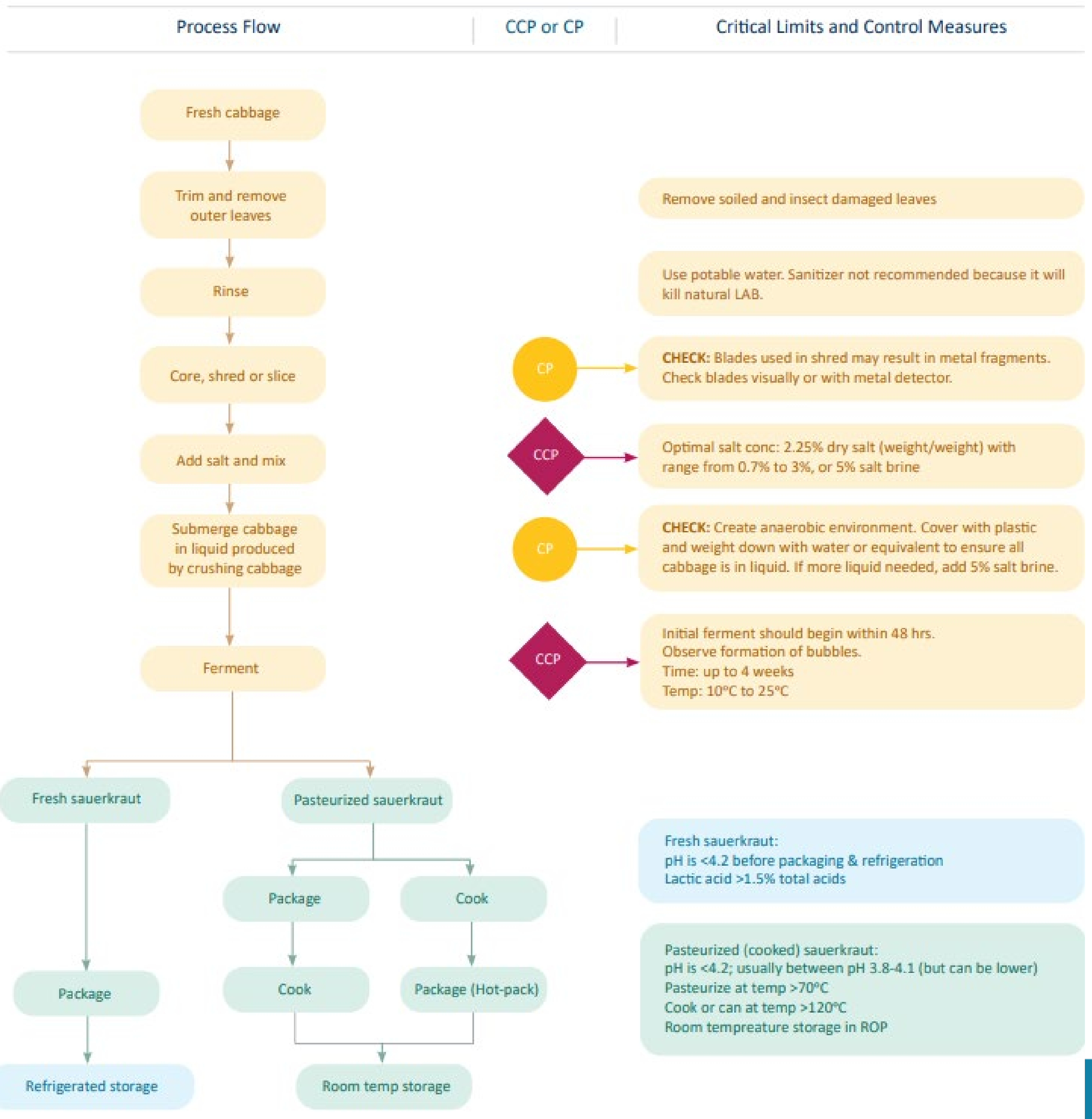
Lower the risk of Biogenic Amines by:

- Maintaining hygienic food production:
  - the facility is clean and sanitary,
  - handling practices are hygienic to limit bacteriophages and bacteria that interfere with the culture process;
- Optimizing the fermentation, for example:
  - regulating time, temperature, moisture content and salt concentrations,
  - using good quality ingredients;
- Purchasing commercial starter culture and/or verifying quality starter culture
- Monitoring expected culture activity occurs within correct timeframe
- Monitoring for expected pH

Sauerkraut

- Fermented Cabbage
- lactic acid bacteria (LAB)
- Commonly wild, can use back-slopping. In large industry starter culture is used to control fermentation.
- Cabbage is chopped, mixed with salt at optimal concentration of 2.25% (range 0.8 to 3% NaCl), and fermented for weeks to months at15°C to 20°C with upper limit of 25°C and lower limit of 10°C
- Final product has a pH of 4.2 or below.
- Hazards of concern include:
  - Spoilage yeasts and molds that grow on surface
  - *E. coli* from unsanitary conditions, and pathogens on raw materials including *Salmonella*, *Listeria* and *Clostridium* spp., however, these are unlikely to survive acidic pH development during fermentation
  - Biogenic amine formation

Sauerkraut Process Flow and Control



Fesikh

- Fermented fish
- Organisms involved in fermentation are *Lactobacillus casei* and *Lactobacillus* spp.
- Wild fermentation
- Fish is washed, eviscerated, salted and fermented. The ingredients are fish (typically mullet) and salt
- Final product has a pH of < 6.5 and product is refrigerated.
- Hazards of concern include:
  - *Clostridium botulinum*
  - Biogenic amine formation (histamine and tyramine)

Food safety measures for fesikh

- Use fresh fish and store at 3.3°C or lower
- Wash and eviscerate the fish prior to fermentation
- Use appropriate salt concentrations (6-10% concentration)
- Ensure the recommended final pH ($pH<6.5$) and water activity ($Aw<0.97$) parameters are achieved
- Refrigerate fish during storage to increase shelf life
- Post-processing such as heat treatment (i.e. exposed to temperature over 85°C for 5 minutes) is recommended, as it can reduces the risk of botulism.

Fesikh Process Flow and Control

Process Flow	CCP	Critical Limits and Control Measures
Acquiring fresh fish	Yes	Refrigerated below 3.3 ° C to avoid growth of pathogens. Total volatile basic nitrogen (TVB-N) for white fish should be < 20mg N/100g for freshness.
Washing fish		
Thorough fish evisceration	Yes	Eviscerate to decrease the risk of botulinum.
Draining fish		
Putrefaction up to 24hrs at 30° C		
Salt curing fish by layering with salt for weeks to months at 6-10% concentration	Yes	Thiobarbituric acid (TBA) should be <3 in a very good salted fish product. Final pH should be between 6-6.5, and available water <0.97.
Shelf life of up to 2wks at lower salt concentrations and 3 months and higher salt concentrations, stored at <3.3 °C	Yes	Ensure the final product is stored at 3.3 °C or lower to decrease the risk of botulinum.

In Summary

- Historically, fermentation is performed as a method of food preservation, where if done correctly, microorganisms break down sugars and starches into ammonia, alcohols and/or acids, preserving food so people can store it for longer periods of time without it spoiling.
- Main food safety concerns with fermentation are:
  - Contaminated raw materials and
  - Fermentation failure/delayed or stunted fermentation
- A food safety plan or process flow can assist with safe production of fermented products.

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