Food and baverage

Besides macroscopic plants and animals, microbes are the major components of biological systems on this earth. Microbes are present everywhere – in soil, water, air, inside our bodies and that of other animals and plants. They are present even at sites where no other life-form could possibly exist–sites such as deep inside the geysers (thermal vents) where the temperature may be as high as 1000C, deep in the soil,under the layers of snow several metres thick, and in highly acidic environments. Microbes are diverse–protozoa, bacteria, fungi and microscopic animal and plant viruses, viroids and also prions that are proteinacious infectious agents. Microbes like bacteria and many fungi can be grown on nutritive media to form colonies (Figure 10.3), that can be seen with the naked eyes. Such cultures are useful in studies on micro-organisms.

What is fermentation- Fermentation is a natural process in which micro-organisms turn sugar into alcohol and carbon dioxide

1. Micro-organisms used for making fermented foods are called “starters”
2. Benefits of food fermentation:
3. Develop flavours, aromas and textures of food, e.g.
4. improvement of flavour and aromas, e.g. from coffee beans to coffee, from grapes to wine
5. Extend the shelf life of food, e.g. from milk to yoghurt and cheese
6. Improve the nutritional value of the product, e.g.
7. improved digestibility (e.g. from wheat to bread)
8. synthesis of probiotic compounds (e.g from milk to yoghurt)

Use of micro-organisms in food production

1. **Production of fermented food**, e.g.

a. Bacteria are used as the starter culture in the production of cheese and yoghurt
b. Mould is used in cheese ripening
c. Yeast is used in making bread and wine
d. Bacteria, mould and yeast are used in making soya sauce

2. **Added to enhance nutritional value of food**, e.g.

a. Bacteria as probiotics

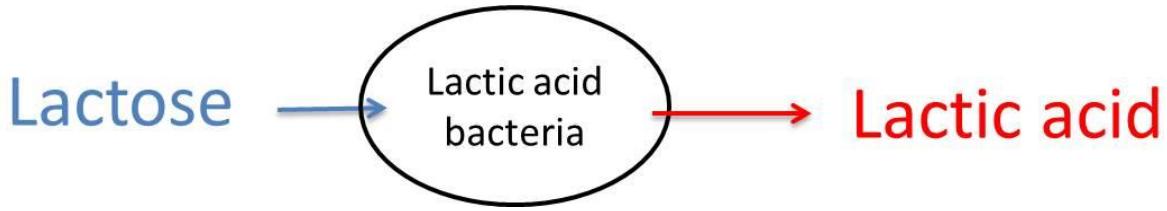
3. **Used as food sources directly**, e.g.

a. Black moss is a kind of blue-green algae

b. Chlorella and seaweed are green algae
c. Mycoprotein (i.e. protein from fungi) is the common ingredient in all Quorn products

Microbes in food and beverage- You would be surprised to know that we use microbes or products derived from them everyday.

1. **Lactic acid** -A common example is the production of curd from milk. Micro-organisms such as *Lactobacillus* and others commonly called lactic acid bacteria (LAB) grow in milk and convert it to curd. During growth, the LAB produce acids that coagulate and partially digest the milk proteins. A small amount of curd added to the fresh milk as inoculum or starter contain millions of LAB, which at suitable temperatures multiply, thus converting milk to curd, which also improves its nutritional quality by increasing vitamin B12. In our stomach too, the LAB play very beneficial role in checking disease causing microbes.



2. **Idli and dosa**- The dough, which is used for making foods such as *dosa* and *idli* is also fermented by bacteria. The puffed-up appearance of dough is due to the production of CO_2 gas. Can you tell which metabolic pathway is taking place resulting in the formation of CO_2 Where do you think the bacteria for these fermentations come from? Similarly the dough, which is used for making bread, is fermented using baker's yeast (*Saccharomyces cerevisiae*).
3. **Drinks**- A number of traditional drinks and foods are also made by fermentation by the microbes. 'Toddy', a traditional drink of some parts of southern India is made by fermenting sap from palms. Microbes are also used to ferment fish, soyabean and bambooshoots to make foods. Kombucha, thought to have been created in Eastern Russia/North Asia, is made by fermenting sweetened tea. It uses **yeasts** to break down sugars into ethanol and carbon dioxide and **bacteria** to break down the ethanol into acids. This keeps the alcohol content relatively low and introduces a sour taste. Kvass is a similarly-produced drink that is popular

in Eastern Europe and Russia. It is typically made from fermented rye bread, with the addition of sugar, **yeasts** and lactic acid **bacteria**.

