The Comparative Fermentation Rates of Budding Yeast, Saccharomyces Cerevisiae, in the Presence of Magnesium Sulfate and Sodium Fluoride

Ryan Guzall, Yahoo! Contributor Network
Nov 6, 2008 "Share your voice on Yahoo! websites. Start Here."

MORE: Magnesium Fermentation Oakland University

The comparative fermentation rates of budding yeast, *Saccharomyces cerevisiae*, in the presence of magnesium sulfate and sodium fluoride

Ryan Guzall

Department of Biological Sciences, Oakland University, Rochester, MI 48309

Summary:

The production of CO_2 via the *S. cerevisiae* fermentation process was measured by means of a test tube/vial system under the influence of a control, an $MgSO_4$ solution and a NaF solution over the period of an hour. The control, the $MgSO_4$ solution and the NaF solution produced the highest, middle and least amount of CO_2 respectively. Magnesium is conclusively essential to the fermentation process of *S. cerevisiae*.

Introduction:

An enhanced fermentation rate of yeast, *Saccharomyces cerevisiae* (a single-celled fungi capable of fermenting carbohydrates), can result in an accelerated production of ethyl alcohol (ethanol). Magnesium appears to be a useful catalytic enzyme when added to the fermentation process of *S. cerevisiae*, resulting in a higher fermentation rate of older cells in comparison to older control cells and maintenance of a higher fermentation rate as ethanol accumulates (Dombek and Ingram 1986). With the high cost of oil making ethanol and other alternative fuels increasingly attractive (Potera 2005) and the possibility that magnesium salts could favor the growth of *S. cerevisiae* and its relative fermentation rate in comparison to other salts (Bautista-Gallego et al., 2008), the effectiveness of magnesium on the fermentation and ethanol production rate of *S. cerevisiae* has the potential to benefit numerous industries. Since the fermentation of glucose yields carbon dioxide, ethanol and energy, CO_2 production level can be measured (since it is the most easily observed) and directly related to ethanol production.

Methods:

On 14 October 2008 in room 212 in the Dodge Hall of Engineering on campus at Oakland University, we marked nine pre-cleaned test tubes numerically, 1-9, and filled each with an 8 ml yeast suspension and 8 ml of 1.0M glucose. Then, to tubes 1, 2, and 3, we added 8 ml of distilled H_2O as a control.

Tubes 4, 5, and 6 were then filled with 8 ml of 0.01M $MgSO_4$ and tubes 7, 8, and 9 were filled with 8 ml of 0.1M NaF. Each tube was covered with a pre-cleaned vial and inverted three times. All tubes remained upside down in their respective vials for the duration of the experiment. The initial meniscus level of each inverted solution was marked. The solutions were allowed to rest in a test tube rack for a period of one hour at which time the new meniscus level was measured. The difference between the initial and final meniscus level on each tube was then recorded as CO_2 production per tube.

After recording the level of CO_2 production for each vial and categorizing the results based on solution, our results were added to a list of class results for the same experiment. The class results were then used to derive mean CO_2 production for each solution. The significance of differentiation between the three solutions was calculated by means of the Kruskal-Wallace test after which three separate Mann-Whitney tests were used to compare mean differentiation between each of the three groupings in order to determine which substance most affected CO_2 production.

Results:

Review of mean CO_2 production data suggested significant differentiation for *S. cerevisiae* between the control, $MgSO_4$ and NaF solution groups (table 1). Production levels were differentiated most highly for the $MgSO_4$ v. NaF and Control v. NaF groupings with the $MgSO_4$ v. NaF grouping differentiation slightly more significant as a result of a larger sample size. The Control v. $MgSO_4$ grouping, while also significantly differentiated, was the most closely related of the three groupings and included a few overlapping CO_2 production results.

Table 1

Comparative CO_2 production for *Saccharomyces cerevisiae* under controlled, $MgSO_4$ and NaF enriched conditions. N values represent sample sizes. $T \geq CV$ establishes significance.

Control

$MgSO_4$

NaF

Mean (mm)

39

31

18

N

17

18

18

T

CV

45.43

13.82

P = 0.001*

*Kruskal-Wallace test

Table 2

Saccharomyces cerevisiae CO_2 production differentiation by solution for three groupings. U-value ≤ CV establishes significance.

	U	**CV**	**P***
Control v. $MgSO_4$	23.5	75	0.01
Control v. NaF	0	75	0.01
$MgSO_4$ v. NaF	0	81	0.01

*Mann-Whitney test

Discussion:

The fermentation of glucose by *S. cerevisiae*, which yields equal molar amounts of carbon dioxide and ethanol, showed higher production levels of carbon dioxideunder controlled conditions than any other implying the same for production of ethanol. Fermentation affected by a magnesium sulfate solution ranked second in carbon dioxideproduction while sodium fluoride yielded the least amount of carbon dioxide. These results suggest that magnesium has a positive influence on the production rate of carbon dioxide during the fermentation process and that the control contained an amount of magnesium that was neutralized by the presence of the fluoride anion.

Though mean production was lower for the magnesium sulfate solution than the control, a few specific results overlapped suggesting the addition of magnesium sulfate had no affect for those instances. A lower mean value for the magnesium sulfate solution suggests either that the fermentation process was supersaturated by magnesium or that the sulfate anion adversely affected the production of carbon dioxide. Further experimentation should be performed to determine the affects of magnesium sulfate in comparison to other magnesium and non-magnesium containing salts such as calcium sulfate or magnesium chloride to determine which ion has the greatest affect.

Unknown variables such as the age of the *S. cerevisiae* samples may have affected the outcome of this experiment. Verification of *S. cerevisiae* batch age would allow for additional experiments to determine whether magnesium supplementation affects yeast of a certain age differently than that of another. Additionally, the experimental test tube/vial container allowed for some of each solution to be pushed out of the experimental test tube as the level of carbon dioxide increased. Further experimentation should utilize a better method of measuring the production of the entire original solution, not a fraction of the solution as a function of time. An alternative would be to attach a balloon to the tip of the solution-filled test tube, measure the diameter of the balloon, let an hour elapse and then measure the diameter again to determine carbon dioxide gas production.

Decreased carbon dioxide production levels for *S. cerevisiae* in the presence of a sodium fluoride solution suggest that an absence of available magnesium during fermentation results in an inefficient fermentation process; some level of magnesium is required in order for the process of fermentation to operate at maximum efficiency. Additional magnesium does not guarantee a faster or more efficient means of fermentation/ethanol production and can have an adverse affect on the fermentation process.

Literature Cited:

Bautista-Gallego J, FN Arroyo-Lï¿½pez, A Chiesa, MC Durï¿½n-Quintana, and A Garrido-Fernï¿½ndez. 2008. Use of a D-optimal design with constrains to quantify the effects of the mixture of sodium, potassium, calcium and magnesium chloride salts on the growth parameters of Saccharomyces cerevisiae. *Journal of Industrial Microbiology & Biotechnology*. 35 (8):889-900.

Dombek, K. M., and L. O. Ingram. 1986. Magnesium limitation and its role in apparent toxicity of ethanol during yeast fermentation. *Applied and Environmental Microbiology*. 52:975-81.

Potera, Carol. 2005. Souped-Up Yeast. *Environmental Health Perspectives*. 113 (4):A231.

Results for **The Comparative Fermentation Rates of Budding Yeast, Saccharomyces Cerevisiae, in the Presence of Magnesium Sulfate and Sodium Fluoride**

Published by Ryan Guzall
I am a hockey-loving, scientific musician with flair. View profile