



THE UNIVERSITY OF  
MELBOURNE

# FOOD20006

## Food Microbiology and Safety

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# Food Biotechnology

## Intended Learning Outcomes

- Explain microbial fermentation and its use in food production

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# Food biotechnology

Food biotechnology can be broadly divided into traditional and modern technologies.

Fermentation of foods started as a method to preserve raw ingredients when they are abundant and to develop flavours and improve digestibility of food materials.

Fermentation is a very important part of traditional cultures and cuisines

Some modern approaches to food biotechnology include development of

- new foods using fermentation
- microbial conversion of substrates to products
- biofortification of foods to change their nutritional value or digestibility

In this lecture we shall explore some examples of fermented food and microbial food products



# Fermented foods and starter cultures

- Fermentation means that raw materials are converted by microbes to fermented food
- It requires the growth and metabolism of the microbes which may be bacteria or fungi (yeast and molds)
- nutrients in food are used to generate energy for microbial cell growth
- all kinds of raw materials are fermented: milk, meat, fish, vegetables
- many processes are of ancient origin, but we now know much more about the microbes, their activity and the biochemical processes

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# Fermented food: examples

Food Groups	Examples
Dairy	cheeses, yoghurt, buttermilk, sour cream, dahi, kumiss, kefir
Meat	salami, chorizo, pickled meat, nahm
Cereals	Assignment Project Exam Help breads, dosa, miso
Fruits/vegetables	<a href="https://powcoder.com">https://powcoder.com</a> olives, sauerkraut, kimchi, aachar, pickled fruits, pickled vegetables
Legumes	Add WeChat powcoder tofu, tempeh, soy sauce, miso, natto
Fish	fish sauce, Hákarl, bagoong, tarama, paak, izushi
Beverages	beer, wine, distilled spirits, coffee, cocoa
Starch crop	fermented potato, sweet potato, cassava, bananas
miscellaneous	vinegar, fermented eggs,

# Fermented food: examples

Sake  
Tempeh  
Kombucha  
Shrimp paste  
Miso  
Coffee  
Chocolate  
Kimchi  
Bread  
Sourdough  
bread  
Yoghurt



Beer  
Fish sauce  
Mirin  
Soy sauce  
Sauerkraut  
Stout  
Olives  
Vegemite  
Miso  
Salami  
Kefir



# Microorganisms involved

- There many different types of fermented foods and there are diverse bacteria, yeasts those foods and moulds are associated with such foods

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- A fermented food may be made with a single species or mixture of different bacteria, or combination of bacteria/yeasts/molds

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- if a mixture is involved , then should they should be able to work together (synergistic, not antagonistic) or in sequence
- some cases, the growth of different species is sequential, not simultaneous during fermentation (e.g. fish sauce, yoghurt)



# Sources of the microorganisms involved in fermentation

## Natural fermentation

- using flora of raw ingredients, often variable outcomes

Example: Sauerkraut

- “back-slopping” using some of last batch to inoculate next batch

Example Sourdough or yoghurt

## Controlled fermentation

- pure cultures added. These are often commercially produced for industry
- Raw ingredients may be heated first to kill off natural flora
- high levels, e.g.  $> 10^6$  microbes/ml added to speed up processing and overwhelm any residual flora
- specific growth conditions used to optimise growth
- large scale, consistent, less chance of failure



