

Maximizing returns with yeast

In recent years, the ethanol industry has seen a period of high ethanol prices combined with low corn (maize) costs, resulting in high profitability. But in the past few months trend has been reversed with higher corn prices as demand for this starch source rises — even as growers plant more acreage to corn than ever before. Through 2007-08, when 80 new plants in the United States will increase annual production to 49 billion liters (13 billion gallons), ethanol prices are expected to drop, putting more pressure to increase yield.

The emphasis for ethanol plant managers should be ethanol yield and maximizing production. Thus, a great deal of importance is now being put on the choice of yeast, format, handling, technical service and training to effectively and economically reach maximum production and profitability.

It is important to examine the different formats of yeast and the conditions which make them most effective. Other areas of an ethanol plant, such as process upsets and distillation, have the risk of lowering yield. Fermentation is the only plant operation in which yield can be enhanced through effective handling and optimizing of procedures and parameters. If yeast is not treated with the utmost care and concern, the ethanol yield may be disappointing and the result fiscally unacceptable.

CHOOSING A YEAST

Multiple processing steps have to work in conjunction with one another to effectively and efficiently produce ethanol. From the slurry tank and cooking to hydrolysis of starch into glucose, these processes have to work together well to best prepare for the important component that makes ethanol in the plant — the yeast.

Yeast produces ethanol by transporting glucose through its membrane and through a fairly complicated biochemical process. The selection and care of yeast is very important. There is no use breaking down raw material if the yeast required to make ethanol cannot be effectively and profitably used.

Yeast can grow aerobically (with air) or anaerobically (without air). There are inherent advantages to growing yeast in these different environments. For instance, if yeast is grown aerobically, it requires the presence of large amounts of oxy-

Optimizing fermentation conditions and choosing the correct yeast format can enhance ethanol yields

by Glen Austin and Chris Richards

gen and very low levels of carbohydrate. Very high levels of energy are generated for cell growth, but no ethanol is produced. Essentially, carbohydrates are used for growth and reproduction of the yeast cell without producing ethanol. From one gram of sugar, 0.5 grams of yeast (dry) is made. Large amounts of air are needed when manufacturing yeast, but almost all air should be excluded when producing ethanol.

Conversely, anaerobic yeast growth (typical in an ethanol production facility) leads to lower levels of energy production (see figure 1), requires only a very small amount of oxygen and produces high levels of ethanol. From one gram (g) of sugar, about .05 g of yeast is produced under near anaerobic conditions, but over 90% of sugars provided are converted to ethanol and carbon dioxide.

COMMON ETHANOL YEASTS

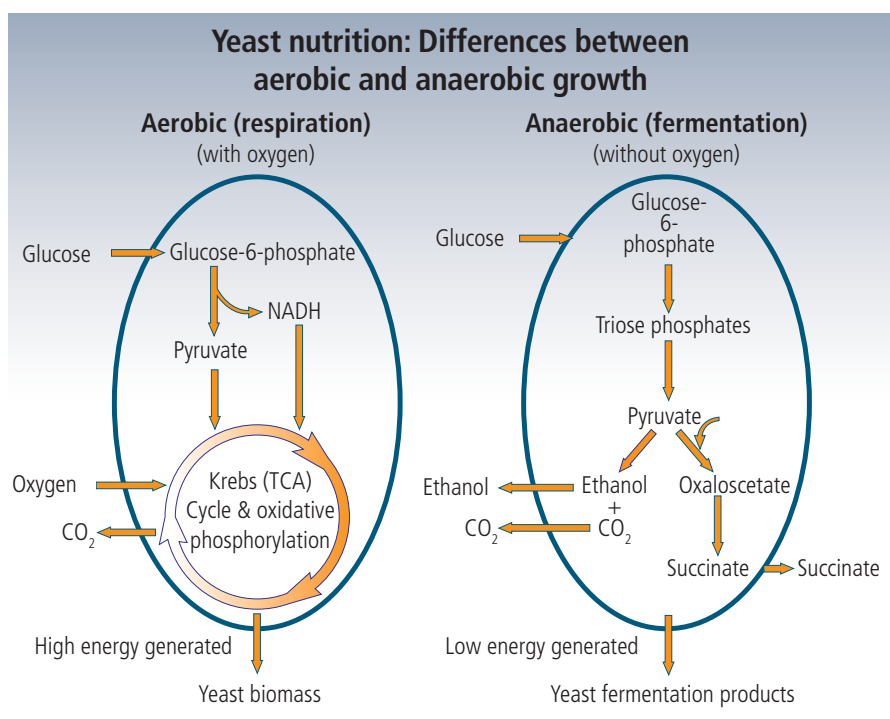
There are four main formats of yeast (see table 1) that are common for use in ethanol production. The most common type is Active Dry Yeast (ADY), or more accurately called Instant Dry Yeast. Some of the advantages of utilizing ADY are shelf life and storage. One disadvantage of ADY is the conditioning or rehydration step that is necessary to prepare the yeast for a faster start in the fermenter.

