**Design Project- Par Baked Bread**

**Part 1 – A: Select Process, Plant & Define Problem**

The process chosen is par baked bread. The ingredients used to bake bread are essentially flour, water, yeast, salt and other ingredients to add flavor, nutrition, color or to change the characteristic of the crumb. The units of operations that are included in par baking bread are mixing of raw ingredients, fermentation, baking, freezing and packaging.

**Part 1 – B: Problem definition**

Purpose:

Our main goal is to completely understand the process of par baking bread.

Objectives:

Upon our understanding of the process we intend to design our own homemade par baked process and also to improve the existing process.

The first step taken in order to accomplish our objectives will be to find formal literature reviews before September 28. Our main target is to obtain at least one book that precisely covers the process of par baked bread. Due to lack of better timing at this point all three of us will be equally looking into find formal literature.

From then, we plan to visit a company that makes par baked bread by no later than October 20. One of the companies that we are looking into visit is Kroger’s in Indianapolis. As of now, we are not completely sure the make par baked bread but it would still be interesting and important to visualize a bread process line in a large company. At this point Ben will be in charge of contacting the company.

By the time that phase 3 is turned in we should be fully aware of how the process works and will be able to calculate any of the mass balances and energy balances in every step that is taken to bake par baked bread. Zach will be in charge of finding any new information about ingredients used in the process. He will also be in charge on getting any information about initial amount of ingredients that will be used in the mass balances. Once we have the mass balances done Priscila will be in charge of the energy balances. We will be performing any calculations and programming together, but Prisicila and Zach will be in charge of any outside information that will be needed for this specific process.

Once we have all the calculations necessary will be making our own par baked bread. For that Zach will again be in charge of the ingredients. Ben will be in charge of finding a place for us to perform our experiments and Priscila will be in charge of the formal written report.

**Part 2: Literature Review**

*History and Basics*

Bread has been one of the main forms of food since early time. There are many proves that bread has been around for a long time. Bread is one of the main foods mentioned in the Bible. Also, in the British Museum’s Egyptian gallery you see proves of bread that were baked over 5,000 years ago. Even further back, a millstone used to grind corn has been found and it thought to be 7,500 years old.

Nowadays bread is still consumed very often on our everyday life. According to breadinfo.com on average an American consumes 53 pounds of bread per year. Since bread is inexpensive and also contains a strong nutrition value for its price, bread is probably the one food eaten by people of every race, culture and religion.

When making bread, there are several things that are very important if the product is going to be good quality. The mixture is mixed together, some doughs use only flour, water, salt, and yeast. Others are enriched with fats. Kneading is an important step that creates long strands of gluten. These strands of gluten act to trap the gas produced by yeast during the rising process. After the dough is kneaded, the dough is divided into the size and shape desired and then let alone to rise. In the baking process the gas, which was produced by fermentation during the rising stage and then trapped by the gluten matrix, expands with the heat of the oven. As the dough bakes the structure of the bread becomes sounder and when the bread cools the gas pockets will remain even after the trapped gas compresses again. One thing to remember while baking is that a lot of moisture is released from the bread and it is a good idea to keep the humidity relatively high in the oven to keep the loaf from drying out to badly.

Any baker with the capability to bake and freeze a product will be able to produce par-baked bread as long some modifications are done to production line.

There are a couple changes to the formulation of dough for par-baked breads. Less sugar should be used to reduce the amount of browning in the bread and less yeast should be used because the lower oven temperatures will not kill the yeast as fast. There is also a continuous fermentation chamber that can be used which moves dough though the chamber under optimal conditions while fermentation is going on. This assures that all the dough that goes into the divider is all the same age which will make a much more consistent product. There will be no need for fermentation chambers if this machine is used which will save on space in the production plant.

There are a few variations when it comes to baking par-baked breads. The first thing to remember is that baking will be stopped as soon as all interactions with the yeast and bread have stopped. This is the point where no more fermentation is going on and the products structure has been completely formed. A vertical oven should be employed in place of a tunnel oven. In a vertical oven, the amount of steam can be carefully controlled as long as there are regular steam injections during the baking process. These injections will help ensure that the crust is soft, thin, and will retain the bread’s moisture. Since vertical ovens move the baking pans upward, they will take up much less space than a tunnel oven. This space is very valuable if used for other applications or other equipment.

