YEAST AND THE PROCESSING OF SUGAR (BIOBREAD)

William O. Gallerizzo
Ellicott Mills MS/ Howard Co. MD

Abstract

The level of yeast activity in bread dough is essential to the texture and quality of bread. The main food for yeast in this process is sugar which is used to make the bread This class has been hired as a research team to investigate and test the viability of using powdered skim milk as an ingredient to making good-tasting, fortified bread.

This is a series of labs designed to take a look at activity levels in yeast by evaluating CO_2 production.

Scenario

Gluten N. Freydoe, President of the Freydoe Baking Company which produces and sells healthful breads, produces a very fine Italian bread. Fr. Freydoe, however, is interested in producing a calcium-fortified Italian bread. Mr. Freydoe has decided that powdered skim milk would be the ideal ingredient to use which would be high in calcium an other vitamins and how a low fat content.

The level of yeast activity in bread dough is essential to the texture and quality of bread. The main food for yeast in this process is sugar which is used to make the bread. Powdered milk also contains certain sugars. Therefore, Mr. Freydoe has decided that the amount of powdered milk added should replace the amount of sugar in the recipe.

This class has been hired as a research team to investigate and test the viability of using powdered skim milk as an ingredient to making good-tasting, fortified bread.

This is a series of labs designed to take a look at activity levels in yeast. Yeast is a type of fungus. It feeds often by decomposing carbohydrates, but can also feed by decomposing other materials. The usually indicator of yeast activity is CO_2 production coming from the decomposition of carbohydrates.

The first lab in the series involves looking at yeast activity involving two different carbohydrates – table sugar (the most common food for yeast) and powdered skim milk (which contains the sugar lactose, but is also used in bread-making as a source of calcium fortification). You will be comparing the amount of carbon dioxide output of yeast for each carbohydrate.

The second lab in the series looks at the volumetric rise in bread dough using the two food sources and any differences in the yeast activity levels when flour is present

(flour, besides being a starch, is a carbohydrate). You are to compare the food type with a quantitative rise in the bread dough.

The third lab in the series is actually not done in Science class, but in the Home Economics class which has the facilities to complete this phase of research and development process.

The fourth lab is a comparative evaluation. The Home Economics class will send back prototype samples of the finished products for you to test. A subjective evaluation will be done on texture, color, and quality. Objective testing will be done on density. At the end of this lab, each group will then decide which bread would be a salable and quality product.

Lab #1 – Yeast Activity

Materials

3 – 50 mL beakers
3 fermentation chambers
Yeast
Water
Sugar
Graduated Cylinder
Triple beam Balance

Procedure

1. Place 10 mL warm water into each of 3 beakers (50 mL size).
2. Add into the first, 2.0 g sugar.
3. Add to the second, 2.0 g powered skim milk.
4. Add to the third, 1.0 g sugar and 1.0 g powdered skim milk.
5. Mark one fermentation chamber for each of the solutions prepared.
6. Add in 0.4 g yeast into each beaker.
7. Pour the contents of each beaker into its own fermentation chamber and make sure that the air is removed from the vertical tube.
8. Allow to stand for 20 minutes, marking the height of the fluid every 2 minutes.
9. At the end of 20 minutes, mark the height of the fluid in the fermentation chambers and measure the amount of height changed into the chart.
10. Place all data in the spreadsheet called Yeast Activity Levels.

Observations

Collect data by measuring the amount of CO_2 in millimeters from the top of the chamber every two minutes.

Time (Minutes)	Chamber One Yeast/Sugar	Chamber Two Yeast/Milk	Chamber Three Yeast/Milk/Sugar
2			
4			
6			
8			
10			
12			
14			
16			
18			
20			

Spreadsheet Layout *Lab #1 – Yeast Activity Levels*

Copy the data from your chart from the lab.
All values should be cumulative in millimeters of height.

