

Yeast

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History

The word “yeast” comes to us from Old English *gist*, *gyst*, and from the Indo-European root *yes-*, meaning boil, foam, or bubble.^[1] Yeast microbes are probably one of the earliest domesticated organisms. People have used yeast for fermentation and baking throughout history. Archaeologists digging in Egyptian ruins found early grinding stones and baking chambers for yeasted bread, as well as drawings of 4,000-year-old bakeries and breweries.^[2] In 1680, the Dutch naturalist Anton van Leeuwenhoek first microscopically observed yeast, but at the time did not consider them to be living organisms but rather globular structures.^[3] In 1857, French microbiologist Louis Pasteur proved in the paper “*Mémoires sur la Fermentation Alcoolique*” that alcoholic fermentation was conducted by living yeasts and not by a chemical catalyst.^{[2][4]} Pasteur showed that by bubbling oxygen into the yeast broth, cell growth could be increased, but fermentation was inhibited – an observation later called the “Pasteur effect”.

By the late 18th century, two yeast strains used in brewing had been identified: *Saccharomyces cerevisiae*, so called top fermenting yeast, and *S. carlsbergensis*, bottom fermenting yeast. *S. cerevisiae* has been sold commercially by the Dutch for bread making since 1780; while, around 1800, the Germans started producing *S. cerevisiae* in the form of cream. In 1825, a method was developed to remove the liquid so that the yeast could be prepared as solid blocks.^[5] The industrial production of yeast blocks was enhanced by the introduction of the filter press in 1867. In 1872, Baron Max de Springer developed a manufacturing process to create granulated yeast, a technique that was used until the First World War.^[6] In the United States, naturally occurring airborne yeasts were used almost exclusively until commercial yeast was marketed at the Centennial Exposition in 1876 in Philadelphia, where Charles L.

Fleischmann exhibited the product and a process to use it, as well as serving the resultant baked bread.^[7]

Nutrition and growth

Yeasts are chemoorganotrophs, as they use organic compounds as a source of energy and do not require sunlight to grow. Carbon is obtained mostly from hexose sugars, such as glucose and fructose, or disaccharides such as sucrose and maltose. Some species can metabolize pentose sugars like ribose,^[8] alcohols, and organic acids. In general, yeasts are grown in the laboratory on solid growth media or in liquid broths. Common media used for the cultivation of yeasts include potato dextrose agar (PDA) or potato dextrose broth, Wallerstein Laboratories nutrient (WLN) agar, yeast peptone dextrose agar (YPD), and yeast mould agar or broth (YM). Home brewers who cultivate yeast frequently use dried malt extract (DME) and agar as a solid growth medium. The antibiotic cycloheximide is sometimes added to yeast growth media to inhibit the growth of *Saccharomyces* yeasts and select for wild/indigenous yeast species. This will change the yeast process. The appearance of white, thread like yeast, commonly known as kahmyeast, is often a by-product of the lacto fermentation (or pickling) of certain vegetables, usually the result of exposure to air. Although harmless, it can give pickled vegetables a bad flavour and must be removed regularly during fermentation.^[9]

Ecology

Yeasts are very common in the environment, and are often isolated from sugar-rich material. Examples include naturally occurring yeasts on the skins of fruits and berries (such as grapes, apples or peaches), and exudates from plants (such as plant saps or cacti). An Indian study of seven bee species and 9 plant species found 45 species from 16 genera colonise the nectaries of flowers and honey stomachs of bees...^{[10][11]} black yeast has been recorded as a partner in a complex relationship between ants, their mutualistic fungus, a fungal parasite of the fungus and a bacterium that kills the parasite. The yeast has a negative effect on

the bacteria that normally produce antibiotics to kill the parasite and so may affect the ants' health by allowing the parasite to spread.^[12]

Reproduction

Yeasts, like all fungi, may have asexual and sexual reproductive cycles. The most common mode of vegetative growth in yeast is asexual reproduction by budding.^[13] Here, a small bud (also known as a bleb), or daughter cell, is formed on the parent cell. The nucleus of the parent cell splits into a daughter nucleus and migrates into the daughter cell.

