Expert Food Consulting Services
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Food Microbiology

Microbiology is the study of microorganisms. These include the general groups of bacterial, yeast & mold and viruses. Although a large portion of the work related to these organisms is focused on eradicating them from our foods through various means, a significant portion of the food industry uses microorganisms to produce their products.

Uses of microorganisms

Fermentation – Alcohol production.

The beer, wine and spirit industry use varieties of yeasts to ferment sugars, derived from various food sources, such as grains, fruits, potatoes, corn, rice, to produce alcohol. Beers are carbonated, in some cases due to the carbon dioxide produced by the yeast, and in other cases due to a carbonation process. Spirits are distilled from weaker alcoholic products to produce more concentrated beverages, which are then blended down and may be flavoured, aged or otherwise treated to produce the desired effects.

Fermentation - Acid Production

The production of vinegars is an extension of wine or cider production, where the fermentation is permitted to continue longer to produce acetic acid, the characteristic note of many types of vinegar. Here, yeasts are predominantly employed.

In the process of producing kosher pickles and sauerkraut, a similar process is used, but salt is used to inhibit the growth of some organisms, and encourage the growth of fairly specific ones. In this case, the organisms are bacteria, which produce lactic acid. When enough acid is produced, the pickles and sauerkraut are essentially shelf stable.

In producing buttermilk, yogurt and kefir, we rely on specific combinations of bacteria to give us a smooth, mild diary product, which delivers health benefits, while extending the life of our fresh milk by several weeks.

Fermentation – flavor production / protein hydrolysis / fat lipolysis

The use of bacteria in producing the enormous varieties of cheese that are available to us are obvious. Combinations of bacteria, yeasts and molds produce highly flavourful products, prized by many. The pungent aromas are the result of breakdown of proteins and fats by the microorganisms

Pungent aromas are appreciated in other products such as soy sauces, salami, fish sauce, and fermented coconut liquor are similarly produced using yeasts, molds and bacteria.

In more sophisticated processes, many different organisms, several of them genetically modified, are used to produce food ingredients such as citric acid, xanthan gum, cocoa and kimchi.

As mentioned above, a major portion of the industry's efforts are focused on inhibiting or killing microbial activity. There are several methods available, and each depends on the end product, the formulation, the organisms that they are trying to stop, and the packaging and storage that will be used.

Thermal (heat) mediated microbial inactivation

a) Pasteurization (in-container) – Containers (usually glass), are filled with product, capped, and passed through a hot-water tunnel to kill the majority of organisms. Some will survive and are usually inhibited by acids and preservatives
b) Cooking – Various forms of heating food products to achieve the desired texture and flavor, which simultaneously reduces the microbial organisms.
    a. Roasting
    b. Poaching
    c. Baking
    d. Deep Frying
    e. Steaming
    f. Pan Frying
    g. Boiling
c) Retort (Commercial Sterilization) – products are placed in a vacuum sealed container and then subjected to very high temperatures under pressure. Canned foods are an example, as are some retort pouches. These foods are considered to commercially sterile (not subject to microbial spoilage) and can be kept for a few years
d) HTST – Liquid product (milk, juice), is passed through a plate heat exchanger, which heats the product to high temperatures (usually around 90 Celcius) for a few seconds, then packaged in cardboard or plastic containers. These products are usually sold refrigerated and have a limited shelf life.

e) UHT – Liquid product is passed through a plate heat exchanger at very elevated temperatures and then packaged in Tetra style containers using an asceptic process. These products are also shelf stable (don't need refrigeration) and have a shelf life ranging from 6 to 12 months.
f) Hot Fill – suitable products (usually with a high enough acid and sugar content) are heated, then filled into containers, then immediately sealed. Examples include certain pasta sauces, some antipastos.
g) Refrigeration – The simplest way of extending the shelf life. Lower temperatures reduce the growth rates of organisms and extend the shelf life.
h) Freezing – freezing inhibits all microbial growth and dramatically extends shelf life. Other processes, such as dehydration (reduced by vacuum packaging) will still occur, so freezing does not keep food indefinitely.