Control

Time	Group 1 Cham. 1 Y & S	Group 2 Cham. 1 Y & S	Group 3 Cham. 1 Y & S	Group 4 Cham. 1 Y & S	Group 5 Cham. 1 Y & S	Group 6 Cham. 1 Y & S
0						
2						
4						
6						
8						
10						
12						
14						
16						
18						
20						

Variation 1

Time	Group 1 Cham. 2 Y & M	Group 2 Cham. 2 Y & M	Group 3 Cham. 2 Y & M	Group 4 Cham. 2 Y & M	Group 5 Cham. 2 Y & M	Group 6 Cham. 2 Y & M
0						
2						
4						
6						
8						
10						
12						
14						
16						
18						
20						

Variation 2

Time	Group 1 Cham. 3 Y & S/M	Group 2 Cham. 3 Y & S/M	Group 3 Cham. 3 Y & S/M	Group 4 Cham. 3 Y & S/M	Group 5 Cham. 3 Y & S/M	Group 6 Cham. 3 Y & S/M
0						
2						
4						
6						
8						
10						
12						
14						
16						
18						
20						

Analysis

1. Which fermentation chamber showed the most gas produced?
   Which type of food was present in the culture fluid?

2. Which fermentation chamber showed the least gas produced?
   Which type of food was present in the culture fluid?

3. Look at the graphs you have set up. Which produced gas at the fastest rate?
   Explain why you thin that this happened.

4. Which food supply do you think might possibly result in the most rise in bread dough? Yeast with sugar, yeast with powdered skim milk, or yeast with a combination of sugar and powdered skim milk? Explain.

Lab #2 – Rising Dough

Materials

3 – 50 mL beakers
Yeast
Water
Sugar
Powdered skim milk
Graduated cylinder
Triple beam balance
White flour

Procedure

1. Mark each beaker to correspond with each type of yeast solution described in the first lab.
2. Prepare the solutions with yeast as described in the previous lab.
3. Into each beaker, place 15 g of white flour and thoroughly mix into a dough.
4. For each dough sample, push in down into the bottom so as to remove all air space. Mark the starting level of the dough.
5. Allow the dough to rise for 20 minutes. Make observations describing the risings every two minutes with marks on the sides of the beakers.
6. Place your data into the spreadsheet called Rising Dough.

Observations

Collect data by measuring the amount of CO_2 in millimeters from the starting level every two minutes.

Time Minutes	Beaker One Yeast/Sugar	Beaker Two Yeast/Milk	Beaker Three Yeast/Sugar/Milk
2			
4			
6			
8			
10			
12			
14			
16			
18			
20			

Spreadsheet Layout *Lab #2 – Rising Dough Levels*

Copy the data from your chart from the lab.
All values should be cumulative in millimeters of height.

Control

Time	Group 1 Beaker 1 Y & S	Group 2 Beaker 1 Y & S	Group 3 Beaker 1 Y & S	Group 4 Beaker 1 Y & S	Group 5 Beaker 1 Y & S	Group 6 Beaker 1 Y & S
0						
2						
4						
6						
8						
10						
12						
14						
16						
18						
20						

Variation 1

Time	Group 1 Beaker 2 Y & M	Group 2 Beaker 2 Y & M	Group 3 Beaker 2 Y & M	Group 4 Beaker 2 Y & M	Group 5 Beaker 2 Y & M	Group 6 Beaker 2 Y & M
0						
2						
4						
6						
8						
10						
12						
14						
16						
18						
20						

Variation 2

Time	Group 1 Beaker 3 Y & S/M	Group 2 Beaker 3 Y & S/M	Group 3 Beaker 3 Y & S/M	Group 4 Beaker 3 Y & S/M	Group 5 Beaker 3 Y & S/M	Group 6 Beaker 3 Y & S/M
0						
2						
4						
6						
8						
10						
12						
14						
16						
18						
20						

Analysis

1. In which beaker did you experience the most rise in dough?
   What was the food combination in that mixture?

2. In which beaker did you experience the least rise in dough?
   What was the food combination in that mixture?

3. Looking at the rise in levels and your yeast output, which type of dough should yield the lightest bread? Explain your answer.

4. Looking at the rise in levels and your yeast output, which type of dough should yield the heaviest bread? Explain your answer.

