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 at 15°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

**Process Flow**

1. **Fresh cabbage**
2. Trim and remove outer leaves
3. Rinse
4. Core, shred or slice
5. Add salt and mix
6. Submerge cabbage in liquid produced by crushing cabbage
7. Ferment

**CCP or CP**

- **CP**
  - **CHECK**: Blades used in shred may result in metal fragments. Check blades visually or with metal detector.

- **CCP**
  - **CHECK**: Create anaerobic environment. Cover with plastic and weigh down with water or equivalent to ensure all cabbage is in liquid. If more liquid needed, add 5% salt brine.

- **CP**
  - Initial ferment should begin within 48 hrs.
  - Observe formation of bubbles.
  - Time: up to 4 weeks
  - Temp: 20°C to 25°C

**Critical Limits and Control Measures**

- Fresh sauerkraut: pH is <4.2 before packaging & refrigeration
- Lactic acid >1.5% total acids

- Pasteurized (cooked) sauerkraut:
  - pH is <4.2, usually between pH 3.8-4.1 (but can be lower)
  - Pasteurize at temp >70°C
  - Cook or can at temp >120°C
  - Room temperature storage in ROP
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

1. Acquiring fresh fish
2. Washing fish
3. Thorough fish evisceration
4. Draining fish
5. Putrefaction up to 24hrs at 30°C
6. Salt curing fish by layering with salt for weeks to months at 6-10% concentration
7. Shelf life of up to 2wks at lower salt concentrations and 3 months and higher salt concentrations, stored at <3.3 °C

Critical Limits and Control Measures:

- 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.
- Eviscerate to decrease the risk of botulinum.
- 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.
- 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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