Introduction to the Revised Bakery Science Lab Manuals

Chloe Shearon

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I chose to revise the Bakery Science I and II lab manuals because I saw an unfulfilled need in the Grain Science Department. I had tossed around the idea of doing a research project, speaking with Dave Krishock and Dr. Becky Miller to explore opportunities and gather ideas, but after taking Bakery Science I and II, I realized I could use my writing skills to streamline the courses and to help future students.

The original lab manuals were written in the late 1980s or early 1990s by Dr. Joel Payne, a previous Bakery Science instructor. Bakery Science I encompasses yeast-leavened baked goods as well as steam-leavened pastries, while Bakery Science II covers chemically-leavened products like high-ratio cakes, snack cakes, and cake doughnuts. The lab manuals contained valuable information about dough rheology and flow, processing techniques, equipment, ingredient functionality and interactions, as well as formulas and instructions for preparing a broad range of bakery products. However, over the following 20-30 years, the lab manuals have been substantially revised by each subsequent instructor to fit each semester's specific needs and time constraints.

While these previous revisions were necessary, a lack of direction and the pressure of time, as well as to simply "fill the gap" and teach the class, caused many .typos and copy-and-paste errors, making the lab discombobulated and loading the students down with extra papers. It was difficult to glean the required information from the jumbled pages, making the classes frustrating. I wanted to clean up the text, making it accessible to every student, as well as to update the source materials and the technologies discussed. Many of the original citations dated from the 1950s-1970s;

many baking fundamentals have not changed since then. However, I believed that customer trends, processing techniques, and available ingredients have changed significantly, and should be included in the lab manuals.

To begin the revision process, I obtained the Word files from Michael Moore, the current lab instructor, and transferred them to my laptop. Since Bakery Science II takes place during the Spring semester, while Bakery Science I occurs during the Fall semester, I chose to revise the manuals in reverse order (Bakery Science II first, then Bakery Science II) so they could be put into use more quickly. I then read through my paper copies of each lab, making note of errors (both grammatical and technical) and writing ideas for expansion in the margins. Next, I drew up a master plan, breaking the project up into goals and writing down main objectives for both semesters of revision. I also wrote a list of personal goals I wanted to achieve through these revisions.

I wanted the lab manual to be:

- Relatively easy to read and understand
- Technical, but not overly so
- A source that encourages students to dig into the technical side and to search out other sources
- Applicable in lab and related to the lecture portion of the course

I then typed a first draft of each lab, using the paper lab with my notes as reference, making more marginal notes as I came across sources that were unclear, outdated, or unnecessarily technical. I chose to completely rewrite each lab for consistency's sake – some wording from the original labs may still exist in the revisions, but most has been significantly changed or updated. I hope that I have successfully made the labs comprehensive and comprehendible, without including unnecessary detail. While an understanding of food and cereal chemistry is essential to success in the Bakery Science field, a highly technical discussion of interactions on the chemical level is not always helpful to students who may not have taken Food Chemistry or Cereal Science before Bakery Science I. Throughout the process, I read many papers from the Journal of Cereal Chemistry, the Journal of Food Science and Technology, and many other sources to understand the background material and to be able to update the labs appropriately. I also attempted to track down the sources originally cited in the manuals.

Some, if not most, of the sources initially found in the lab manuals, were simply references drawn from in the Bakery Science textbook (many uncited or cited improperly). Many others were impossible to find online or in the library, so I did my best to find updated sources with similar information. Source verification, along with the sheer bulk of material to revise, was my major challenge with this project.

I met with Dr. Jon Faubion (my project advisor), Michael Moore, Dr. Becky Miller, Dr. Sherrill Cropper, and Dave Krishock at various occasions to ask questions, seek guidance, or to verify choices I had to make (such as removing or adding experiments).

While I believe that there is still a significant amount of work to be done on the Bakery Science I and II courses, particularly on the formulation side, I am thankful to have had the opportunity to make my mark and get the ball rolling on these lab manuals. It has been great to see the Bakery Science II course use my revisions this semester, and I hope that others continue to think critically about the courses that they are taking and volunteer to take on similar projects as well.