When freezing par-baked breads, the loaf must be cooled down to room temperature before entering the freezer. If the internal temperature of the loaf is too high then a dry shell can develop on the bread that will flake off. Also having the bread at room temperature before it enters the freezer means that it will take less time and will be cheaper to freeze then if it went in at the baking temperature. Par-baked bread should be 90% frozen when it leaves the freezer. If the bread is in the freezer too long, freezer burns can develop and if it is not in the freezer long enough, the loaf can collapse. Par-baked bread should never be thawed and refrozen due to quality suffering. One freezing system that some manufacturers are selling for par-baked breads is a vacuum-based cooling system. The claim for this cooling system is that the bake time can be lowered by 20%. This works because the system lowers the breads temperature to 50 F in about seven minutes, which eliminates the need to bake the bread until a hard crust forms which normally will maintain the volume of the bread. After the bread has been vacuum-cooled, it can be immediately placed in its packaging and then put into the freezer where the temperature will reach -10 F over time.

*The Process of Fermentation*

The tools for fermentation have been around since the dawn of life on planet earth, however fermentation as an instrument for food production was not instituted until man began to walk the earth. The first fermentation (although accidental) can be traced to early humans storing milk in the stomachs of slaughtered animals. This lead to the discovery of yogurt, from the capacity of milk to sour rapidly due to its high lactic acid content.

Bread fermentation mostly likely arose as soon as human began using fire for cooking. When humans began to grind flour, wheat and other grains, they noticed that when mixed with water and agitated then cooked they began to ferment, producing new aromas and flavors. This was due to the lactic acid bacteria and yeast organisms in the environment, and is referred to as lactic acid fermentations. The outcome favored the strong organisms that could withstand the acidic mixture, and yields early forms of ‘bread’ (4).

Eventually, early populations found that denser concentrations of ground grains in water when baked yielded sourdough or leavened breads. Before the development and culture of today’s “Baker’s Yeast”, leavened bread refers to the process of using day old dough and mixing it with the new dough mixture. This causes the dough to be more consistent and bake faster due to the addition of live yeast cells, and in ancient times this technique was highly valued and thought of as an art form.(1)

Overtime people found that when different amounts of the components (most importantly yeast and flour) were used, breads molded and baked differently. The basic idea - which will be explained later in greater detail – is that organisms known as yeast utilizes the sugars and oxygen in the dough to create more yeast cells and carbon dioxide, where carbon dioxide is what causes the bread to ‘rise’ or leaven. The chemical pathways that occur in bread making our broken up into two main reactions, the first being the aerobic fermentation. This process can be chemically explained with this simple equation:

bread_fermentation.gif

*Bread Ingredients (3)*

alcohlic_fermentiation.gifBread fermentation also implements the usage of anaerobic fermentation, which has byproducts of Ethyl alcohol and carbon dioxide.

*Bread Ingredients (3)*

The first chemical reaction is used in produces the other yeast cells and CO2, where the second creates alcohol and CO2, which after burni­ng off in the baking process leaves much of the aromas and flavors we enjoy in breads today. It should be noted that this anaerobic process is also used in alcoholic drink fermentation.

The overall process of yeast bread fermentation occurs in a few major steps. First the flour is mixed with water; the amount of each is what leads to the great variety of bread types. (One should note that the amount of water in solution will affect the ‘crumb’ or center of the bread, where higher percentages of water will yield coarser textures.) After the flour and water are thoroughly mixed, cultured yeast is added.

This was done in ancient times by the addition of old dough that already contained yeast. Often, bakers would keep a mixture of 50% flour and 50% water with live yeast in reserve, and continue to ‘feed’ the blend to keep the yeast alive. They could then take small amounts of the concoction to add yeast to their breads for baking. This process was not understood until 1676 when Anton van Leeuwenhoek discovered that yeast was a cell and that different strains of these cells produced different results. In modern times scientists have been working on culturing the ‘perfect’ yeast cell. Today *Saccharomyces cerevisiae* is implemented as the most often used yeast strain. (4)

After yeast is added to the mixture, the dough is left for an allotted period of time to let the yeast fuel the reactions listed above. However this reaction is nowhere near as simple as stated above; at this point enzymes are called into play.

The main component of the grains we use for bread making and fermentation are the grains starches. Starch belongs to the chemical compound class known as carbohydrates, and is comprised of many sugar (or glucose) molecules linked together. Yeast by itself cannot break these bonds and ferment the sugars, so it has to rely on two other enzymes: Alpha-amylase and Beta-amylase. Initially starch exists in two forms: an unbranched chain known as amylose and a branched chain called amylopectin. The enzymes that digest these chains are the amylases.

First, the starch has to be broken down into complex sugars, such as maltose and dextrin. Maltose is a two glucose molecule, where dextrin is a multi-glucose molecule. The enzyme α-amylase does this part, attacking the starch virtually everywhere alone its amylopectin chains. So, the dough must contain some α-amylase for this purpose, however too much α-amylase will liquefy the starch. Where yeast can handle the Maltose through its enzymes, the dextrin must be further broken down by the enzyme β-amylase.

