EVERY DEGREE COUNTS

Temperature is key to fermentation success

Yeast face a number of synergistic stress factors in ethanol production (Figure 1). Maintaining an ideal temperature range during the fermentation process is a difficult task that all ethanol plant operators face, especially in the hotter months (Figure 2). The optimum temperature range for yeast fermentation is between 90˚F-95˚F (32˚C-35˚C). Every degree above this range depresses fermentation.

While elevated temperature is problematic in all phases of ethanol production, it is specifically hazardous during the later stages of fermentation. As ethanol accumulates, the optimum temperature range to maximize ethanol growth becomes more narrow (Figure 3). Higher temperatures also increase yeast sensitivity to lactic and acetic acids, which causes lower ethanol yields.

Yeast can usually tolerate short-term fluctuations in temperature. However, operating above ideal temperatures for longer stretches of time can significantly reduce ethanol yield.

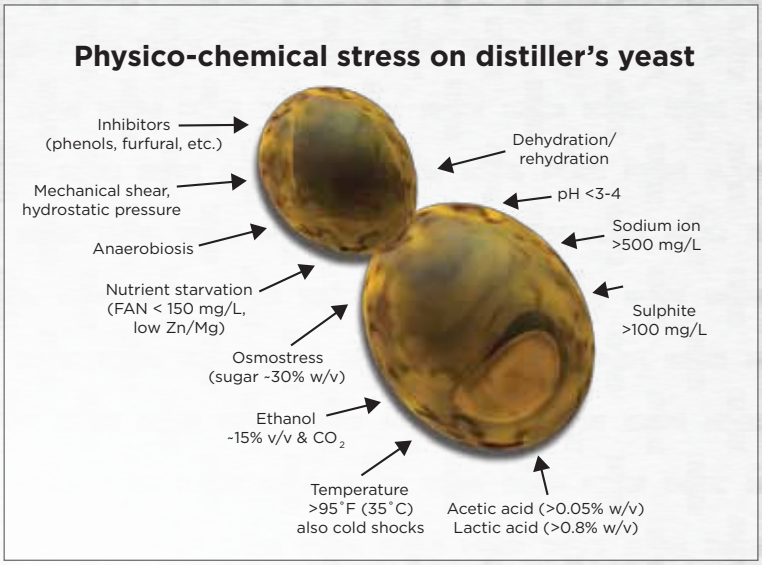


Figure 1: Ethanol plant operators must monitor these stress factors through all phases of fermentation or production can be compromised.

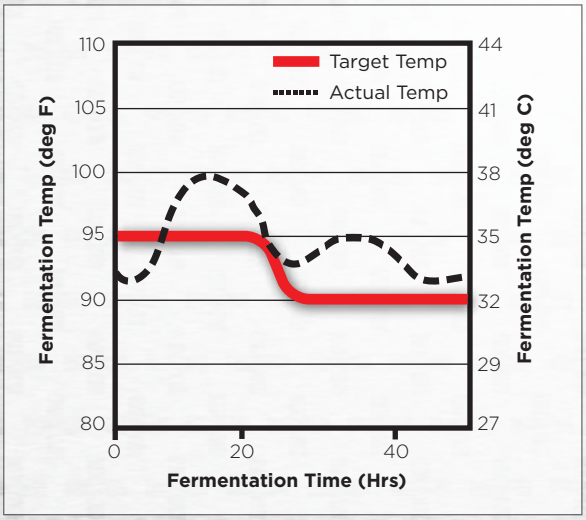


Figure 2: Some production facilities may have trouble controlling temperature during hotter months.

The effects of high temperature spikes on fermentation performance may vary greatly depending on multiple parameters:

- The time in the fermentation process the temperature change occurs
- The duration of the temperature spike
- The amount of yeast pitched
- The yeast nutrition being used

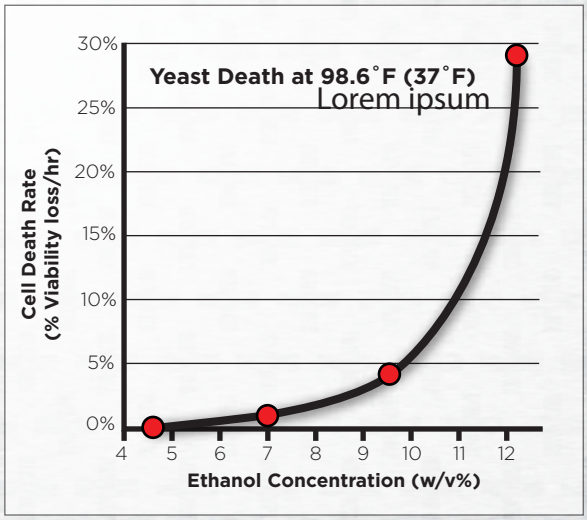


Figure 3: Temperature becomes critical in later fermentation stages where ethanol concentration totals are higher.