GRSC 636
Baking Science I
Lab Manual

Fall 2018

The Effects of Ingredient and Process Variation in Yeast-Raised Bakery Products

Edited by Chloe Shearon

Spring 2018

Many thanks to Dr. Jon Faubion, Dr. Sherill Cropper, Dr. Joel Payne, Dave Krishock, and Michael Moore, all of whom helped assemble this lab manual in one way or another. Editing the Bakery Science I and II Lab Manuals has been a wonderful capstone for my senior year of college, and has firmly cemented my knowledge and understanding of the baking process. It was a privilege to work with you all.

Lab #1 – Orientation (Basic Straight Dough Procedure)

To minimize unintended experimental 'error', you must work accurately and adhere closely to the timing schedule given by the instructor. Changes may be made to the formulas during the course of the lab – the instructor will let you know on a case-by-case basis. Take note of physical dough properties and measurements like Final Dough Temperature at each processing step on the provided data sheet. Exact replication of technique is necessary so that the effect of the intended treatment variations will show through in final results. Do not place any flour on your bench or scale when handling dough. Simply use a plastic dough scraper to separate dough from surfaces to which it sticks.

Mix Doughs, then Bulk Ferment for 1 hour at 81°F:

Mix doughs to optimum, which depends on the type of flour and the amount of water used. Optimum mix time will vary somewhat across different mixers due to variations in RPMs and bowl-hook configurations. Read the formulas carefully each week – some indicate mixing to optimum after the addition of the salt, while others may require teams to under- or over-mix their doughs.

Record mixing times on your team's data sheet. Place mixed dough into a stainless steel (SS) fermentation bowl. Record its temperature and the time at which its mixing ended. Place the dough into a fermentation cabinet to bulk ferment for 1 hour. Instructor will verify optimum mix.

Divide and shape, then bench rest 15 min:

Bring the fermented dough to your team's scale. Weigh two pieces of dough at 539 grams. Gently stretch each out vertically on table surface, pat out the dough gently with hands, fold in thirds, turn, then fold the dough piece in half. Be careful to avoid tearing the skin**. Proceed to the intermediate proof step and place the loaf pieces on your bench covered with plastic for 15 minutes.**

Molding, Pan, and Proof:

Place each rested semi-loaf upside down onto the entry belt pointed toward the Oshikiri moulder, which will sheet them out then roll them into cylinders. Place molded cylinders into greased bread pans with the crease (seam) centered in the bottom of the pan. Attach tags to loaf ends, then place panned doughss into the proofer. The final rise, referred to as the "proof", should bring the loaves to a height of 2 cm above the top of the pan. A plastic template will be used to verify this measuerement. Proofing will take about 55-75 minutes, depending on proof room temperature and experiment.

Bake:

Bread loaves produced in lab will be baked 425°F for 20 - 22 minutes. Allow enough space between pans to provide adequate heat transfer to the panned loaves, otherwise the loaf walls will be very weak, and will collapse.

Measure loaf volume:

After the loaf comes out of the oven, allow it to cool for 15-20 minutes. During cooling, the structure will set and will be able to withstand the weight of the canola seeds used in the volumeter. While the loaves are cooling, calibrate the volumeter relative to the 1675 cc wooden block. After the loaves have cooled, weigh them (in grams) and use the volumeter to determine the volume (cc) and specific volume (volume/weight). **For most labs, 400 cc of rapeseeds must be removed to accommodate for the large loaf volumes produced. Make sure to add 400cc back to your observed volume heights for accuracy**.

Once you have filled out your paper data sheet and completed all the formula steps, input your team's data into the master data sheet on the computer in Shellenberger 109. This data will be used to compare variations and create graphs for visual interpretation of said variations.