# Kimchi: Lactic acid fermentation

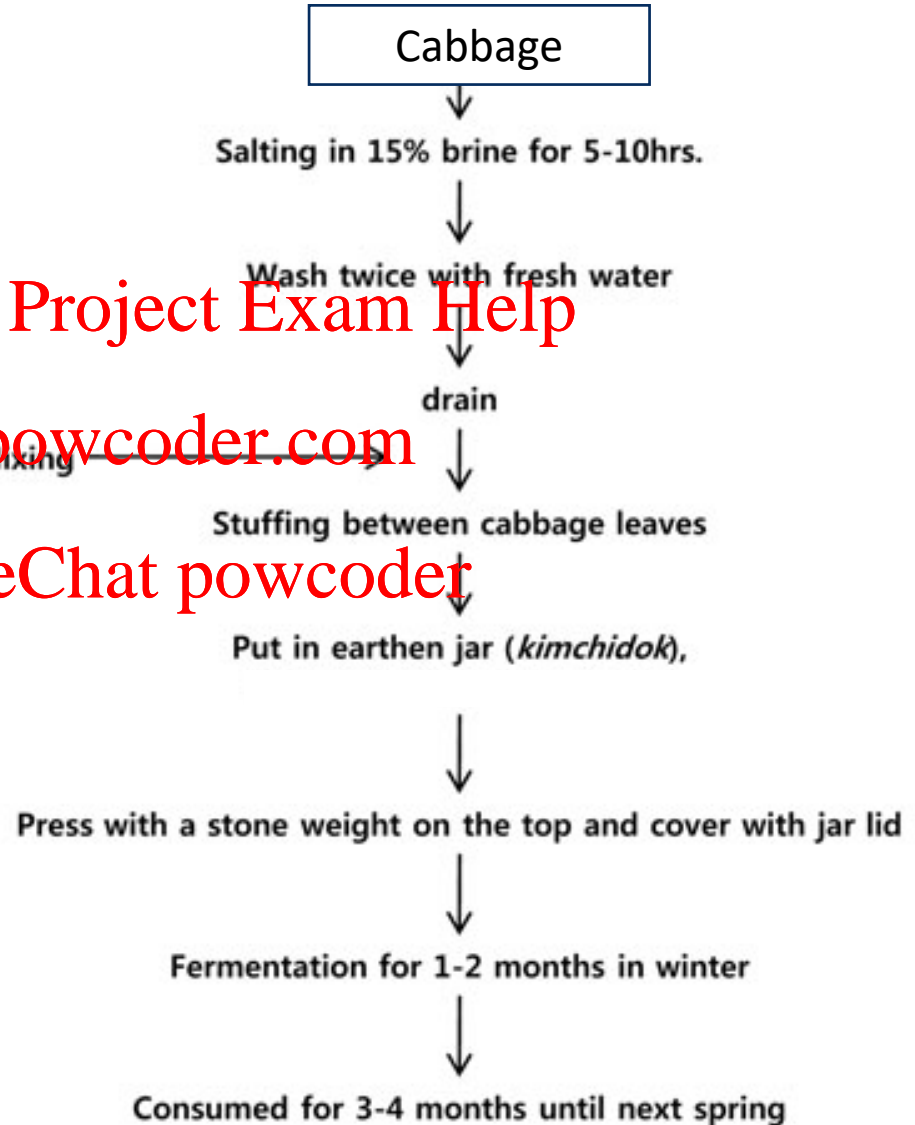
Example of natural fermentation  
which relies on natural flora of plants  
and ingredients

Shredded radish  
Chilli  
Garlic  
Green onion  
Ginger  
Fish sauce or oyster sauce

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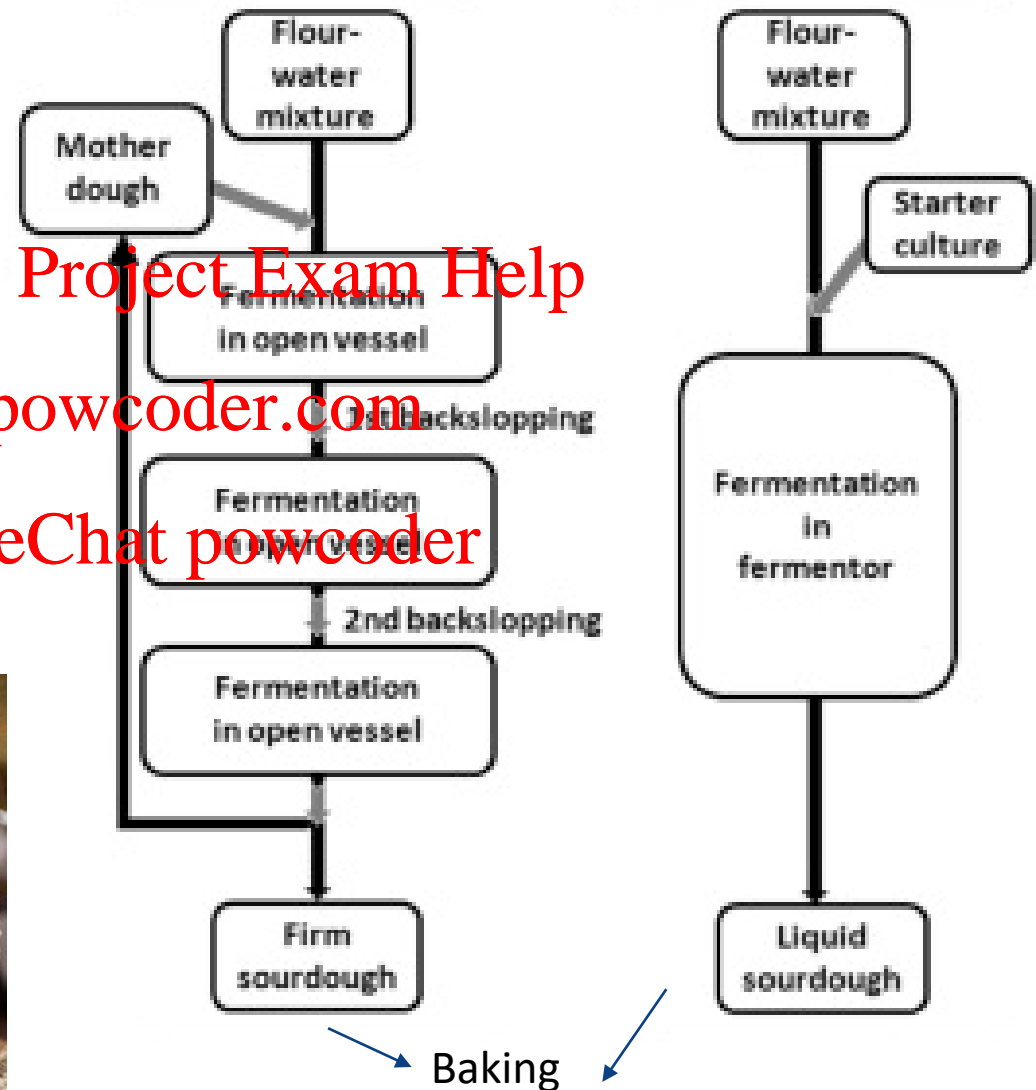
# Sourdough: Lactic acid fermentation

