MICROBIAL ACTIVITY ON FOOD

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Introduction

Microorganisms depend on the same kind of nutrients as humans for their growth and multiplication. While one or another microorganism can attack and decompose almost all of the vast array of organic substances found on earth, ranging from shoes and ships and sealing wax to gasoline and carbon monoxide, and make them serve as sources of energy and the substance of protoplasm, human food provides a ready source of nutrients. It also often provides a conducive environment for their growth.Although most microorganisms, such as molds, yeasts and bacteria are harmless some do cause food spoilage and others produce toxins that if ingested can cause food poisoning. Therefore from the beginning of human existence man has spent much effort and time protecting his food from microbial contamination. Humans have adopted food preservation techniques such as smoking, cooling, drying, salting etc. as far back as 3500 B.C. but it was not until the 19th century that the relationship between food spoilage and microorganisms was understood.

The Food - Microbe Relationship

Microorganisms use food for their own growth. Let us look at the food-microorganism relationship from the point of view of the microbes.
The tiny bacterial cell, barely visible to us even when magnified a thousand fold, is in fact a microcosm of activity. It lives, it grows, it dies. It has imprinted within it a record of the past and it contains the potentiality for its progeny. For it to grow it needs nutrients. The nutrients are essential for generation of energy and the synthesis of the substance of protoplasm.These the microbes must get from their immediate environment. Further the nutrients must be able to get into the cell and it must be usable by the cell's machinery.
When the microbial cell comes in contact with varying substances in its environment or in the substrate where it is found, some it rejects and some it welcomes and takes within itself, and transforms into other substances. Again some of these it degrades, some it synthesizes into other complex substances and some it returns to the external world. Thus there is a hurly burly of activity despite the small space it all takes place in.

Bacterial nutrients include proteins, carbohydrates, lipids and minerals together with water. Human food also contains these same components. Some microbes are able to utilize only the simple sugars, amino acids and fatty acids but even the more complex and large carbohydrate, protein and fat molecules found in food are utilized by others. Many available foods are large molecules that cannot diffuse through the semi permeable membrane that surrounds the bacterial protoplasm, and would be useless unless previously digested outside the cell.This they do by secreting enzymes into the surrounding medium and bringing about extracellular digestion of these complex molecules. Hydrolysis reactions introduce water at the points of cleavage of large molecules and break them down to small molecules, disaccharides into monosaccharides, proteins into proteoses, peptones,polypeptides, simple peptides, and amino acids. Polysaccharides like starch or cellulose into disaccharides and monosaccharides, fats to fatty acids and glycerol and so on (fig.1).

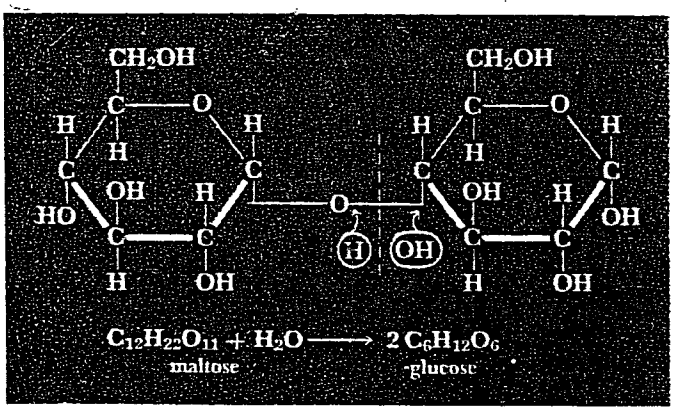

Fig.1 Hydrolysis of a disaccharide

The smaller molecules can then diffuse or be transported through the semi permeable membrane and then be utilized.

Food Spoilage

Microorganisms cause spoilage by changing the physical structure and chemical constituents of the food. The microbial metabolic products that replace food constituents are generally unacceptable to the human palate and aesthetic sense because of their malodorous and slimy nature, unpleasant appearance, and off-flavours they impart to the food. In our daily lives we often see instances of food spoilage, and discard foods such as bread, fruit and cooked food. Sometimes large stocks of food have to be discarded from warehouses due to spoilage caused by poor storage. The main reason for such spoilage is attack by microorganisms.

Foods in their natural form - like fruits, vegetables, and cereals, after harvest, meat after slaughter, and fish after being caught - are easily spoilt because they provide the right conditions (nutrients and environmental conditions) for the growth of food spoilage yeasts, bacteria, molds and viruses.

The process of food spoilage is in fact very complex with many kinds of microbes operating at the same time and in stages, to produce various chemical metabolites. In protein foods for instance, along with the complex protein molecules are also found amino acids and peptides of smaller molecular weight. These are normally found in the juices of meat and fish. During the initial stages of protein putrefaction it is these simple molecules that are first attacked, producing foul smelling metabolites such as cadaverine, putrescine, organic acids, carbon dioxide, hydrogen sulphide and ammonia. Non protein food components such as sugars also may be attacked at the same time. These activities increase the microbial population. Once the low molecular weight compounds are exhausted, other microorganisms, which are capable of producing proteolytic enzymes that can digest the large protein molecules, become active and multiply on the food, resulting in oligopeptides and amino acids. The oligopeptides are further hydrolysed by peptidases which are again attacked by the first stage microorganisms leading to

further accumulation of putrefactive substances. Eventually the accumulated toxic substances in the putrefying material poison the microorganisms themselves, and the process of putrefaction slows down.