KSU BAKING SCIENCE FORMULA

PRODUCT: White Pan Bread

FORMULA NO: 1 (Control)

Control Formula for Straight Dough,
Delayed salt

DATE OF ISSUE: 7/01/2015

BAKER'S%	INGREDIENTS	WEIGHT/GRAMS
100	Bread Flour	700
62.5	Water	438
1.8	Yeast (instant)	12.6
1.6	NFDM	11.2
3.0	A.P. Shortening	21.0
6.0	Gran. Sugar	42.0
1.57	Dough Conditioner	11.0
2.0	Salt	14.0
	Total weight:	**1,249.8 g**

NOTES: **Scale two dough pieces each weighing 540 grams.**

INSTRUCTIONS

1. Place **All DRY** ingredients (except salt) in McDuffie bowl
2. **Add water slowly.**
3. Mix 30 sec on 1^{st} speed
4. Mix 3:30 on 2^{nd} speed

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5. Add salt and mix 30 seconds on 1^{st} speed
6. Mix for 2 minutes on 2^{nd} speed. Check for gluten development.
7. Continue mixing to optimum gluten development.

Total time on 2^{nd} speed after the addition of the salt: ___________

Desired Dough temp: 79-81°F
26-27°C

Friction Factor: 45°

Final dough temp:__________

Premixing Notes:

1. The amount of water to be used was determined in a series of test bakes.
2. **Calculated Water Temperature =**

(3 times Desired Dough Temp.) **--** (Room temp. + Flour temp. + Friction factor)

(3 times ___________________) **--** (__________ + __________ + ___________)

= ________________________

3. The optimum mixing time is the amount of time in **2^{nd} speed after the addition of the salt.**

GRSC 636 LAB DATA SHEET

Group# ______________________
Lab #________________________ **Today's Date____________**

Dough #						
Water temp. (F°)						
Mixing time (2nd Stage)						
1st Speed						
2nd Speed (post-salt)						
F.D.T. (F°)						
Processing Times						
Ferment: Time in (1hr)						
Ferment: Time out						
Rest (15 min)						
Proof: Time in						
Proof: Time out						
Oven: Time in						
Oven: time out						
Internal loaf temperature:						
Wt. (g)						
Volume (cc)						
Specific Volume (vol./wt.)						
Bread Scoring						
Crust color (20pts)						
Break and Shred (10pts)						
Grain (20pts)						
Crumb Color (20pts)						
Texture (20pts)						
Symmetry (10pts)						
Total (100pts)						

COMMENTS:

NOTE: This data sheet must be submitted with each lab report.

Lab #2 – Optimum Water Levels and Mix Time

Background

As water is added to flour, it begins to penetrate the outer surfaces of the dense flour particles and weakens starch-protein bonds. Mixing action rubs the outer surfaces against each other and exposes more of the dry flour granule. This process continues until all of the flour is hydrated or until there is no free water left in the system. In an optimally formulated system, enough water will be added to create a cohesive, viscous dough that will be further developed through mixing.

As mixing continues, two polypeptides inherently found in wheat, glutenin and gliadin, begin to interact and bond. The long glutenin strands entangle the small, globular gliadin proteins. Mixing action creates a 3-D protein matrix (a “fishnet” structure) by stretching and folding the hydrated gluten strands (Pyler 45). This structure helps entrap and retain gas cells during fermentation, proofing, and baking. As mixing continues, the dough begins to develop bulk elasticity and the surface becomes drier. The dough also is now capable of “time-delayed extensibility”, which enables gas cells to expand during fermentation and allows for oven spring during baking.

Overmixing

If mixing continues past the optimum point, the dough will lose all bulk elasticity, become sticky and overly extensible, and will appear wet and soft. The dough quickly becomes stringy and breaks down. Overmixed doughs will not be able to entrap gas cells, leading to a final product with large and coarse grain and low final volume (Pyler 19).

Optimizing Water Levels and Mix Time

The optimum mix time of a dough corresponds with the point at which the dough’s viscosity, elasticity, and resistance are all at their maximum point. The flour has been completely hydrated relative to the amount of water added to the formula, but the dough has not yet been overmixed.

Optimum mix times can be found for various water levels. If low % water has been added, the dough will be stiffer and less viscous. Flour particles will rub against each other more easily and more dry surface area will be exposed quickly. On the other hand, higher water levels increase the separation between flour granules and slows the abrasion rate during mixing. Extremely high amounts of water have a detrimental effect on the protein matrix and reduce gas retention capabilities.

Optimum combinations of water, flour, and mix time can be determined within a dough system (e.g. straight dough) to maximize dough and final product qualities. Because different flours will have various optimum conditions due to environmental, genetic, and physical factors, test baking is necessary to determine the ideal combination for a particular flour.