Uses

The useful physiological properties of yeast have led to their use in the field of biotechnology. Fermentation of sugars by yeast is the oldest and largest application of this technology. Many types of yeasts are used for making many foods: baker's yeast in bread production; brewer's yeast in beer fermentation; yeast in wine fermentation and for xylitol production. So-called red rice yeast is actually a mold.^[14]

Beer

Beer is fermented by brewer's yeast

Brewing yeasts may be classed as "top cropping" (or "top-fermenting") and "bottom-cropping" (or "bottom-fermenting").^[15] Top cropping yeasts are so called because they form a foam at the top of the wort during fermentation. An example of top-cropping yeast is *Saccharomyces cerevisiae*, sometimes called an "ale yeast".^[16] Bottom-cropping yeasts are typically used to produce lager-type beers, though they can also produce ale-type beers. These yeasts ferment well at low temperatures. An example of bottom-cropping yeast is *Saccharomyces pastorianus*, formerly known as *S. carlsbergensis*. The wild yeasts are repressed, which ensures a reliable and predictable fermentation.^[17]

Wine

Fresh grapes with visible bloom.

Yeast is used in winemaking, where it converts the sugars present in grape juice (must) into ethanol. Yeast is normally already present on grape skins (the white powder called “the bloom”). Fermentation can be done with this endogenous “wild yeast,”^[17] but this procedure gives unpredictable results, which depend upon the exact types of yeast species present. For this reason, a pure yeast culture is usually added to the must; this yeast quickly dominates the fermentation. The wild yeasts are repressed, which ensures a reliable and predictable fermentation.^[17]

Baking

Yeast, the most common one being *S. cerevisiae*, is used in baking as a leavening agent, where it converts the fermentable sugars present in dough into the gas carbon dioxide. This causes the dough to expand or rise as gas forms pockets or bubbles. When the dough is baked, the yeast dies and the air pockets “set”, giving the baked product a soft and spongy texture. The use of potatoes, water from potato boiling, eggs, or sugar in a bread dough accelerates the growth of yeasts. Most yeasts used in baking are of the same species common in alcoholic fermentation. In addition, *Saccharomyces exiguus* (also known as *S. minor*), a wild yeast found on plants, fruits, and grains, is occasionally used for baking. In bread making, the yeast initially respire aerobically, producing carbon dioxide and water. When the oxygen is depleted, anaerobic respiration begins, producing ethanol as a waste product; however, this evaporates during baking.^[18]

It is not known when yeast was first used to bake bread. The first records that show this use came from Ancient Egypt.^[1] Researchers speculate that a mixture of flour meal and water was left longer than usual on a warm day and the yeasts that occur in natural contaminants of the flour caused it to ferment before baking. The resulting bread would have been lighter and tastier than the normal flat, hard cake.

When yeast is used for making bread, it is mixed with flour, salt, and warm water or milk. The dough is kneaded until it is smooth, and then left to rise, sometimes until it has doubled in size. Some bread dough's

are knocked back after one rising and left to rise again. A longer rising time gives a better flavour, but the yeast can fail to raise the bread in the final stages if it is left for too long initially. The dough is then shaped into loaves, left to rise until it is the correct size, and then baked. Dried yeast is usually specified for use in a bread machine; however, a (wet) sourdough starter can also work.

Industrial ethanol production

The ability of yeast to convert sugar into ethanol has been harnessed by the biotechnology industry to produce ethanol fuel. The process starts by milling a feedstock, such as sugar cane, field corn, or other cereal grains, and then adding dilute sulphuric acid, or fungal alpha amylase enzymes, to break down the starches into complex sugars. A *glucoamylase* is then added to break the complex sugars down into simple sugars. After this, yeasts are added to convert the simple sugars to ethanol, which is then distilled off to obtain ethanol up to 96% in concentration.^[21]

Root beer and other sweet carbonated beverages can be produced using the same methods as beer, except the fermentation is stopped sooner; producing carbon dioxide, but only trace amounts of alcohol, and a significant amount of sugar is left in the drink. *Kvass*, a fermented drink made from rye, is popular in Eastern Europe; it has a recognizable, but low alcoholic content. Yeast in symbiosis with acetic acid bacteria is used in the preparation of *kombucha*, a fermented sweetened tea.

