Lesson 3

Fermented foods
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1. Introduction
Microorganisms involved in food fermentation

- Acetic acid bacteria (vinegar)
- Propionic acid bacteria (emmental cheese)
- Moulds (cheese, soy sauce, Sake, Tempeh)
- Lactic acid bacteria
- Yeasts
1.1. Lactic Acid Bacteria (LAB)

- Gram-positive
- Asporogenic
- Aerotolerant anaerobic (catalase negative)
- Ferment glucose producing:
  - Mainly lactic acid (homofermentatives)
  - Lactic acid, CO₂, ethanol/acetate (heterofermentatives)
Activities of LABs in food

- **Lactic fermentation**
- **Malolactic fermentation**

Malic acid $\rightarrow$ Lactic acid

Improves wines (reduces acidity, improves body and tasting..)

- **Antimicrobial activity**
  - Acid pH (3.5-4.5)
  - Organic acids (Lactic and Acetic)
  - Ethanol (heterofermentation)
  - Bacteriocins (Nisin)
  - \( \text{H}_2\text{O}_2 \)
  - Diacetyl…..

Health-promoting effects

- Relief lactose intolerance
- Stimulation of immune system (activate macrophages, increase levels of IgA and \( \gamma \)-interferon)
- Antitumor effects (reduce activity of enzymes that transform pro-carcinogens in carcinogens)
- Hypcholesterolaemic action
- Inhibition of gut pathogens (shorter duration of diarrhoea in human infants)
1.2. Yeasts

- *Saccharomyces cerevisiae*: (Fermentations of fruits and vegetables)
  - Aerobiosis: oxidation $\rightarrow$ CO$_2$ + H$_2$O (biomass)
  - Anaerobiosis: fermentation $\rightarrow$ ethanol + CO$_2$

- *Debaryomyces hansenii*: halotolerant (meat in brine, fermented sausages)

- *Kluyveromyces marxianus* (milk fermentation: Kefir, Koumiss, butter)
  Hydrolyze lactose and ferments galactose

- *Schizosaccharomyces pombe* (tropical fermented beverages)

- *Zygosaccharomyces rouxii*: osmo-halo-tolerant (fermentation of vegetables in brine)
2. Fermented Meats

Unprocessed (non-pasteurized) Meat (decontamination with acid solutions)

+ Salts + Spices + Glucose + Starters

15-40°C / 20-60 h (controlled humidity)

Smoked, drying, pasteurization, refrigeration?

LABs (*Lactobacillus, Pediococcus*)

Nitrate-reducing bacteria (*Stph., Micrococcus*)

Lipolytic (*Micrococ, Penicillus, Debaryomyces*)
3. Fish fermentations

Very perishable

neutral pH,†† water and soluble nutrients (nitrogen compounds)

*Rigor Mortis* limited (pH > 6.2)

- **Fish sauce** (*Nam Pla*): Fish, shellfish (viscera, plankton) + 25% NaCl
  
  3-18 months / 25-35°C : fermentation + autolysis

  Filtration and maturation (months)

- **Fish paste**: partially dehydrated (sun-dried, salted), limited autolysis

- **Fish + vegetables** (*Izushi*): fish meat + 10-20% salt ➔ Sun-dried

Botulism ➔ Lactic fermentation (< 1 month) ➔ Vegetables (rice, garlic)
4. Fermented Milk

4.1. Cheese

4.2. Yoghurt
4.1. Cheese

(Consolidated curd of milk solids in which milk fat is entrapped by coagulated casein)

Mild Pasteurization  ➔  Starters addition  ➔  Coagulation (rennet)  ➔  (1-16 hours)

Ripening  ➔  Salt added?  ➔  Whey extraction (heat, mechanical action)  ➔  (1 week to > 1 year)

Starters:

*Lc. lactis* + *Lc. cremoris*: Low cooking temperature

*Strep. thermophilus* + *Lb. bulgaricus*: High cooking temperature

+ *Propionibacterium freudenreichii*: Emmental

+ *Penicillium roqueforti*: Mould ripened (Roquefort, Cabrales, Blue)

+ *Penicillium camemberti*: Soft cheese (Brie, Camembert)

Problems: Antibiotics, Phage infections
4.2. Yoghurt

Raw milk → Addition of milk powder → Homogenize

(↑ solids not fat)

Inoculation (Pack) → Pasteurization (80-90°C / 30 min)

(Lb. bulgaricus, Strep. thermophilus)

Incubation (3-4h /40-43°C) → Refrigeration (3 weeks)

pH: 4.5 → pH: < 4.0

Pasteurization

Cooperative fermentation:

Strep. thermophilus → Formic acid, piruvate, CO₂

Peptides, aas

Lb. bulgaricus

Problems:

- Phage infections
- Antibiotics
5. Vegetable Fermentations

Natural Fermentation (no blanching)

**Salting:** selection of LABs + inhibition of pectinolytic enzymes

*Leuco. mesenteroides* → *Lb. brevis + Pediococcus cerevisiae* → *Lb. plantarum*

Acidification (pH < 3.8) + anaerobiosis + aromatic substances

**Problems:**

Listeriosis

Spoilage by yeasts (inhibition of LABs due to low pH → ↑ [saccharides])

!!Buffered brines!!