Bibliography

Pyler, E. J., and L. A. Gorton. “6.A.2. Mixing stages”. Baking Science & Technology, vol. 2, Sosland Pub., 2008, p. 19.

Pyler, E. J., and L. A. Gorton. “1.D.1.f.ii. Gluten formation”. Baking Science & Technology, vol. 2, Sosland Pub., 2008, p. 45.

KSU BAKING SCIENCE FORMULA

PRODUCT: White Pan Bread

FORMULA NO: #1 (Control)

Control Formula for Straight Dough,
Delayed salt

DATE OF ISSUE: 7/1/2015

BAKER'S%	INGREDIENTS	WEIGHT/GRAMS
100	Bread Flour	700
62.5	Water	438
1.8	Yeast (instant)	12.6
1.6	NFDM	11.2
3.0	A.P. Shortening	21.0
6.0	Gran. Sugar	42.0
1.57	Dough Conditioner	11.0
2.0	Salt	14.0
	Total Weight	**1,249.80**

NOTES:____

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Scale two dough pieces each weighing 539 grams.

INSTRUCTIONS

8. Place **All DRY** ingredients (except salt) in McDuffie bowl
9. **Add water slowly.**
10. Mix 30 sec on 1^{st} speed
11. Mix 3:30 on 2^{nd} speed
12. Add Salt and mix 30 seconds on 1^{st} speed.
13. Mix for 2 minutes on 2^{nd} speed. Check for gluten development.
14. Continue mixing to optimum gluten development.

Total time of 2^{nd} speed after the addition of the salt: ____________

Desired Dough temp: 79-81°F
26-27°C

Friction Factor: 45°

Final dough temp:__________

Premixing Notes:

4. The amount of water to be used was determined in a series of test bakes.

5. **Calculated Water Temperature =**

(3 times Desired Dough Temp.) **--** (Room temp. + Flour temp. + Friction factor)

(3 times ___________________) **--** (__________ + __________ + ___________)

= ________________________

6. The optimum mixing time is the amount of time in 2^{nd} speed after the addition of the salt. **ALL** remaining dough's **will** be mixed using this optimum mixing time for the Control dough.

KSU BAKING SCIENCE FORMULA

PRODUCT: White Pan Bread

FORMULA NO: 2 & 3 (**water variations**)

Control Formula for Straight Dough, Delayed salt

DATE OF ISSUE: 7/1/2015

BAKER'S%	INGREDIENTS	WEIGHT/GRAMS
100	Bread Flour	700
TBD	Water	
	Dough 2	From lab prep sheet
	Dough 3	From lab prep sheet
1.8	Yeast (instant)	12.6
1.6	NFDM	11.2
3.0	A.P. Shortening	21.0
6.0	Gran. Sugar	42.0
1.57	Dough Conditioner	11.0
2.0	Salt	14.0

NOTE: **Scale two dough pieces each weighting 539 grams.**

INSTRUCTIONS

1. Place **All DRY** ingredients (except salt) in McDuffie bowl
2. **See water amount to be added below.**
3. Mix 30 sec on 1st speed
4. Mix 3:30 on 2nd speed.
5. Add Salt and mix 30 seconds on 1st speed
6. Continue mixing on 2nd speed for the same duration as the control.

Mix time in 2nd speed: _______

Desired Dough temp: 79-81°F
26-27°C

Friction Factor: 45°

Final dough temp: ____________

Note:
The instructor will determine the variation water levels through test baking and will advise the groups mixing variation 2 (low water) and variation 3 (high water) on the exact amounts during lab.