Two ways of adding cultures: back slopping vs starter culture inoculation

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# Yoghurt: example of a dairy fermentation

- Yoghurt fermentation (plain yoghurt)
- a semisolid mass, from coagulation of milk by starter-culture bacteria
- sharp, acidic taste, smooth texture
- flavour— acetaldehyde (aroma), lactate (tart taste), diacetyl and acetate
- 90% of taste is due to the acetaldehyde
- many variants of plain yoghurt

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# Batch process of yoghurt production:

1. Mix ingredients, standardize (can +/- water, milk solids, etc.)
2. Heat by pasteurization (mandatory in Australia)
  - a. kills off pathogens, and reduces microorganisms that would compete with starter culture
  - b. destroys enzymes and immunoglobulins (may interfere)
  - c. also improves gel formation/texture (denatures whey proteins)
  - d. releases nutrients favourable to starter culture bacteria
3. homogenise – break fat globules down to smaller, more consistent size > smoother/creamier product
4. Starter culture added (44-46 °C)
5. 6 hrs incubation leads to ~pH 4.8 (lactic acid levels measured)
6. Rapidly cooled to 29 °C to stop further fermentation
7. Packaged and cooled to 4.4 °C and stored 24 hr ( to pH 4.3)

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# Starter cultures for yoghurt production:

*Streptococcus thermophilus* & *Lab. delbrueckii ssp. bulgaricus*

Initial ratio of 1:1

excellent for yoghurt fermentation

other bacteria may be added, such as “probiotic” species

e.g. *Lab. acidophilus*, *Bifidobacterium* spp.

