Brewing Yeast

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10 grams pressed yeast has a surface area of 10 m^2 contact surface, this explains the tremendous activity of yeast.

Yeast is the only living organism which can change from respiration to fermentation. The production of alcoholic beverages, which has taken place for thousands of years, depends on this fact.

Yeasts are unicellular micro-organisms which can obtain the energy they need in the presence of oxygen (*aerobic*) by respiration and in the absence of oxygen (*anaerobic*) by fermentation.

During beer production the sugar in the wort is fermented by the yeast into alcohol. For this purpose yeast fungi of the species *Saccharomyces cerevisiae* are used. Selected strains of this yeast are systematically isolated and grown as pure culture brewers' yeasts.

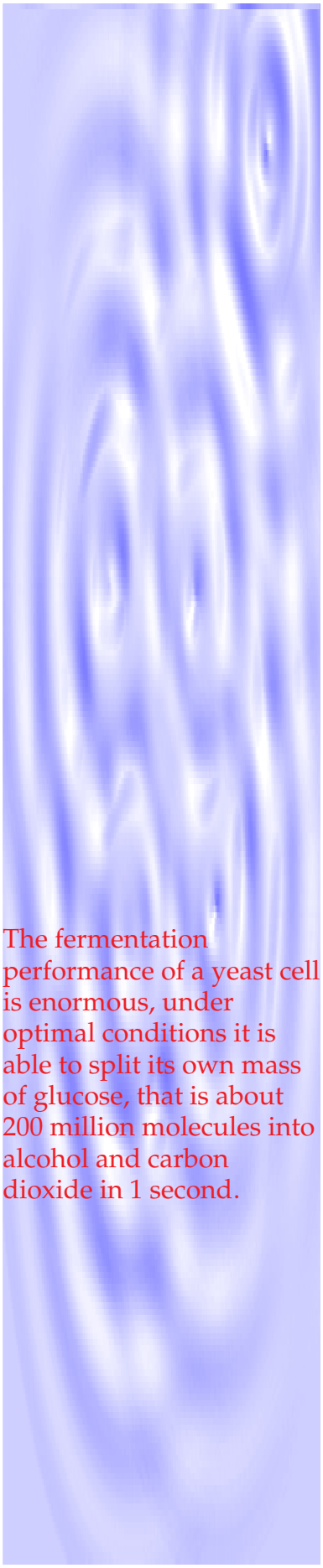
Because yeast does not only produce alcohol during fermentation but a range of other flavour materials, its metabolism has a great influence on the taste and character of the beer. Knowledge of the structures and composition of yeasts, their metabolism and their growth is important in producing high quality beer.

Yeast cells contain about 75% water. The composition of yeast dry matter consists predominantly of proteins and carbohydrates:

• Proteins	45 - 60%
• Carbohydrates	25 - 35%
• Fat	4 - 7%
• Inorganic	6 - 9%

In addition yeast has a high vitamin and enzyme content, the main vitamins in yeast are B_1 and B_6.

To grow and multiply yeast is adapted to use organic substances, particularly carbohydrates in the form of sugars. Yeast is able to utilise these sugars both in the presence of oxygen and when oxygen is excluded. The aerobic breakdown, which produces more energy is called respiration and the anaerobic breakdown, which produces less energy is called fermentation. Of the carbohydrates only sugars are respired or fermented by yeast. An important parameter for distinguishing individual yeast species is their ability to respire or ferment various sugars. Whether a sugar is used aerobically or anaerobically depends principally on the oxygen availability. In the presence of oxygen, yeasts obtain their energy by respiration. When the oxygen is removed metabolism changes to fermentation.



The fermentation performance of a yeast cell is enormous, under optimal conditions it is able to split its own mass of glucose, that is about 200 million molecules into alcohol and carbon dioxide in 1 second.

During the initial stage of brewery fermentations, the yeast requires a lot of energy, a great deal of oxygen must be supplied to the yeast to initiate this process quickly. In the subsequent phases of fermentation and maturation the processes are performed anaerobically and oxygen would be detrimental to the flavour of the beer.

The preferred carbohydrate sources for brewing yeast are low molecular weight sugars. Yeast is able to use many mono-, di- and trisaccharides. Polysaccharides, such as starch and cellulose, are not used by yeast.