Lab #3 – Baking Bread Prototypes

Scenario

The Life Science class is investigating the activity levels of yeast in the process of designing and making calcium-fortified bread. You, as a Home Economics class, are a significant part of this research process. You are responsible to do the prototype fabrication. You will be given a recipe for Italian Bread. There will be two variations from the standard recipe in which powdered skim milk will be substituted for the sugar, which feeds the yeast. Each group will be given one recipe to bake. You will be required to follow the recipe you are given strictly as written. This is important because you are making the prototypes for testing.

Each recipe makes two loaves. Your group must put one finished load into a plastic bag with a twist tie and properly mark the loaf. Your group may eat or keep the second loaf.

Control Group Recipe

Materials

5 cups unsifted flour
1 tablespoon sugar
1 tablespoon salt
2 packages active, dry yeast
1 tablespoon softened margarine
1 and a half cups very warm tap water (120^0F to 130^0F)
Vegetable oil

Procedure

Day One

1. In a large bowl, thoroughly mix 1 and a half cups flour, and the sugar, salt and undissolved yeast. Add the margarine.
2. Gradually add tap water to the dry ingredients and beat 2 minutes at medium speed of an electric mixer, scraping the bowl occasionally.
3. Add a half cup of flour. Beat at high speed for 2 minutes, scraping the bowl occasionally.
4. Stir in 2 cups of flour to stiffen the dough.
5. Turn out onto lightly floured table top or counter top and knead the dough for 10 minutes to make it smooth and elastic, lightly flouring with the remaining flour.
6. Cover the dough with plastic wrap and then a towel. Let the dough rest for 20 minutes.

7. Divide the dough in half. Roll each half into an oblong shape about 15 inches long and 10 inches wide.
8. Beginning at the wide side, roll up the dough tightly and pinch the seam to seal. Taper the ends.
9. Brush the dough with vegetable oil. Wrap the dough loosely in plastic wrap and place in the refrigerator overnight.

Day Two

1. Preheat the oven to 425^0F.
2. Remove the dough from the refrigerator and carefully uncover.
3. Let the loaves stand for 10 minutes on a greased baking sheet
4. Gently make three or four diagonal cuts across the top with a sharp knife.
5. Bake in the oven for 30 minutes until golden brown.
6. After the bread has cooled, place one loaf in a plastic bag and properly label it according to the recipe type. Keep the second loaf.

Experimental Group One Recipe

Materials

5 cups unsifted flour
2 1/3 tablespoons powdered skim millk
1 tablespoon salt
2 packages active, dry yeast
1 tablespoon softened margarine
1 and a half cups very warm tap water (120^0F to 130^0F)
Vegetable oil

Procedure

Day One

1. In a large bowl, thoroughly mix 1 and a half cups flour, and the sugar, salt and undissolved yeast. Add the margarine.
2. Gradually add tap water to the dry ingredients and beat 2 minutes at medium speed of an electric mixer, scraping the bowl occasionally.
3. Add a half cup of flour. Beat at high speed for 2 minutes, scraping the bowl occasionally.
4. Stir in 2 cups of flour to stiffen the dough.
5. Turn out onto lightly floured table top or counter top and knead the dough for 10 minutes to make it smooth and elastic, lightly flouring with the remaining flour.

6. Cover the dough with plastic wrap and then a towel. Let the dough rest for 20 minutes.
7. Divide the dough in half. Roll each half into an oblong shape about 15 inches long and 10 inches wide.
8. Beginning at the wide side, roll up the dough tightly and pinch the seam to seal. Taper the ends.
9. Brush the dough with vegetable oil. Wrap the dough loosely in plastic wrap and place in the refrigerator overnight.

Day Two

1. Preheat the oven to 425^0F.
2. Remove the dough from the refrigerator and carefully uncover.
3. Let the loaves stand for 10 minutes on a greased baking sheet
4. Gently make three or four diagonal cuts across the top with a sharp knife.
5. Bake in the oven for 30 minutes until golden brown.
6. After the bread has cooled, place one loaf in a plastic bag and properly label it according to the recipe type. Keep the second loaf.

