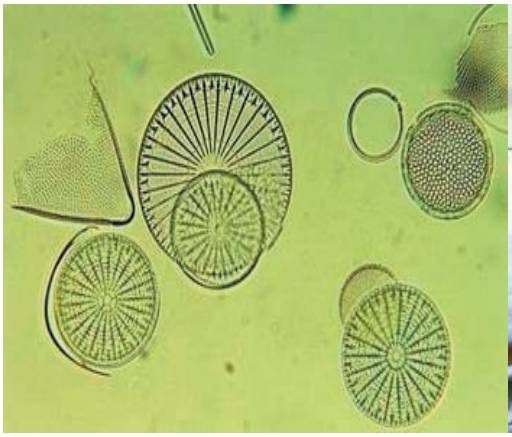

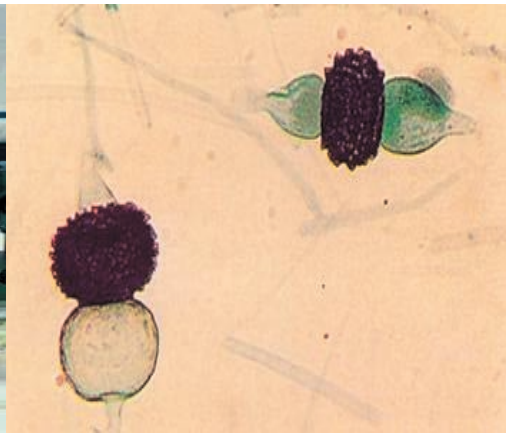

TECH TIPS

Issue #10 August 2006

Microbiology

What is Microbiology?

Microbiology is the study of living organisms too small to be seen by the naked eye. It includes inspection under the microscope, identifying the requirements for their growth and the chemical inputs and outputs of these organisms.

Why study Microbiology?

We are all influenced by microorganisms every day and they are everywhere. We use beneficial organisms to make food and other products. Hazardous organisms can make us sick or cause our deaths. Our overall well-being depends on us understanding how microorganisms function.

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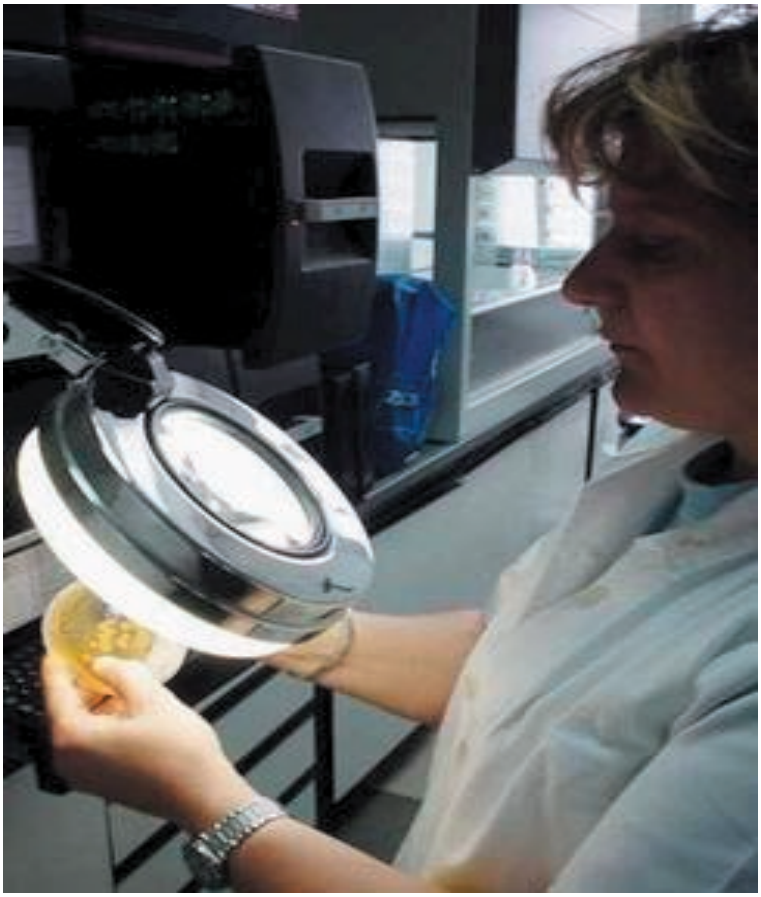
BENEFICIAL ORGANISMS

Many organisms are constantly being used in controlled circumstances to provide useful products for our consumption or well-being.