For beer production it is important which sugars are fermented by the yeast. The fermentable carbohydrates include:

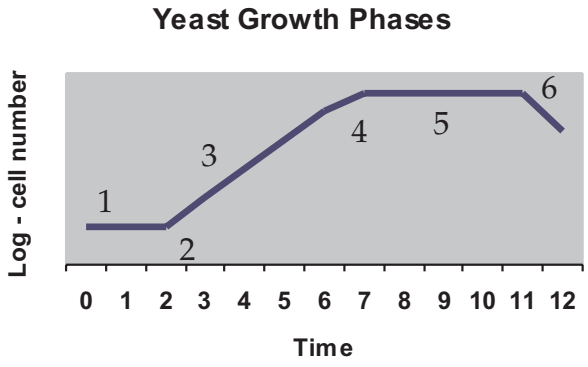
- Monosaccharides - glucose, fructose, manose, galactose.
- Disaccharides - maltose, sucrose.
- Trisaccharides - raffinose, maltotriose (by some yeasts)

Yeast metabolism depends on an adequate supply of inorganic substances. The following are needed to maintain good yeast viability:

- Potassium
- Sodium
- Calcium
- Magnesium
- Copper
- Iron
- Manganese
- Zinc
- Sulphate
- Phosphate
- Nitrate

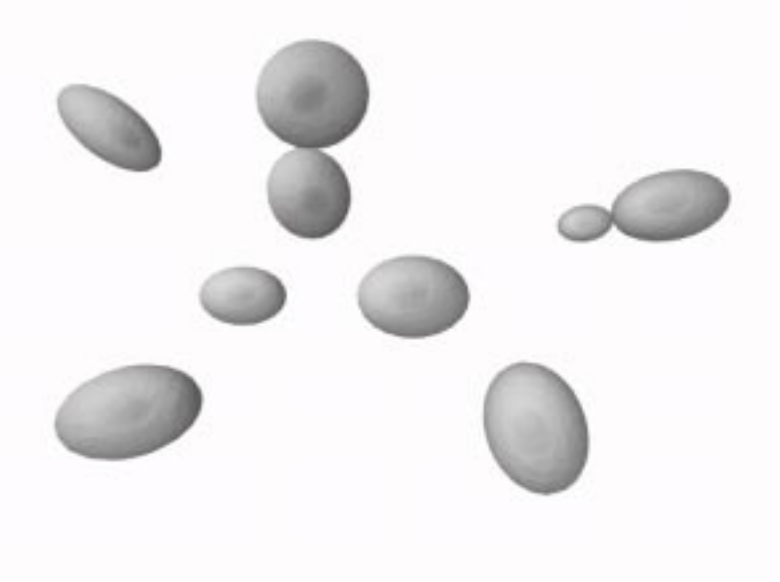
Normal wort contains sufficient amounts of the above salts or ions.

Yeast normally reproduces by budding. During budding a small bubble like protuberance from the mother cell is formed into which part of the cytoplasm as well as a daughter nucleus, formed by division, passes. In some yeast strains the mother and daughter cells separate from one another completely, in other strains the cells remain connected to one another and form chains. When the yeast is pitched into fresh wort in the brewery they begin to grow. This growth does not occur at a constant rate but is divided into six phases.



1 Lag Phase - The yeast cells metabolism becomes active, the length of this phase depends on the type of yeast, its age and the conditions within the wort. The lag phase ends with the first cell division.
2 Acceleration phase - The rate of cell division continuously increases.
3 Exponential phase - The growth rate is constant and at a maximum. The cell number doubles every 90 to 120 minutes.
4 Deceleration phase - Because of various factors such as the reduction in the amount of nutrient and the increase in the amount of growth inhibiting products, the lag phase occurs for only a limited time. Then the growth rate gradually decreases.
5 Stationary phase - There is a balance between the number of newly formed cells and the cells which die.
6 Declining phase - In this last phase the rate of cell death exceeds the rate of new cell formation.

In brewing yeasts are divided into two major groups - *top and bottom fermenting yeasts*. There are a number of differences between the way these yeasts ferment.