4. **Cheese**- the milk protein cheese is a generic term for a diverse group of milk-based food products. Cheese is produced throughout the world in wide-ranging flavors, textures, and forms. Obtained by milk fermentation Coagulated mixture of proteins including casein Enzymetic process (rennin) Cheese Whey Lactic bacteria are used Renin may be obtained From the calf stomach or produced by microorganism Cheese, is one of the oldest food items in which microbes were used. Different varieties of cheese are known by their characteristic texture, flavour and taste, the specificity coming from the microbes used. For example, the large holes in 'Swiss cheese' are due to production of a large amount of CO_2 by a bacterium named *Propionibacterium sharmanii*. The 'Roquefort cheese' are ripened by growing a specific fungi on them, which gives them a particular flavor. Cheese Varieties Ripening of the cheese by Bacteria Mold Soft cheese water content 50-80 % Ripened by surface growth Semi-hard40-45% Briefly cooked to lower the curd content Hard cheese <40% Ripened with inoculation of spores of mold Penicillium roguefortii Salting cheese with sodium chloride. The mould *Penicillium* is used in the production of cheese, e.g. roquefort , stilton, gorgonzola and danish blue

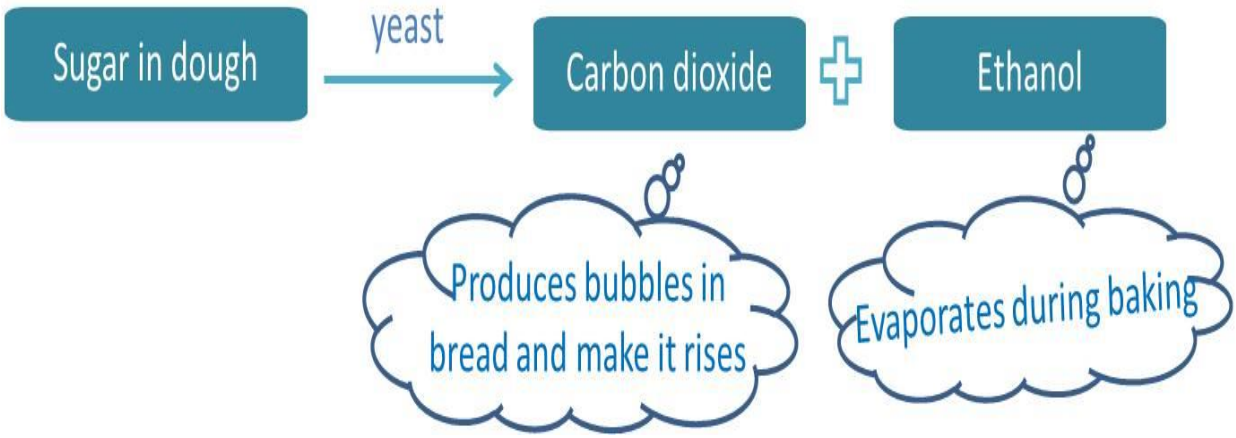
5. **Yogurt**- Fermentation of milk by Lactobacillus bulgaricus and Streptococcus thermophilus at 40-45 ◦C. After 4 hrs, sufficient acidity is generated, good to enhance shelf life. Flavour is imparted by accumulation of lactic acid and acetaldehyde produced by L. bulgaricus. Commercially produced from pasteurized skimmed milk with added milk powder.