Growing yeast is a fairly sophisticated process. Although aerobic yeast propagation in an alcohol plant is tempting and often considered in the fuel ethanol industry, there are some

Table 1: Yeast types

Type	solids	Packaging	Storage	Shelf life
Cream	15%-20%	Bulk	Refrigerate	2 weeks
Fresh bag	30%-40%	Unprotected	Refrigerate	4-6 weeks
Instant dry	94%-96%	Protected	Room temp	1.5-2 years
Stabilized liquid	19%-26%	Totes, bulk	Refrigerate	2-3 months

Source: Ethanol Technology



disadvantages to aerobic propagation, which make it difficult to be successful. The technology to provide proper aeration (>1 vol. of air/vol. of medium/min.) and control of substrate addition at less than 0.1% weight/volume are not possible from a practical standpoint in a typical ethanol plant. There is a high capital cost for the equipment necessary to utilize proper propagation. It also takes specialized training in order to make sure that the propagation is monitored properly.

Under aerobic conditions, mash (substrate) must be used in order to grow the yeast to the levels needed to efficiently and quickly produce ethanol. That mash could have been used for producing ethanol instead of extra yeast cell mass.

If propagation is carried out in the ethanol industry, anaerobic conditions are used. After inoculation of purchased yeast, anaerobic growth occurs in fermentation conditions so that this yeast, given time, can multiply into the higher numbers (near 250 X 10⁶) that are totally viable and can be used to inoculate larger fermenters.

In this industry, however, so called “propagators” are mostly utilized and designed to assist in the rehydration or “conditioning” of *dry* yeast. This is nec-

essary because ADY used directly has a longer lag phase, lower activity (vitality) and viability compared to fresh bag or cream yeasts.

The “conditioning” process is also a possible source of contamination because conditions exist for both yeast and bacterial growth. Therefore, both organisms are vying for the same carbohydrates and other nutrients for growth, creating potential for yield loss.

CAKE, CREAM YEASTS

Another type of yeast is cake or compressed yeast. This yeast form has not been dried and does not require rehydration. Therefore, a much shorter lag phase results and the yeast starts with higher activity compared to ADY.

Basing fermentation decisions on cell counts may be misleading. Due to the reduced lag phase and resulting faster start, potential cell count differences are equalized during the early stages of growth. This allows the yeast to be used on a pound-for-pound basis, thus removing the notion of the potential advantages of using ADY. As a result, although conditioning can and is done, cake yeast could also be added directly to a fermenter.

The last type of yeast is cream yeast. There are two basic types of cream yeast: fresh yeast harvested before the drying process and a stabilized cream.

The stabilization process allows shelf life to be extended from two weeks to as much as three months. This is significant in terms of shipping and storage, and allows dosing to be optimized around the need for inventory.

Liquid or cream yeasts have many advantages. Cream yeast can be used in a direct pitch mode. This gives plants the flexibility to add the yeast directly to the fermenter as opposed to “conditioning.” This form is already liquid and exhibits better vitality and viability.

Better viability and activity results in the yeast adapting more quickly to produce ethanol. Most yeasts have to go through a lag phase of growth. Since liquid yeast is ready to grow, it is able to produce ethanol much more quickly.

The risk of infection is also reduced since no “conditioning” is necessary and competing organisms are not introduced into the fermentation.

With liquid yeast, process control systems can be automated, eliminating the use of manual labor for dosing. This allows the operator to concentrate on other areas of the process. It also eliminates propagation tankage, cleaning of the equipment and contamination risks.

Each form of yeast has its own storage, shelf life and process requirements impacting performance. Effective managers who understand their process realize that to truly maximize profitability, yield improvement is critical. Large gains can be accomplished through optimizing fermentation conditions and choosing the correct yeast format. **BB**

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