-but don't compete well or survive well during fermentation

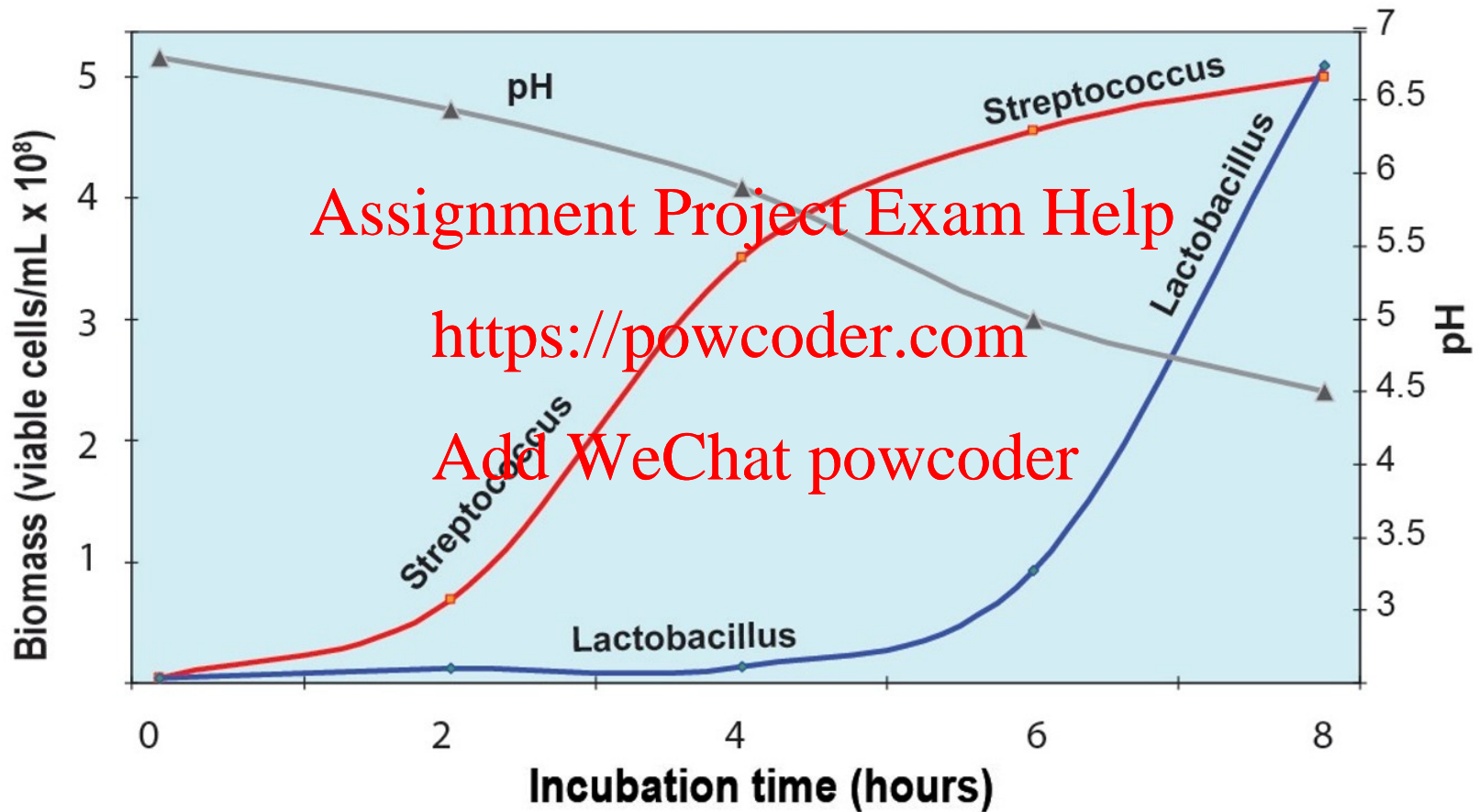
-so often added after fermentation

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# Yoghurt culture



*Streptococcus* produces formate which is used by *Lactobacillus* which in turn produces amino acids used by *Streptococcus*



# Protooperation: Growth of starter cultures in yoghurt production

Two strains show synergy or 'proto-cooperation'

## *Streptococcus*

- grows rapidly in oxygen, produces formic acid and CO<sub>2</sub>
- removes oxygen, and under anaerobic conditions formic acid & CO<sub>2</sub>
- stimulate growth of *Lactobacillus*

## *Lactobacillus* as good protease activity

- digests casein to amino acids (outside cells).
- Some of these (glycine, valine, leucine) are needed by *Streptococcus*, so stimulates its growth

pH drops to 5.5, then *Streptococcus* grows poorly while *Lactobacillus* grows further until pH is at target (pH 4.8)



# Inoculation of yoghurt



**Ingredients:** Milk solids (99%) (emulsifier (soy lecithin)), live lactic cultures (*L.bulgaricus*, *S.thermophilus*, *L.acidophilus*).

Starter culture.

In this case all of the ingredients for the yoghurt are in the sachet. This is for home use

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**Quantitative Information**

Approx. servings per sachet : 5

Serving Size: 200g of made-up yogurt

Average quantity per 100g (100g)

Energy	579kj	290kj
	139kcal	69kcal
Protein, total	4.9g	3.9g
- gluten*	<3ppm	<3ppm
Fat, total	7.4g	3.7g
- saturated	5.0g	2.5g
Carbohydrate, total	10.3g	5.2g
- sugars**	10.3g	5.2g
- lactose	10.3g	5.2g
Sodium	69mg	34mg
Calcium (31% of RDI***)	249mg	124mg