6. **Fermented meats**- A delicacy in some middle-east countries. Fermentation of meat is carried out during curing by lactic bacteria and Pedicoccus cerevisiae. Several types of salamis, sausages and pepperoni are produced by fermentation gives flavor and taste. Sausage is meat (pork is most commonly used, but beef, mutton and turkey meat are also used) that has been finely chopped or ground and blended with various ingredients, seasonings and spices. Curing salts contribute to taste, colour, safety, stability and texture of the product. Lactic acid bacteria are usually the starter cultures sometimes *Debaryomyces* yeasts and *Penicillium* moulds are also used.

7. **Fermented fish** products are more commonly seen in Hong Kong. Lactic acid bacteria is often involved in the fermentation of fish products.Fermented fish is not common in Guangdong cuisine, but in other cuisines, e.g. smelly mandarin fish is a famous anhui dish, Hongeo is fermented skate fish in Korean cuisine.

8. **Bread**- The dough is fermented in the presence of sugar and yeast. Saccharomyces cerevisiae, the Baker's yeast is mostly used in leavening process. Fresh or dried yeast is used in making yeast bread. In the presence of oxygen, yeast produces carbon dioxide gas bubbles and ethanol (alcohol). The gas bubbles expand when heated and push up the dough. The alcohol vaporises and escapes from the dough. Used to make bread and other fermented doughs such as buns and doughnuts and biscuits. Floor and water is used to bind the flour together to form the structure of the bread. It needs to be warm to help the yeast grow.Yeast is a living organism that requires certain conditions for growth:

a. Sugar in the dough is the food for the yeast to grow
b. Warmth helps the yeast to grow
c. if it is too hot, it kills the yeast
d. if it is too cold, it will slow down the rising process.
e. Normally grown at 30◦C on molasses which is Having low conc. of sugar (0.5-1.5%) Rich in mineral salts pH about 4.5 During fermentation, sugar content of molasses is meticulously controlled as higher conc. is deterrent to respiratory enzymes.



9. **Fermented vegetables or pickles** are produced by LAB by the fermentation of pickled vegetables such as sauerkraut and kimchi from cabbage.

10. **Soya sauce**- Moulds are used to produce specific flavours and textures in several food products, e.g. moulds *Aspergillus oryzae* and *Aspergillus sojae* are used in the production of soya sauce and miso.
11. **Vinegar** is an alcoholic liquid that has been allowed to sour. Used to flavor and preserve foods. Ingredient in salad dressings and marinades. Used as a cleaning agent. Two successive fermentations of grape juice, raisins or malt.

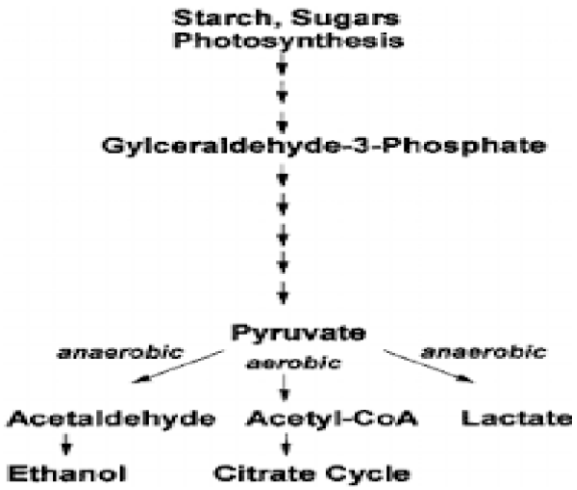
I. S. cerevisiae anerobically converts carbs to alcohol.

II. Oxidative transformation of alcohol to acetic acid by Acetobacter and Gluconobacter. Starting material includes Citrus fruits Apple Pear Vegetables like potatoes Malted cereals Sugary syrups such as molasses, honey etc.

12. **Production of organic acids** Acetic acid Citric acid Gluconic acid Lactic acid Gibberallic acid- Citric acid production Citric acid is a weak organic acid. It is a natural preservative/conservative and is also used to add an acidic, or sour, taste to foods and soft drinks. Aspergillus niger is used for commercial production Various strains of A. niger are used in the industrial preparation of citric acid and gluconic acid and have been assessed as acceptable for daily intake by the World Health Organisation.

