Food biodegradation agents

1. Enzymes:

Enzymes are complex globular proteins found in living organisms and act as catalysts for speeding up the rate of biochemical reactions. Enzymes are naturally present in foods and can therefore potentially catalyse reactions which could lead to food biodeterioration. The action of enzymes can be used to beneficial effect by the food industry to produce food products and is, for example, commonly used in the manufacture of hard cheese. However, it is usually necessary to inactivate enzymes (i.e. denature the protein) present in food and on packaging surfaces using heat or chemical means in order to preserve and extend the shelf life of foods.
Fruit and vegetables being major sources of enzymes provide many examples of the nature and action of these agents of food spoilage. Another problem with fruits and vegetables is enzymic browning that results from damage or cutting of the surface and exposure to the air. This is due to the action of polyphenoloxidase, which in the presence of air oxidizes phenolic constituents. Failure to inactivate enzymes completely often shortens the storage life of packaged foods. This is rarely an issue with canned foods but is a factor to consider with frozen fruits and vegetables.

2. Microorganisms

The term microorganism includes all small living organisms that are not visible to the naked eye. They are found everywhere in the atmosphere, water, soil, plants and animals. Microorganisms can play a very important role in breaking down organic material. This action of degrading organic material is what food preservation techniques aim to counteract.
Temperature regulation is the most commonly used method to kill or control the number of microorganisms present within foods and on packaging material surfaces. Five categories of temperature-sensitive microorganisms are used to define the preferred temperature range for their growth.
 Psychrotrophic (cold tolerant), which can reproduce in chilled storage conditions, sometimes as low as 4°C. Having evolved to survive in extremes of cold, these are the easiest to destroy by heat.
 Psychrophilic (cold loving), which have an optimum growth temperature of 20°C.
 Mesophilic (medium range), which have an optimum growth temperature between 20 and 44°C. These are of greatest concern with packaged foods.
 Thermophilic (heat loving), which have an optimum growth temperature between 45 and 60°C. In general, these organisms are only of concern if packaged foods are produced or stored in temperate climates.
 Thermoduric (heat enduring), which can survive above 70°C, but cannot reproduce at these temperatures.

3. Bacteria

Bacteria are single-celled microorganisms that normally multiply by binary fission, that is they divide into two cells following a period of growth. If conditions are favourable for reproduction, one bacterium can divide into two by fission, so that after 11 hrs there can be more than 10 million cells. This is a level where organoleptic spoilage of the food is apparent due to the production of off-flavours, unpleasant odours and slime or it can result in toxin release. There are four stages in bacterial growth

 lag phase, during which the bacteria are acclimatising to their environment, which can be several hours long;

 log phase, during which reproduction occurs logarithmically for the first few hours. Conditions for growth are ideal during this period;

 stationary phase, during which the bacteria's reproduction rate is cancelled by the death rate;

 mortality or decline phase, during which exhausted nutrient levels or the levels of toxic metabolites in the environment prevent reproduction, with the result that the bacteria gradually die off.

The simplest method of identifying bacteria is according to their appearance, which approximates to spherical, rod and spiral shapes. Bacteria require water, proteins, carbohydrates and lipids for growth. In
addition, small quantities of vitamins and trace elements are needed to support and catalyse metabolism. Water is essential for bacterial growth because it facilitates the transport of small molecules through the outer cytoplasmic membrane of the bacterial cell via osmotic pressure gradients. All bacteria need a supply of xygen to oxidise their food in order to produce energy and for growth. Some bacteria obtain their oxygen directly from the air (aerobic bacteria), whereas others obtain oxygen from their food (anaerobic bacteria).

Light is not an essential requirement for bacterial growth because the cells do not synthesise food using light energy. Instead, light has a destructive effect on bacteria because of the ultraviolet (UV) component that causes chemical changes in the cell proteins. Bacteria prefer to grow in conditions where light is excluded. This effect is utilised by using UV light to sterilise bottled water where the limitation of transparency is not a restriction.

Not all bacteria are pathogenic or the cause of food spoilage. Bacteria have been used to beneficial effect in food fermentation and preservation processes to extend the shelf life of certain foods. One example that has been exploited for many years is the deliberate introduction of lactic acid bacteria for the fermentation of milk to produce yoghurts.

4. Fungi

Fungi are a group of microorganisms that are found in nature on plants, animals and human beings. Different species of fungi vary a great deal in their structure and method of reproduction. Yeasts are single-cell organisms of spherical, elliptical or cylindrical shape and the size of yeast

cells varies considerably. Moulds belong to a large category of multi-celled threadlike fungi. Moulds attach themselves to their food, or substrate, using long threads called hyphae.

Conditions for the growth of yeasts and moulds are similar to those for bacteria. They can survive at lower available water levels, which is why bread is at risk of mould spoilage but not of spoilage by bacteria which are unable to grow. Fungi also have a greater resistance to osmotic pressure than bacteria and can grow in many commercial jams and marmalades. Fungi present on packaging surfaces and in food will be killed by the heat process applied to the packaged food. Both yeasts and moulds are more tolerant to high acidity levels, with yeasts being able to grow between pH 3.0 and 7.5, and moulds between pH 2.0 and 8.5.

Generally, fungi are less tolerant to high temperatures than bacteria. Yeast cells are facultatively anaerobic and moulds almost exclusively aerobic. In the absence of oxygen, yeast cells break down sugar to alcohol and water, while in the presence of oxygen, sugar is broken down to carbon dioxide and water. The former reaction is used in the fermentation of alcoholic drinks; however, within the fermenting liquid, conditions lie between anaerobic and aerobic and hence alcohol and carbon dioxide are produced.

5. Non-enzymic biodeterioration

One further category of biodeterioration worthy of mentioning is that of nonenzymic browning. An important reaction in foods takes place between the sugar constituents and amine-type compounds, which results in progressive browning and the development of off-flavours. An example of foods in which this type of quality deterioration takes place is dehydrated foods, especially dried potato and vegetables, fruit juices, both dried and concentrated, and wine. These complex chemical reactions are known as Maillard reactions.