Lactobacillus plantarum	fermentation of pickles
Penicillium roqueforti	roquefort cheese
Penicillium notatum	original source of penicillin
Streptococcus lactis	cheddar cheese
Streptococcus thermophilus	yogurt
Saccharomyces cerevisiae	baker's yeast
Aspergillus oryzae	malting barley
Saccharomyces ellipsoideus	fermentation to make wine



TYPES OF MICROORGANISMS

Bacteria are single-celled organisms which are found virtually everywhere. They reproduce by undergoing binary fission which is the splitting of one organism into two new ones. Under conditions ideal for the organism they can divide every 20 minutes. This means that one organism can become more than 2,000,000 in 7 hours. They are so small that these 2,000,000 cells can fit onto the head of a pin. Some bacteria can form spores which are very hardy and can survive otherwise harmful conditions.

Yeast is microorganisms which come in a great variety of shapes (oval, spherical, elongate, and elliptical). Some yeasts reproduce by binary fission and some form spores but most yeast develop buds which grow out of the parent and eventually the buds separate as a new individual. Yeast can grow in high acid products like fruit juices, high sugar syrup products and high alcohol products like wine.

Molds appear as branching filaments, called hyphae, resembling tufts of cotton. The hyphae can be imbedded in soil or dead plant material anchoring the mold. Some hyphae will develop special structures that produce spores. The spores are designed to be carried on air and when released will spread on air currents and will grow into new molds. Molds can produce very poisonous substances called mycotoxins.

A virus is not a true organism. It is a complex chemical structure that requires living cells in order to reproduce. When a virus infects a cell it injects its genetic material, nucleic acid, into the cell. This genetic material then directs the cell's metabolic machinery to produce new virus structures. The cell cannot survive and it will eventually rupture releasing the new viruses. Sometimes the new virus growth is delayed a long time, even years, before the cycle finishes and viruses are released. Viruses can be carried on food products.

FACTORS AFFECTING GROWTH OF MICRO-ORGANISMS

FOOD: The fuel that supplies energy to organisms. It comes from carbohydrates and protein. Food also provides chemical building blocks and vitamins and minerals necessary for growth. Food for people is food for microorganisms too.

ACIDITY: Most organisms of concern to the food industry grow best in the pH range 6-9. Bacteria are more sensitive to pH than yeast or mold. Bacteria can grow in the pH range of 3.5-10.5 but pathogens will not grow below pH 4.0. Yeast will grow in the pH range of 1.5-8.5 while mold will grow in the range 1-11.

TIME: Under ideal conditions bacteria will grow and one cell will divide into two every 20 minutes. Bacteria will rest (LAG phase) while they get used to a new environment, its food source and acidity. Once they are used to it they will start to grow exponentially (LOG phase).

TEMPERATURE: Bacteria will grow over a wide temperature range, 0-60°C. The optimal range for most bacteria is 30-40°C. These are called mesophiles. Thermophiles grow at higher temperatures (50-70°C) while psychrophiles grow at lower temperatures (0-20°C). Molds and yeast are sensitive to heat and will not grow at high temperatures.

OXYGEN: Most microorganisms require oxygen to grow. They are called aerobes. If they can only grow in the absence of oxygen they are anaerobes. If they can grow with or without oxygen they are facultative anaerobes. Most yeasts and molds are aerobes.