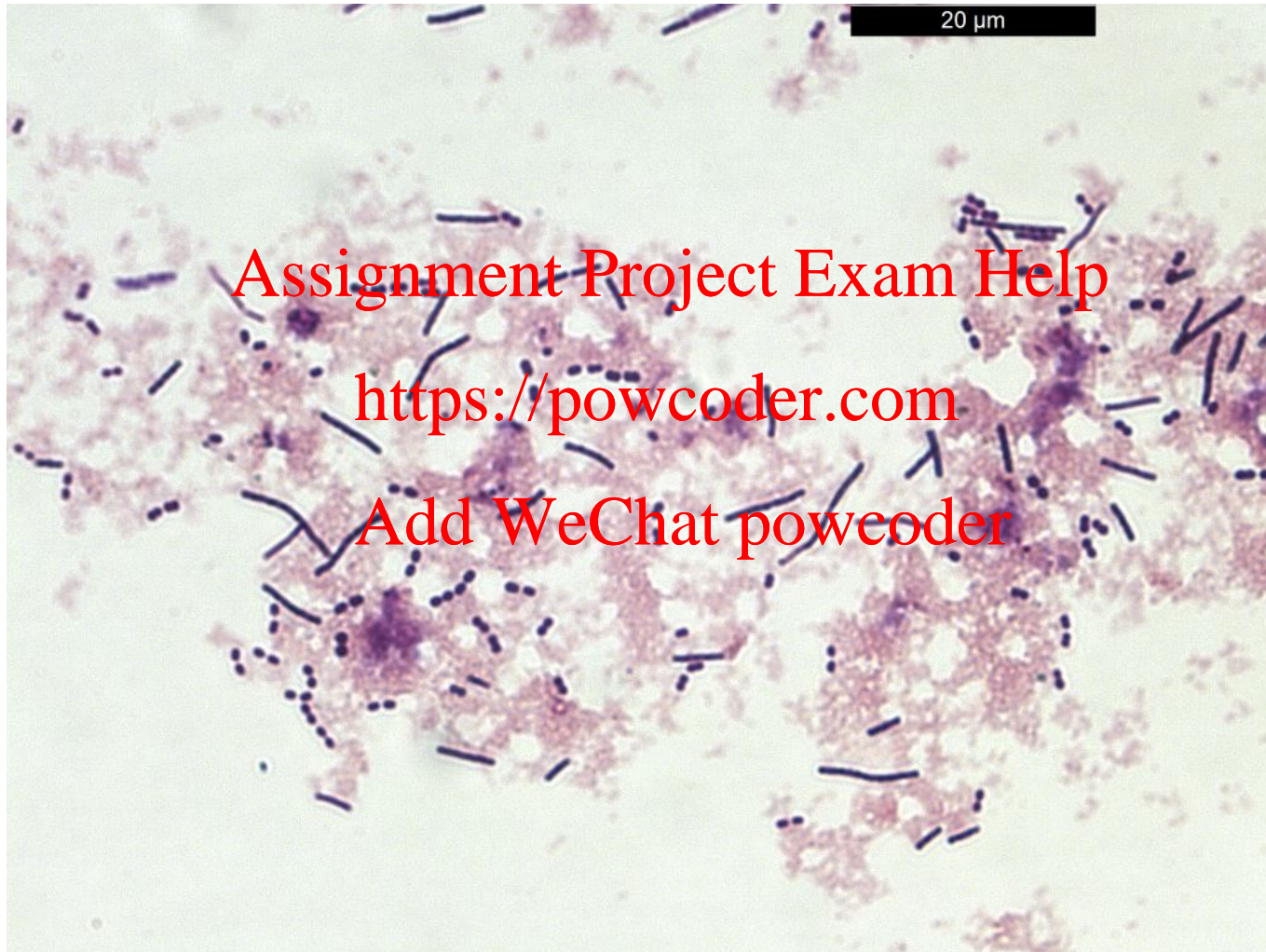
\*Nil detectable at testing.

\*\* Not all is added sugar, some of this is natural milk sugar (lactose).

\*\*\* % Recommended Dietary Intake.



# Live bacteria in yoghurt



Gram stain, HBJ



# Summary: Fermented food

- There are many types of fermented food
- Bacteria, yeasts and moulds used to ferment food might be part of the natural flora of animals or plants
- Starter cultures are pure cultures of characterised organisms which are safe to use to make food
- Lactic acid bacteria play a major role in food fermentation
- Examples: Kimchi, Sourdough bread, Yoghurt

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