KSU BAKING SCIENCE FORMULA

PRODUCT: White Pan Bread

FORMULA NO: 4&5 (**mixing variations**)

Control Formula for Straight Dough,
Delayed salt

DATE OF ISSUE: 7/1/2015

BAKER'S%	INGREDIENTS	WEIGHT/GRAMS
100	Bread Flour	700
62.5	Water	438
1.8	Yeast (instant)	12.6
1.6	NFDM	11.2
3.0	A.P. Shortening	21.0
6.0	Gran. Sugar	42.0
1.57	Dough Conditioner	11.0
2.0	Salt	14.0
	Total Weight	**1,249.80**

NOTE : **Scale two dough pieces each weighing 539 grams.**

INSTRUCTIONS

1. Place **DRY** ingredients (except salt) in McDuffie bowl
2. **Add water (calculate temp below).**
3. Mix 30 seconds on 1st speed
4. Mix in 2nd speed
   - **Dough 4** -- 30 seconds
   - **Dough 5** -- 10 minutes
5. Add Salt and mix 30 seconds on 1st speed
6. Continue mixing in 2nd speed
   - **Dough 4** -- 2 minutes
   - **Dough 5** -- 2 minutes

Desired Dough temp: 79-81°F
26-27°C

Friction Factor: 45°

Final dough temp: ____________

GRSC 636 LAB DATA SHEET

Group# ______________________
Lab #________________________ **Today's Date**____________

Variation #						
Water temp. (F°)						
Mixing time (2nd Stage)						
1st Speed						
2nd Speed (post-salt)						
F.D.T. (F°)						
Processing Times						
Ferment: Time in (1hr)						
Ferment: Time out						
Rest (15 min)						
Proof: Time in						
Proof: Time out						
Oven: Time in						
Oven: time out						
Internal loaf temperature:						
Wt. (g)						
Volume (cc)						
Specific Volume (vol./wt.)						
Bread Scoring						
Crust color (20pts)						
Break and Shred (10pts)						
Grain (20pts)						
Crumb Color (20pts)						
Texture (20pts)						
Symmetry (10pts)						
Total Points (100pts)						

COMMENTS:

Lab #3 – Ingredient Functionality: Effects of varying sugar, salt, shortening, and surfactant levels

Background

The "leanest" possible formula for French bread contains only flour, water, yeast, and salt. When other ingredients are added like milk, sugar, or fat, the texture, volume, flavor, and shelf life of the finished product will change, allowing the baker to have more control over the final attributes of their product and increase or decrease richness, volume, and many other characteristics. In this lab, the effects of changing ingredient levels will be observed through test baking.

Salt

According to Dubois, Salt is commonly used at levels of 1.25-2.50% of the flour weight; 2.0% is most frequently used (qtd. in Pyler 434). Salt affects fermentation, elastic resistance to flow and gas cell formation, as well as flavor.

Salt inhibits the growth and activity of yeast by changing the osmotic pressure of the system and causing the yeast cells to lose water. Salt levels may be adjusted to help slow or speed fermentation. Salt's ability to influence osmotic pressure also helps reduce the growth of spoilage organisms by reducing the free water available in the product.

Viscosity, or elastic resistance to flow, is affected by the addition of salt. Miller and Johnson (qtd. in Pyler 434) believe that salt interacts with and inhibits proteolytic enzymes, which hydrolyze peptide bonds. By reducing the "cutting" action of these enzymes, salt helps tighten and strengthen the gluten matrix, decreasing the likelihood of producing soft, unworkable doughs.

Sugar

Sugars are often added to doughs to add a pleasant, sweet flavor, and to provide food for the yeast cells. The addition of sucrose also modifies final product texture, creating a softer, moister loaf of bread. An enzyme present in yeast, **invertase**, breaks down the disaccharide into monosaccharides. These products of hydrolysis, glucose and fructose, are easily fermented. High fructose corn syrup contains equal parts glucose and fructose and is often used instead of sucrose because of its low price and easy processing qualities.

In leaner formulas containing little or no added sucrose, yeast is able to utilize maltose to continue the fermentation process. Flour contains 1-2% simple sugars. The addition of α-amylase, through the addition of malt, hydrolyzes the damaged starch present in the flower, breaking it down into maltose. After any easily fermentable sugars are exhausted, yeast fermentation lags. After this lag time, yeast is able to break down the maltose disaccharide using the enzyme **maltase** and uses the resulting glucose to continue the process of fermentation. However, in most commercial formulas, sucrose or HFCS is added to reduce lag time during processing.