13. Beer and wine- Beer and wine are alcoholic drinks made by fermentation reactions that use yeasts to convert sugar into ethanol . Ethanol is the type of alcohol found in wine and beer.

A. Beer- Barley is the principal grain used in the production of beer Main steps in producing beer. Barley contains enzymes to convert starch to simple sugars (malt) which is needed for fermentation. Soaking barley in water for germination. Germination of barley activates the starch-breaking enzymes. Variety of barley determines the colour, texture and flavour of beer. Hops are added to give flavours, aromas, and bitterness in the beer. Hops also act as preservative.
B. Wine- The word “wine” usually refers to wine made from grapes. Wines are made from fermented juice of fruits (usually grapes), grains and vegetables. The sugar in fruit juices and starch in grains/ vegetables contribute to yeast fermentation. The yeast strain used in wine production determines the flavours found in wine. White wines can be made from white, green, red/black grapes and red wines are made from red/ black grapes. red wines are produced from dark-coloured grapes that are fermented together with their skins (which contain most of the colour pigments). sulfites are usually added to red wines to maintain their red colour. Chinese wine, whiskey and sake are made from grains. Vegetables can also be used such as potatoes (for vodka), sweet potatoes (for Korean Shochu), cassava (for tequila) and sugar cane (for rum).
C. **Whisky**- Whisky is obtained by fermenting mixed’ grains of corn, wheat, bailey, etc. The product of fermentation is then distilled



14. **Probiotics-** Bacteria is used as probiotics to enhance the nutritional value of food. Probiotics are live microbial food ingredients (i.e. bacteria) that have a beneficial effect on human health. Probiotics maintain a healthy digestive system by improving the intestine's microbial balance and also strengthen the immune system. Yoghurt is one of the most familiar sources of probiotics. the most common probiotic bacteria added to yoghurt are *Lactobacillus* and *bifidobacterium.*
15. **Single cell protien**- SCP from Algal sources Economical as algae utilize solar energy for growth. Chlorella and Spirulina (blue-green algae). Food from these sources contain 65% protein, 20% carbohydrates and remaining 15% include lipids, fibre, pigments etc. SCP from Bacteria Cheap SCP is obtained from bacteria growing on cheap agricultural and mineral wastes Cellulomonas and Alcaligenes are mostly used Fungi as source of SCP Saccharomyces, Candida utilis and Torulopsis can be grown on wastes from paper industry and forestry Rhodosporium sphaeroides produce a cell mass that contains more than 50% lipids.

Advantages of using microorganisms for SCP production

a. Protein synthesis is much more rapid than higher living systems.
b. Microbes have short generation time.
c. Easily modifiable genetically for determining the amino acid composition.

d. Microbes have high protein content (7.12g protein Nitrogen/100g dry weight).
e. Microbes can be grown on media containing cheap sources of C and N.
f. Easy regulation of environmental factors for efficient yield.

16. **Production of Amino Acids** Amino acids are consumed in a variety of markets. The largest by volume is the food flavoring industry. Monosodium Glutamate, alanine, aspartate, arginine are all used to improve the flavor of food. L-lysine is directly produced from carbs by using Corynebacterium glutamcum, an auxotroph MSG is produced by Arthrobacter, Corynebacterium and Brevibacterium

17. **Food Flavors**- All kinds of preserved foods, such as soft drinks, milk products and beverages are flavoured suitably. The flavouring compounds are mostly purine nucleotides, including inosinic acid (IMP), and GMP. Yeast is commercial source of flavouring compounds Bacillus subtilis also enzymetically produces purine nucleotides through fermentation.

18. **Chocolate**- Chocolate originally comes from cocoa beans. These beans are not able to be used to make chocolate until they have been fermented. Naturally occurring **yeasts** and **bacteria** complete this process over a period of 6-10 days. The fermentation destroys the unwanted seed coating of the bean and prevents it from being able to grow. Importantly, it also begins to form some of the desirable flavours that are recognisable in chocolate