MOISTURE: All organisms require some water to survive. The amount of water available for microbes is referred to as water activity (a_w). The minimum a_w for spoilage bacteria is 0.9, for yeast 0.88 and for mold 0.8. Most foods have a a_w of greater than 0.99 so they are susceptible to spoilage.

CONTROLLING MICROBIAL GROWTH

We have identified the factors that affect the growth of microorganisms. What can we do about each factor to control the growth of microbes?

FOOD: Plants must be cleaned well after processing in order to remove the food sources which microbes will feed on.

ACIDITY: Using acids to "pickle" foods has been around for a long time to preserve foods. Bringing the pH to 4 or less significantly reduces spoilage. Fruits, fruit juices and fermented foods are naturally below pH 3.5 which protects them from bacterial spoilage.

TIME: Microorganisms require time to grow. Shortening risky processing steps and reducing the time that optimal growth factors exist will reduce the risk of food spoilage.

TEMPERATURE: Foods are generally refrigerated or frozen because this will slow down the growth of all microorganisms and completely stop the growth of most of them. Psychrotrophs remain a concern.

OXYGEN: Since spoilage organisms require oxygen to grow, an effective control measure is to reduce or eliminate oxygen. This is done by packaging foods in sealed plastics such as bags or in cans. It is also done by storing food in an oxygen deleted environment such as apples stored under carbon dioxide. Be aware, however, that some pathogens will grow without oxygen (Clostridium botulinum).

MOISTURE: By reducing moisture you will improve the storage life of foods. This can be done by drying and curing such as by smoking meats. Dry noodles have a long shelf life. You can reduce the water available to microbes in food by adding salt, sugar or alcohol.

SPOILAGE

The term spoilage when applied to foods means one of the food's desired characteristics has been altered. The important characteristics are appearance, odor, taste or texture. If this happens quickly enough it will shorten the food's shelf-life. Spoilage is caused by microorganisms. Any microorganism that is not intentionally added to a food is a potential spoilage organism. While not desirable, these organisms do not cause illness.

Examples are:	Organism	Effect
Meat	Pseudomonas	slime
Vegetable-Potato	Fusarium	tuber rot
Fruit	Penicillium	blue rot / mildew
Milk	Pseudomonas Bacillus	bitterness coagulation
Cheese	Mold	off flavors

INDICATOR ORGANISMS

The existence of pathogens in a food plant is a serious problem. However, pathogens are not always tested for directly. This is because it can be dangerous to do so and it is very time consuming. What is done instead is a microbiologist will look for an indicator organism. This is an organism similar to the pathogen but a different species so it is not harmful. If you look for coliforms and there is none present then there is no *E. coli* present and the pathogen *E. coli* O157:H7 will also not be present. If you find coliforms then you might have to test further to see if the pathogen *E. coli* O157:H7 is present.

PATHOGENS

Pathogens are microorganisms which can cause illness in humans and in extreme cases can cause death. The illnesses are mostly gastrointestinal. The most susceptible people are young children, the elderly and people already with something else (immunocompromised).

THREE WELL KNOWN PATHOGENS ARE:

Salmonella: food poisoning organism which can cause nausea, vomiting, cramps, diarrhea, fever, headache (vomiting and diarrhea lead to dehydration)

- -found in soil, water, sewage, animals, humans
- -can survive a long time on dried foods
- -grows at pH 4-9 and between 5-45°C
- -killed by heating

Listeria: in healthy people causes flu-like symptoms

- -in immunocompromised people can cause meningitis, spontaneous abortion, miscarriage
- -found in water, soil, on plants
- -grows at refrigeration temperatures
- -killed by pasteurization and easily killed by chemical sanitizers

E. coli O157:H7: the term coli comes from colon, the large intestine, because it is found in the colon of warm-blooded animals

- -most outbreaks linked to undercooked beef, raw milk, and recently vegetables and unpasteurized apple cider
- -fecal contamination is the source
- -causes severe cramping, bloody diarrhea, vomiting
- -toxin it produces can lead to hemorrhagic colitis and hemolytic uremic syndrome which destroys the liver