Experimental Group Two Recipe

Materials

5 cups unsifted flour
one half tablespoon sugar
1 and a half tablespoons powdered skim millk
1 tablespoon salt
2 packages active, dry yeast
1 tablespoon softened margarine
1 and a half cups very warm tap water (120^0F to 130^0F)
Vegetable oil

Procedure

Day One

1. In a large bowl, thoroughly mix 1 and a half cups flour, and the sugar, salt and undissolved yeast. Add the margarine.
2. Gradually add tap water to the dry ingredients and beat 2 minutes at medium speed of an electric mixer, scraping the bowl occasionally.
3. Add a half cup of flour. Beat at high speed for 2 minutes, scraping the bowl occasionally.
4. Stir in 2 cups of flour to stiffen the dough.

5. Turn out onto lightly floured table top or counter top and knead the dough for 10 minutes to make it smooth and elastic, lightly flouring with the remaining flour.
6. Cover the dough with plastic wrap and then a towel. Let the dough rest for 20 minutes.
7. Divide the dough in half. Roll each half into an oblong shape about 15 inches long and 10 inches wide.
8. Beginning at the wide side, roll up the dough tightly and pinch the seam to seal. Taper the ends.
9. Brush the dough with vegetable oil. Wrap the dough loosely in plastic wrap and place in the refrigerator overnight.

Day Two

1. Preheat the oven to 425^0F.
2. Remove the dough from the refrigerator and carefully uncover.
3. Let the loaves stand for 10 minutes on a greased baking sheet
4. Gently make three or four diagonal cuts across the top with a sharp knife.
5. Bake in the oven for 30 minutes until golden brown.
6. After the bread has cooled, place one loaf in a plastic bag and properly label it according to the recipe type. Keep the second loaf.

Lab #4 – Prototype Evaluation

Materials

Three loaves of brad prototypes from lab #3
White bread with sugar growth medium
White bread with powdered milk/sugar growth medium
White bread with milk growth medium
Ruler
Triple beam balance

Procedure

1. Work first with the bread made with the sugar growth medium. Cut the loaf in half.
2. From the cut side of the half loaf, cut a 1 –2 cm slice.
3. From the interior of the slice (do not use crust), cut cubes. Measure the dimensions and calculate the volume using l(v)(h) = v.
4. On a triple beam balance, measure the mass of all four cubes together.
5. Divide the mass by 4 to calculate the average density of the bread. Density (grams per cm^3) = Mass (grams) / Volume (cm^3).
6. Record the information on the chart provided.
7. Repeat steps 2 – 6 for the other two prototypes.
8. Cut a slice of each bread type and keep them separated.
9. Rate the breads on the basis of their textures.
10. Rate the breads on the basis of their flavors.
11. Rate the breads on the basis of their weights.
12. Rate the breads on the basis of their crusts.
13. Rate the breads on their colors.
14. Compare the bread which used straight sugar with the other two which used milk.

Observations

After you have collected data on the mass, volume, and density, put your data into the spreadsheet called Bread Prototype Evaluation. This will calculate the density. Check your figure against the spreadsheet. Also, put in your opinion information. This is so you can easily compare your data when answering questions later.

Bread Prototype

Type	Yeast/Sugar	Yeast/Milk	Yeast/Sugar/Milk
Volume			
Mass			
Density			

Where: d = m/v or (Density = mass/volume)

Opinion (subjective information)

The bread using only sugar as its yeast growth medium is the standard you are to use to judge the other two breads. Test the bread first. See what its qualities are. For this bread, call all values "3" to set the standard and then evaluate the other two on the basis of how they compare with the standard bread as greater than or lesser than.