On a chemical level, sugars bind and structure water, reducing the amount of formula water available to the starch polymers and preventing moisture migration during storage. Because less water reaches the starch granules, as sugar increases, starch gelatinization is delayed. Higher temperatures must be reached to provide adequate kinetic energy to hydrate and plasticize the starch granules. As gelatinization is delayed, starch granules are less able to swell. They do not bond as tightly to the gluten network and can't provide additional strength, creating a softer crumb. Additionally, these loose, weak bonds slow the creation of additional hydrogen bonds during storage, reducing the perception of staling.

Shortenings

The addition of fat interrupts the gluten structure in the dough, tenderizing and shortening the bite and providing a richer flavor. Additionally, dough becomes increasingly extensible as shortening is added and is better able to entrap gas, allowing gas cells to expand more easily. This phenomenon creates higher oven spring and an increase in final product volume. Up to 3% shortening is typically used, Pyler says (182). Wade says that if excessive fat is added to the dough, the gluten matrix will not be able to form properly (qtd. in Mamat et al 2012). If the gluten matrix is underdeveloped, the final product will be dense, with a low final volume and coarse grain.

Surfactants

Surfactants reduce interfacial tension between two separate "phases" (e.g. water and oil) and cause them to combine easily without separating. For this reason, surfactants are crucial to the production of quality high-ratio cakes. However, the use of surfactants in bread production is for another reason. Surfactants are thought to form complexes with amylose during the gelatinization process, limiting the amount of amylose that can leach out of the starch granule and delaying the denaturation of gluten (Ghiasi et al 1982). These "complexes" reduce the amount of swelling that can occur and push back the point at which the structure of bread is "set", allowing for more oven spring and a product with greater volume. Finally, the interactions between surfactants and amylose molecules reduce the amount of material available to form hydrogen bonds, therefore slowing the staling process.

The two most popular surfactants for use in bread are sodium stearoyl-2-lactylate (SSL) and calcium stearoyl-2-lactylate (CSL), partially due to their strengthening properties. SSL and CSL interact with proteins, improving gas retention capabilities and allowing for greater volume, as well as helping preserve a fine grain and crumb structure.

Bibliography

Ghiasi, K., et al. “Gelatinization of Wheat Starch. I. Excess-Water Systems.” Cereal Chemistry, vol. 52, no. 2, 1982, pp. 81–85., www.aaccnet.org/publications/cc/backissues/1982/Documents/chem59_81.pdf.

Mamat, Hasmadi, and Sandra E. Hill. “Effect of Fat Types on the Structural and Textural Properties of Dough and Semi-Sweet Biscuit.” Journal of Food Science and Technology, Springer India, 29 Apr. 2012, www.ncbi.nlm.nih.gov/pmc/articles/PMC4152542/.

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Pyler, E. J., and L. A. Gorton. “8.B.1.e. Fats”. Baking Science & Technology, vol. 2, Sosland Pub., 2008, p. 182.

GRSC 636 LAB DATA SHEET

Group# ______________________
Lab #________________________ **Today's Date**____________

Variation #						
Water temp. (F°)						
Mixing time (2nd Stage)						
1st Speed						
2nd Speed (post-salt)						
F.D.T. (F°)						
Processing Times						
Ferment: Time in (1hr)						
Ferment: Time out						
Rest (15 min)						
Proof: Time in						
Proof: Time out						
Oven: Time in						
Oven: time out						
Internal loaf temperature:						
Wt. (g)						
Volume (cc)						
Specific Volume (vol./wt.)						
Bread Scoring						
Crust color (20pts)						
Break and Shred (10pts)						
Grain (20pts)						
Crumb Color (20pts)						
Texture (20pts)						
Symmetry (10pts)						
Total Points (100pts)						

COMMENTS:

Lab #4– Yeasted Dough Systems

Although the straight dough procedure is the one discussed in the previous 4 labs, there are many other common means of bread production. These procedures include sponge and dough, liquid brew, remix straight dough, continuous mix, and Chorleywood. Today's lab will cover sponge and dough, liquid brew, and the remix straight dough methods. More information about the other procedures may be found in the attached Lallemand Baking Update.