EFFECTIVE PATHOGEN CONTROL MEASURES

Physical:

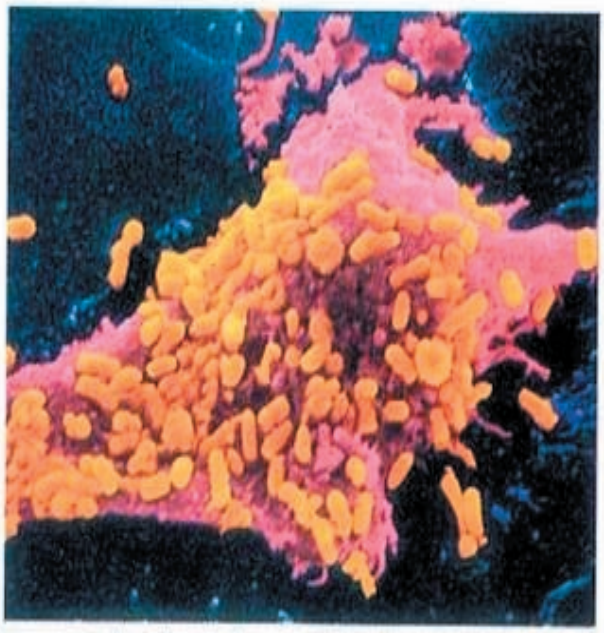
1. Keep ingredients, raw materials and finished product as cool as possible
2. Keep raw materials and finished products separate to prevent post production contamination
3. Ensure good employee hygiene – effective hand washing techniques
4. Ensure proper processing temperatures – if heating, high enough to kill microbes

Chemical:

1. Washing
   - for effective cleaning use the proper product and concentration
   - clean for the proper length of time, at the right temperature
2. Sanitizing
   - use chemical sanitizers or hot (185°F, 80°C) water
   - use chemicals at the correct concentration

Monitor effectiveness of cleaning and sanitizing

- pre-operation inspection and environmental testing
- audit for compliance



7.719 Escherichia coli ou colibacille, MEB
E. coli bacteria, SEM

SANITIZERS

	Advantages	Disadvantages
Sodium Hypochlorite	- effective against a wide range of microorganisms - inexpensive - not affected by hard water - available in liquid and powder	- chloride dissipates with exposure to light and high temperatures - irritating to skin and tissue - loses effectiveness with pH increase - corrosive to gaskets and soft metals
Iodine	- effective against wide range of microorganisms - less irritating than chlorine - less corrosive than chlorine - color indicates presence	- increased pH decreases antibacterial activity - may discolor equipment - should not be used above 120°F
Peracetic Acid	- environmentally safe - can be used in carbon dioxide environment - effective against wide range of microorganisms	- pungent odor - concentrate is irritant - corrosive to metals
Acid Anionic	- low corrosion on equipment - combines acidified rinse with sanitizing soap - not affected by hard water	- more expensive than other sanitizers - antimicrobial activity decreases with increasing pH - may foam too much for some CIP systems
Quaternary Ammonium Chloride	- non-irritating - non-corrosive - active over wide pH range - leaves residual bacteriocidal film	- moderate to high foaming - leaves residual bacteriostatic films - activity decreases in presence of anionic materials
Chloriode Dioxide	- not affected by hard water - used at low concentration - produces no THM's or chlorophenols - effective against wide range of microorganisms	- must be generated on site - loses effectiveness at pH > 10

SOURCES OF CONTAMINATION IN A FOOD PLANT

Microorganisms are found everywhere in nature. They are ubiquitous. In a food plant you should be aware of the following sources of contamination.

- Incoming raw materials and packaging
- Openings to the outside (doors, windows, vents)
- Pests (rats, mice, birds, etc.)
- Standing water
- Floor drains
- Ceilings, leaks
- Equipment (especially moving between areas)
- Cleaning and maintenance tools
- Biofilm in water hoses
- Condensation
- People - unwashed hands
  - shoes, boots, coats

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