Freydoe Baking Company – Bread Prototype Rating Scale
(this scale is progressive with "5" being the highest rating)

Texture To Touch And Taste					
Sugar	1	2	3	4	5
Sugar/Milk	1	2	3	4	5
Milk	1	2	3	4	5
Flavor					
Sugar	1	2	3	4	5
Sugar/Milk	1	2	3	4	5
Milk	1	2	3	4	5
Weight					
Sugar	1	2	3	4	5
Sugar/Milk	1	2	3	4	5
Milk	1	2	3	4	5
Thickness of Crust					
Sugar	1	2	3	4	5
Sugar/Milk	1	2	3	4	5
Milk	1	2	3	4	5
Color					
Sugar	1	2	3	4	5
Sugar/Milk	1	2	3	4	5
Milk	1	2	3	4	5
Product Overall Quality					
Sugar	1	2	3	4	5
Sugar/Milk	1	2	3	4	5
Milk	1	2	3	4	5

Bread Prototype Evaluation

Enter your data from the lab called *Prototype Evaluation.*

Density of Bread made with Sugar Cultured Yeast (Control)

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	TOTALS
Mass							
Volume							
Density							

Density of Bread made with Milk Cultured Yeast (Variable 1)

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	TOTALS
Mass							
Volume							
Density							

Density of Bread made with Sugar/Milk Cultured Yeast (Variable 2)

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	TOTALS
Mass							
Volume							
Density							

Opinion Survey, Bread made with Milk Cultured Yeast (Variable 1)

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	TOTALS
Mass							
Volume							
Density							
Crust							
Color							
P.O.Q							

Opinion Survey, Bread made with Sugar/Milk Cultured Yeast (Variable 1)

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	TOTALS
Mass							
Volume							
Density							
Crust							
Color							
P.O.Q							

Analysis

1. Compare the three prototypes.
   How were the three breads similar?
   How were the three breads different?

2. Which bread should contain the highest nutritional level? Explain.

3. What relationship is there, if any, between the type of food used to culture yeast and the qualities of the bread produced with that culture? Use factual information from the charts or spreadsheet to explain your answer.

4. If you had a choice to purchase one of the three types of bread, which would you purchase? Use factual and opinion information to explain your answer.

Teacher's Notes

Divide the class into six groups with each group testing control and experimental conditions. A main focus of this lab series is to illustrate the rapid accumulation of data through several teams simultaneously testing the same variables. Another main focus of this lab is to illustrate the roles that are played by different divisions within a research company. Although the R&D department may test for the possibility of a new idea, the theoretical concept may be brought to reality through fabrication by another department and the prototypes are then sent back for analysis. In this way, a Science class may test food variables for yeast activity, with the Home Economics class producing the prototypes, that will be sent back to the Science class for analysis.

In the first and second labs, since the data is totally quantitative, all data should be graphed by height in millimeters over time (two minute intervals). This may be done as part of the data entry to the spreadsheets, or it could be done on graph paper as a homework follow-up to each lab.

For Middle School, or where there are single-period classes, it may be advisable for the teacher to prepare the media solutions prior to class to expedite the activity. Otherwise, students may prepare the solutions on the first day, and hold them over until the next day. Either way, the teacher should pre-head water in large beakers to a temperature between 50^0C and 60^0C to be used in the lab.

The third lab in this series involves mixing dough, baking breads and testing the end products when the respective combinations of "regular" and "fortified" recipes are used. This is designed to be done in the Foods class of the Home Economics Department or in Science class with access to ovens either in school or at home as a cross-curricular connection. Three variations of a recipe for bread based on the three yeast/food configurations are sent to Home Economics class o be prepared and baked "according to specifications" of prototypes. If coordination with a Home Economics Department is not possible, then the third lab could be given as a home lab since this phase could be time consuming. The bread recipe used calls for dough to be mixed on one day with the bread being baked the following day after refrigeration for up to 24 hours. The third lab has its own introduction which may be given to students in the Home Economics class which explains to them their part in the project and helps to tie the cross-curricular connection for the student who may be taking the particular Home Economics class but not the particular Science class.

The fourth lab in the series involves Product Testing from both subjective and objective directions. The ultimate questions are: Should the company really produce this product, and is it good enough to be produced?

There are many possibilities for variations, such as comparing sugar with honey as two different food sources, testing the output of different varieties of yeast against the standard envelope variety, as well as changing other variables. This series encourages imaginative experimentation that exceeds a 40-minute, one-class environment.