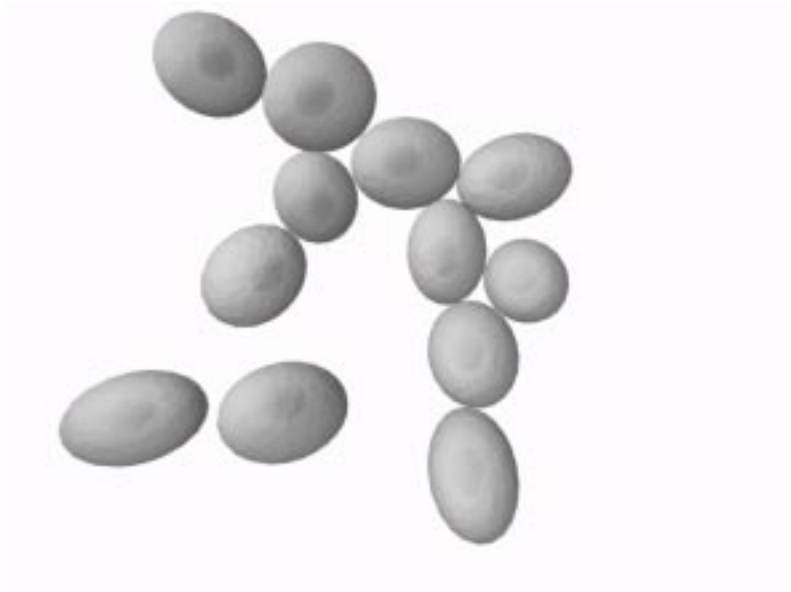


Bottom Fermenting Brewers Yeast

Top and bottom yeasts can be differentiated under the microscope by means of their budding behaviour. Bottom fermenting yeasts occur mainly as single cells or pairs of cells, whereas top fermenting yeasts form chains of budding cells. In the case of top fermenting yeasts the mother and daughter cells remain attached to one another for a longer time and as a result branched chains of cells are formed. In the case of bottom fermenting yeasts the mother and daughter cells separate from one another when the division is complete.

The most important physiological difference between top and bottom fermenting yeasts relate to the fermentation of the trisaccharide raffinose. Bottom fermenting yeasts can ferment raffinose completely whereas top fermenting yeasts can ferment only a third of the trisacchride.

Another characteristic of top fermenting yeasts relates to their different flocculation behaviours. Top fermenting yeasts are therefore divided into powdery and flocculent yeasts. In the case of powdery yeasts the cells remain very finely divided in the fermentation medium and sink slowly to the bottom only at the end of fermentation. The cells of flocculent yeast, clump



Top Fermenting Brewers Yeast

together after a short time to form large flocs and then settle rapidly. Bottom fermenting yeasts do not form flocs.

The flocculation ability of yeast is of great practical importance. Flocculent yeasts produce a clear but less fully fermented beer, whereas powdery yeasts and bottom fermenting yeasts produce a turbid beer with a high degree of attenuation.

Top and bottom fermenting yeasts differ with regard to fermentation temperature. Fermentation's with bottom fermenting yeasts are performed between 4 °C and 12 °C. In the case of top fermenting yeasts 14 °C to 25 °C is used.

Yeast Propagation

For propagation of a pure culture yeast, cells which have performed well in practice are used.

There are three stages in pure yeast propagation:

1 Isolation of suitable yeast cells.
2 Multiplication of the yeast in the laboratory till sufficient vigorously fermenting yeast is obtained.
3 Yeast multiplication in the brewery till a sufficient amount is obtained to pitch a complete brew.

The yeast should be isolated from the active phase of fermentation. Drops containing single cells can be isolated under the microscope and several grown in wort at the normal fermentation temperature. The most vigorously fermenting yeast colony is absorbed onto sterile filter paper and added to 5ml of sterile wort. If the yeast cells are not going to be used immediately the yeast cells are grown on a solid medium, usually wort agar. The sealed sample is kept in a fridge at 0 ^{o}C to 5 ^{o}C.

The increase in the number of yeast cells is achieved by transferring the vigorously fermenting contents of one vessel into another vessel containing 10 times as much sterile wort. Sterile air or oxygen is bubbled into the wort to maintain the yeast in growth phase rather than fermentation phase. Volumes of wort up to 25 litres can be grown this way, which is sufficient to pitch a 1000 litre brew.

The main points of importance with yeast propagation are:

- The operation must be performed under sterile conditions right through to pitching the yeast in the brewhouse wort.
- Intensive sterile aeration or oxygenation of the yeast is necessary for rapid yeast growth.
- Brewing wort should be used for yeast propagation as the hop bittering compounds exert an inhibiting effect on the growth of bacteria.

Propagation Vessel

1 Sterile air filter - allows excess pressure to escape.
2 Sample tap - allows sterile air or oxygen to be bubbled through the wort.
3 Inoculation connection - for adding sterile yeast to wort.

Note - The cut away section in the main body of the vessel is to allow a view of the inside and does not exist in the real vessel.