Chemical Inhibition

a) Potassium sorbate – inhibits certain types of bacteria and mold, but does not kill them
b) Sodium benzoate - inhibits certain types of bacteria and mold, but does not kill them
c) Sulfites – kills most microorganisms, but is considered an allergen in certain countries.
d) Nitrates / nitrites – permitted in cured, heat treated meat products to inhibit the growth of Clostridium species
e) Smoking – smoke contains many chemicals which extend the shelf life of meats, fish and cheese
f) Lactates – salts of lactic acid, which inihbit bacterial growth
g) Acetates / Diacetates – recently approved to inihibit the growth of Listeria species in certain meat products, these are salt of acetic acid (the acid in vinegar)
h) Food acids
    a. Acetic acid – Used in pickling, either in diluted form or produced using fermentation
    b. Lactic acid – Used directly, or as a product of fermentation
    c. Citric acid – Commonly used fruit acid (mostly found in citrus fruits), used to reduce the pH (increase the acid content) in various foods
    d. Fumaric acid/ adipic acid / tartaric acid / phosphoric acid – Less commonly used (although phosphoric is used in colas), to impart both acidity and flavour
i) Sugars, sugar alcohols
    a. Sugars are highly effective in competing for available water, which organisms need to grow. The more sugar, present, the less able organisms grow. A solution of 64% sugar will permit almost no growth of spoilage organisms. They reduce Water activity (Aw).
    b. Sugar alcohols – work in a similar manner as sugars. Examples include glycerin (glycerol) and sorbitol.

j) Salts
    a. Salts, especially sodium chloride, is widely used as an inhibitor of microbial growth. Beef jerky is predominantly preserved using salt. Although salt also reduces the Water Activity, the amount needed to completely stop bacterial growth usually makes food unpalatable.
k) Gases (Ozone, CO2, Nitrogen, Vacuum)
    a. Gases - Used in a process called Modified Atmosphere Packaging (MAP), this changes the combination of gases in the head spaces above a product in the package. A variety of gases can be used singly or in combination to produce the desired effect. Commonly found in deli packed pasta (refrigerated) and meat products
    b. Ozone is used as a means of killing bacteria in water
    c. Vacuum inhibits the growth of organisms which require oxygen. It is used in meat products and requires refrigeration, since organisms which don't require oxygen (such as Clostridium) can still grow unless inhibited.
l) Nisin
    a. Nisin is a polypeptide (very short protein) produced by bacteria cultured on milk. It has a broad spectrum effect against Gram negative organisms and has been found to inhibit Listeria effectively. It is mostly used in dairy products.

Hurdle Technology – Relies not on one specific means of stopping bacterial growth, but will use a combination approach using several technologies. A sauce may be produced by boiling it in a vat, then hot-filling it, and adding preservatives to create the best shelf life.

Irradiation

a) Gamma Irradiation – Used on specific food products. In Canada, it is restricted to spices and potatoes. In the US, certain meat products may also be utilized. By calculating the appropriate effective dose, a commercially sterile product may be produced. In North America, either Cobalt 60 or Electron Beam sources are used
b) Ultraviolet – Used to sterilize water. Has limited penetration (a few centimeters), and is thus not commonly used.

Ultra-high Pressure – A technology that has become more commercialized in the past 10 years, Ultra High Pressure can reduce bacterial loads on a variety of products, thereby extending the shelf life dramatically. Especially well suited are products which don't lend themselves to heat treatment (fresh berries, guacamole, ground meat)

Dehydration – As noted before, reducing the amount of water available to microorganisms can limit or stop their growth. Dehydrated foods can have very long shelf lives with little chance of spoilage

a. Air drying – Used for pieces (banana, apple chips, grains, rice), which, with very low moisture content will last for years.
b. Drum Drying – Used for various products that have been turned into pastes (fruit and vegetable powders). The paste is applied to the surface large, heated drum, which evaporates the moisture and leaves a fine powder
c. Freeze Drying (lyophilization) – Used for fruit, meat and vegetable pieces. Products are frozen, then placed in a vacuum chamber, and the water is boiled (sublimated) off at low temperatures. Afterwards, the product may be kept as pieces, or powdered as desired.
d. Spray Drying – Predominantly reserved for thinner fluids, products are atomized into a heated chamber and precipitated as dried powder.

Resource

FTC International Consulting Ltd. is a Pitt Meadows, BC based food consulting company that provides technical consulting services to manufacturers, wholesalers, retailers and brokers of food and natural health products.
Professional consultants are available to assist with issues relating to food labelling, nutrition analysis, regulatory compliance, as well as food product development, quality systems and organic certification.
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Walter Dullemond is the president and found of FTC International Consulting. He is educated as a microbiologist has over 20 years experience as a professional food scientist, with projects in Canada, the US, the Philippines, Vietnam, South Africa and Europe