Several bacteria produce slimy microbial polysaccharides or dextrans from various disaccharides present in foods and syrups rendering them unpalatable and unpleasant to the consumer.

Food Poisoning

Man has to contend not only with the quantitative and qualitative losses to his food supply, resulting in much economic loss, but also with the greater danger to human health caused by another group of microorganisms - the pathogenic bacteria. These or the toxic products of their metabolism enter the human body through food, and cause food poisoning. The term food poisoning describes a state in which the victim suffers an acute attack of abdominal pain and diarrhoea, sometimes accompanied by vomiting and fever lasting, usually, one to two days, but sometimes a week or more. There are other reasons for food poisoning such as contamination by toxic chemicals and natural toxicants. But it has been estimated that about 70% of cases of food poisoning is due to contamination by pathogenic microorganisms.

In many foods it is possible to identify a major change brought about by food spoilage. However in the case of food poisoning an outwardly recognizable sign of spoilage may not be found. Therefore there is no warning that the food has become poisonous.
A food becomes poisonous by the activity of a large number of microorganisms. Natural mechanisms such as acid in the human gut are often enough to kill a few bacteria eaten in the food. They also have to contend with another barrier, the human immune system. Only when the food is initially contaminated with a large number of organisms or if their numbers are allowed to increase on the food itself (due to improper storage) that a dangerous situation can arise. To avoid the problem of taking in a high dose of organisms the food must be stored at temperatures too low or too high to permit bacteria growth. i.e. food should be stored below 5oc or above 55°c.

Food poisoning is caused by bacterial types such as *Salmonella* and *Shigella*, *Escherichia coli*, *Clostridium botulinum* and *Staphylococcus aureus*.

Salmonella infections The typical symptoms of this type of food poisoning, which develop from 12 to 36 hours after the offending meal, are vomiting, diarrhoea and abdominal pain. The person may run a high temperature. Usually the symptoms pass off in two or three days, but the illness can sometimes be fatal especially in the very old and very young, and those who are already suffering from other diseases.

Escherichia coli Most strains of this species are harmless bacteria inhabiting the human gut. Some strains, however, have a harmful effect on the gut, and are known as enteropathogenic strains. Enteropathogenic *E. coli* infections are a particular threat to young children, but they also account for some cases of travellers' diarrhoea. The symptoms may resemble those of cholera, dysentery or salmonella infection.

Shigella infections Bacillary dysentery is caused by bacteria of the genus *Shigella*. The resulting diarrhoea may be mild or very severe. Food can be the source of the infection, but *Shigella* usually spreads by the "faecal-oral" route, from contaminated hands to mouth or from carriers of the infection.

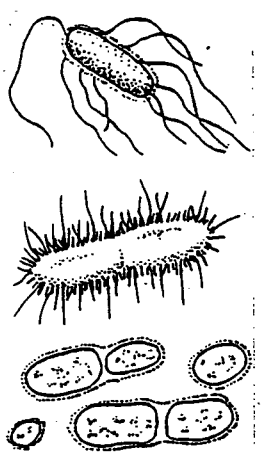

Fig.2 Some infections spread by food

Clostridium botulinum produces a toxin called botulinal toxin, perhaps the most potent natural toxin known, a small dose of which amounting to 0.01 mg is fatal to man, or 1 mg of the purified natural toxin can be said to contain 31 million lethal doses for the mouse. In man it causes paralysis especially of the respiratory muscles, apparently by interfering with the release of acetylcholine at the ending of peripheral motor nerves. The less dangerous staphylococci are widespread upon the skin and mucous membranes of the human body. Food handlers need to be specially careful as the organism can be transmitted to food by a cough or a sneeze or from the skin and it can then multiply rapidly on the food at room temperature.
S.aureus produces a toxin that is not inactivated by ordinary cooking methods, so cleanliness and storage of food at low temperatures is essential to prevent the growth of these bacteria.
Both *Cl.botulinum* and *S.aureus* produce what are called exotoxins (toxins secreted to the outside medium) which are soluble protein poisons. Salmonella on the other hand produces an endotoxin. Endotoxins are complexes of polysaccharides, protein and lipid and are released when the bacteria are lysed in the small intestines. Their potency is low, 1mg usually containing not more than 10 lethal doses for the mouse.
Salmonella that are found in meat, fish, eggs and poultry are easily killed by cooking and therefore it is the cooked food that has to be carefully stored.

Food Preservation

The need for man to preserve food against microbial attack that causes food poisoning and spoilage is the birth of the modern food industry. Food preservation aims at destroying or inhibiting microorganisms by methods such as sterilization, pasteurization, canning, etc. The six basic principles of food preservation are

1. Moisture removal (sun drying, spray drying, drum drying),
2. Heat treatment (sterilization, pasteurization),
3. Low temperature treatment (cooling, freezing),
4. Acidity control and fermentation,
5. Use of chemical additives (Propionic acid, Sorbic acid, sodium metabisuphite),
6. Irradiation.

These are based on controlling the conditions (moisture, PH, temperature, gases) affecting the growth and multiplication of microorganisms.