β-amylase is typically found in abundance in grain and flour, where it is used to digest amylase completely into Maltose. These amylase chains are what hold the dextrin together, so the β-amylase performs the second half of the work by breaking the dextrin up so that all of the sugar particles are in Maltose form or smaller.

At this point, the yeast cells take over, applying their enzyme maltase to break the bonds of the Maltose and form glucose. Once the starch has been broken down into these simple sugars, the yeast can then ferment them with the help of zymase into the ethyl alcohols and carbon dioxide. Should the sugar be sucrose, there is another step required. Invertase must first digest the sucrose into glucose and fructose, where zymase then ferments it. (3)

After the allotted amount of time, the yeast in the dough will begin to undergo its chemical process and produce the products listed above. It is at this point when bakers may decide to knead the dough (releasing CO2 and allowing the dough to obtain more reactions) and flatten it. This process of kneading will let the yeast continue to react in the dough, allowing for better tastes and aromas when cooked. Finally, the dough is placed in a cooking device and baked. The yeast, with the help of the catalyzing agent heat, will continue to produce the reactants, as here is where bread begins to swell due to carbon dioxide production. At 46 ºC, the yeast ceases to function and dies, as the alcohols are burnt off and the bread is cooked. (5)

This process over being ‘cooked’ actually makes up quite a few different steps. When heated, starch will absorb water into its granules and eventually burst, or lyse, its contents. This gel which is the after product is commonly referred to as sauces or gravies. However in bread, due to its high amounts of flour, the starch will rarely absorb enough water to bust and will just saturate and form a network of granules that are contacting on all sides.

The reason bread retains its structure after the baking process is complete is due to the gluten in the starch. Gluten is formed from the insoluble proteins glutenin and gliadin. When the dough is kneaded, the gluntenin forms long strands of chain like proteins where the glaiden is uses to tie bridge these strands together. The resulting structure or network or strands is called Gluten(6). The gluten, when heated, releases its water which is quickly absorbed by the starch granules. This drying and hardening consequently causes the gluten to set and become rigid, which leads to its structure.

All these different steps and components lead to how we know bread today.

*Components and Microorganisms*

There are many components that contribute to break making. Here I will list them with their major roles and factors.

Flour is of course the main ingredient of bread making. Flour can be made from any assortment of ground plant, however for our purpose wheat is the common bread making grain used. Wheat is comprised of starches and proteins, which in turn are made of more sub-particles. For this report, we will focus on the wheat grains.

1. Flour
   1. Wheat – typically comprised of the entire what grain, endosperm and bran.
      1. This grain is made of mostly Starches and Proteins.
         1. Starch is 70% of the grain
         2. Protein consumes 8%
         3. Minor components make up the rest.
      2. Grain also contains β-amylase and α-amylase, which are used to break down the bonds joining the long glucose strands (starches).
2. Yeast – Most commonly *Saccharomyces cerevisiae* or Baker’s yeast
   1. Enzymes
      1. Maltase
         1. Breaks down the maltose sugars, leaving free glucose for yeast fermentation.
      2. Zymase
         1. Zymes does the work of fermentation on the sugars
      3. Invertase
         1. Invertase digests the sucrose into glucose and fructose for use by zymase.
   2. Reproduction
      1. Yeast reproduces extremely fast, doubling the amount of cells every 90 minutes. This is done by
   3. Commercial production
      1. Annually over 1 million tons of yeast is made (however this yeast is used in baking and brewing) which is over 100 times the amount of all other microbes produced.
3. Liquid – Usually milk or water, used in the reaction process. Milk gives the crumb a softer texture, which water creates a the hard crust.
4. Salt – Flavoring, but also the addition of salt can be used to slow the process reaction.
5. Egg – Adds color and flavor to t he crumb and crust.
6. Fats – often called shortening because it lubricates the strands of the gluten and causes them to break more easily. This of course leads to a softer and tenderer product.
7. Sugar – Since yeast uses sugar, it can affect the reaction a number of different ways, but typically helps the bread rise and adds flavors.
8. Seasonings / Other – Manipulates flavor and consistency. Also may manipulate the reaction.

*Bread Ingredients (3)*

*Basic Market Data*

Although we search vigorously, we could not find much market Data. Below is what we found.

In 1999, the market for baked goods (either pre-baked or in bakeries) exceeded 23 billion in the U.S. This was comprised of 5.5 billion in Bakeries and 17.5 billion in prebaked goods. (8) However, it was found that fresh baked goods are selling more than packaged goods, leading us to believe that par-baked goods and their semi-fresh baking style will appeal to the mass populous. It was predicted in 2004 that this would rise to 29 billion, with fresh baked options and increase in variety leading the economic growth. Also, consumers seeking organic alternatives will be enjoy the par-baked breads since they are sterilized in the partially baked process, and this important with the fact that organic foods can sometimes lead to microorganism infestation because of the lack of herbicides.

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