If significant temperature deviations are expected, actions can be taken to minimize impacts. These include:

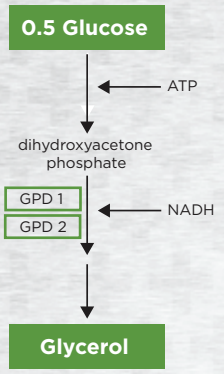
- Increase yeast dose
- Increase nitrogen addition
- Increase exogenous glucoamylase (GA) dose
- Decrease fermentor solids

TRANSFERM® Yield+

Robust at high temperatures

TRANSFERM® Yield+ is a game-changing new yeast that has demonstrated consistent performance at higher temperatures. An advanced strain of Saccharomyces cerevisae, TRANSFERM Yield+ has shown:

- Up to 4% yield gains in ethanol
- Reduction in glycerol of 30%
- Reduction in separately purchased GA enzyme



Yeast makes glycerol for two reasons:

1. To respond to high sugar levels and temperatures required in the ethanol fermentation process
2. To balance internal yeast metabolism (redox potential) by using glycerol as an electron acceptor

Mascoma scientists incorporated a metabolic pathway in TRANSFERM Yield+ that reduces glycerol production and increases ethanol production.

Although TRANSFERM Yield+ is bioengineered to generate less glycerol in ideal conditions, it still produces "stress glycerol" in stressful conditions. This means that TRANSFERM Yield+ maintains a thermal robustness profile that is as good as or better than conventional yeast strains when in high-temperature scenarios.

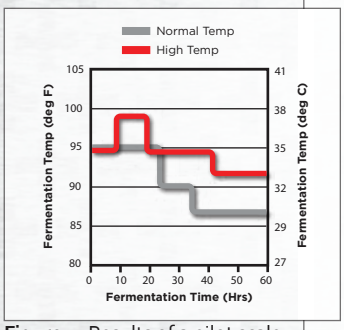
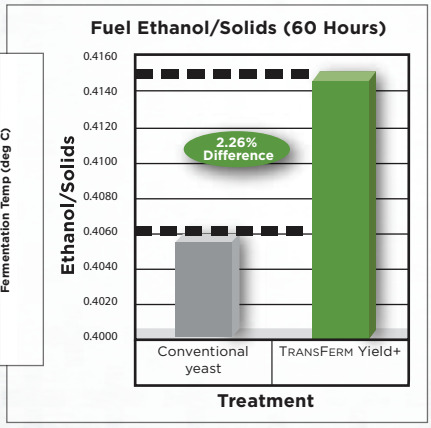


Figure 4: Results of a pilot scale test with high temperature profile.



TRANSFERM Yield+ was evaluated against conventional yeast under a high temperature profile in pilot plant scale (7500 gal fermentation) (Figure 4). After 60 hours TRANSFERM Yield+ finished with 2.26% more ethanol than the conventional yeast.

During a temperature stress test in a 110 million gallon per year (MGY) facility (Figure 5), both TRANSFERM Yield+ and the conventional yeast decreased in performance as temperatures rose. But TRANSFERM Yield+ continued to outperform conventional yeast through all temperature profiles studied.

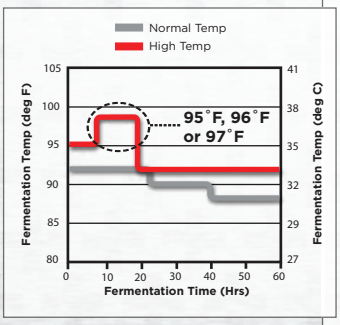
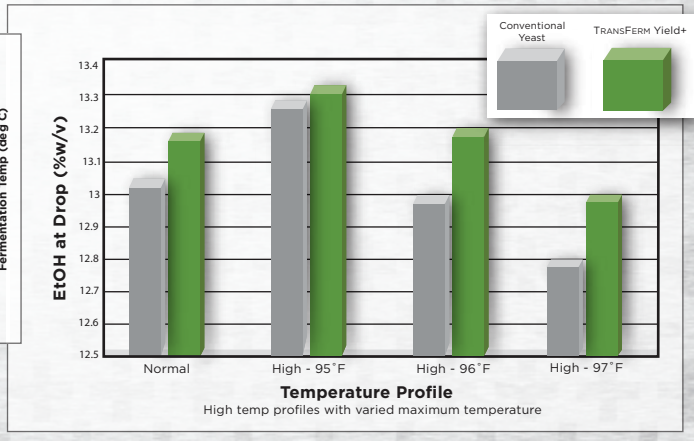


Figure 5: Results of a test of 3 high temperature profiles in a 110 MGY facility.



TRANSFERM Yield+ sets a new standard for fermentation efficiency in fuel ethanol production. Talk to your Lallemand Biofuels & Distilled Spirits or Mascoma Representative to learn more about TRANSFERM Yield+.

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