Nutritional supplements

Yeast is used in nutritional supplements popular with vegans and the health conscious, where it is often referred to as “nutritional yeast”. It is a deactivated yeast, usually *S. cerevisiae*. It is an excellent source of protein and vitamins, especially the B-complex vitamins, whose functions are related to metabolism, as well as other minerals and cofactors required for growth. It is also naturally low in fat and sodium. Some brands of nutritional yeast, though not all, are fortified with vitamin B₁₂, which is produced separately by bacteria. Nutritional

yeast, though it has a similar appearance to brewer's yeast, is very different and has a very different taste. Brewer's yeast is a good source of B-complex vitamins but, contrary to some claims, it contains little or no vitamin B₁₂.^[18]

Probiotics

Some probiotic supplements use the yeast *S. boulardii* to maintain and restore the natural flora in the gastrointestinal tract. *S. boulardii* has been shown to reduce the symptoms of acute diarrhea in children,^[19] prevent reinfection of *Clostridium difficile*,^[20] reduce bowel movements in diarrhea-predominant IBS patients,^[21] and reduce the incidence of antibiotic, traveler's,^[21] and HIV/AIDS^[22] associated diarrheas.

Aquarium hobby

Yeast is often used by aquarium hobbyists to generate carbon dioxide (CO₂) to nourish plants in planted aquariums.^[23] A homemade setup is widely used as a cheap and simple alternative to pressurized CO₂ systems. While not as effective as these, the homemade setup is considerably cheaper for less-demanding hobbyists.

There are several recipes for homemade CO₂, but they are variations of the basic recipe: Baker's yeast, with sugar, baking soda, and water, are added to a plastic bottle. A few drops of vegetable oil at the start reduces surface tension and speeds the release of CO₂. This will produce CO₂ for about 2 or 3 weeks; the use of a bubble counter determines production. The CO₂ is injected in the aquarium through a narrow hose and released through a diffuser that helps dissolve the gas in the water. The CO₂ is used by plants in the photosynthesis process. ^[23]

Science

Several yeasts, in particular *S. cerevisiae*, have been widely used in genetics and cell biology. This is largely because *cerevisiae* is a simple eukaryotic cell, serving as a model for all eukaryotes, including humans for the study of fundamental cellular processes such as the cell cycle, DNA replication, recombination, cell division, and metabolism.

On 24 April 1996, *S. cerevisiae* was announced to be the first eukaryote to have its genome, consisting of 12 million base pairs, fully sequenced as part of the Genome project. ^[24]

Yeast extract is the common name for various forms of processed yeast products that are used as food additives or flavours. They are often used in the same way that monosodium glutamate (MSG) is used and, like MSG, often contain free glutamic acid. The general method for making yeast extract for food products such as Vegemite and Marmite on a commercial scale is to add salt to a suspension of yeast, making the solution hypertonic, which leads to the cells' shrivelling up.

Pathogenic yeasts

Some species of yeast are opportunistic pathogens that can cause infection in people with compromised immune systems.

Food spoilage

Yeasts are able to grow in foods with a low pH, (5.0 or lower) and in the presence of sugars, organic acids and other easily metabolized carbon sources. The growth of yeast within food products is often seen on their surface, as in cheeses or meats, or by the fermentation of sugars in beverages, such as juices, and semi-liquid products, such as syrups and jams. ^[25] During their growth, yeasts metabolize some food components and produce metabolic end products. This causes the physical, chemical, and sensible properties of a food to change, and the food is spoiled. ^[26] .

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