Straight dough is practical in laboratory applications because of its intolerance to formula and process adjustments; it is easy to see the effects of changing a certain variable. However, this sensitivity is detrimental to the production of a bulk quantity of consistent product. Large-scale production facilities frequently avoid straight dough formulas and instead choose one of the three following methods.

Sponge and Dough

Sponge and dough is the most common bread production method in the United States due to increased flexibility in processing and better tolerance to slight variations in ingredient level, mix time, and bulk fermentation time.

First, a sponge containing water, yeast, and approximately 70% of the flour is mixed and then fermented in troughs for 2.5-4.5 hours (Bakerpedia 2018). After fermentation, the sponge is added to the remaining ingredients and mixed to optimum development, then allowed to rest and bulk ferment for a short period known as floor time. The dough is then run through processing equipment to divide, shape, proof, and mold it into the desired finished product.

Bread produced using the sponge and dough method often has an improved flavor and aroma, better crumb grain, and extended shelf life than straight dough products. Lower levels of yeast may also be used. Several factors contribute to this phenomenon. The lengthy ferment not only allows biochemical products to accumulate, increasing flavor and aroma, but also allows α-amylase to digest the damaged starch. This reduces the material available to form hydrogen bonds and creates a dough with increased extensibility and potential for oven spring. However, this may also allow for increased gas cell coalescence. To prevent coalescence and avoid dense, coarse finished products, lower water levels are often used in sponge and dough systems to reduce the potential for over-extensibility. Additionally, the increased fermentation time enables the yeast to react more fully and produce more carbon dioxide gas. The "digestion" of the damaged starch and reduction in hydrogen bonds also slows crumb firming and staling. Finally, the baker may adjust the quantity of yeast, the fermentation temperature, and/or the fermentation time to speed up or slow down the total rate of fermentation of the sponge.

Liquid Brew

The liquid brew procedure is similar to the sponge and dough method, but the brew stage contains much less flour than a sponge (usually around 40%). The brew is bulk fermented and may be kept in a temperature-controlled holding tank for later use. It is then piped into the mixer and mixed with the remaining ingredients. The dough may or may not receive additional floor time after mixing, depending upon the desired processing qualities and form of the final product. For example, hamburger buns begin as rounded dough balls that flatten into the final bun shape; therefore, the dough is not allowed to rest, which maximizes extensibility.

Remix Straight Dough

The remix straight dough procedure is similar to a traditional straight dough, but mixing is divided into two stages by bulk fermentation. First, all of the ingredients are mixed together briefly into a shaggy, undeveloped mass. The dough is then bulk fermented. After bulk fermentation ends, the dough is then mixed until full development. The process continues with floor time, dividing, rounding, proof, and baking, like the traditional straight dough method.

Remix straight dough provides processing flexibility because the second mix helps subdivide the gas cells and reduce coalescence and collapse. Therefore, the length of the bulk ferment is variable and may continue for quite some time. Also, since the dough will begin to develop chemically during the bulk ferment, the total mixing time is minimized.

Notes on hydration and mix time in multi-stage doughs

Observe that the mix times are shorter in the sponge and dough and liquid ferment formulas than in the straight dough formula (page??). This phenomenon is due to two main factors: the gradual hydration of the flour particles during the sponge or brew phase, and the protein-lysing activity of the proteolytic enzymes present in the flour.

Fermentation generates acidity, lowering the pH of the dough system and increasing the quantity of positively-charged hydrogen ions. These positively-charged sites cause the individual proteins within the gluten matrix to be slightly repelled from one another and facilitate hydration, reducing mixing time.

However, if some of the salt was added into the sponge, the amount of mixing time required to create a fully-developed dough increases as the salt level increases. The negative chloride ions (Cl-) are attracted to the positively charged areas on the gluten proteins, “shielding” these charges and reducing the amount of repellence that occurs. The proteins are less likely to unfold quickly, so extra energy and mix time must be used to fully hydrate the gluten proteins.

Notes on α-amylase sources in multi-stage doughs

Malt is commonly added to bread formulas as a source of α-amylase enzymes. As discussed previously, these enzymes hydrolyze damaged starch to create maltose and dextrins. The addition of malt helps to reduce the amount of added sugar needed to provide fermentable carbohydrates for the yeast, and will also increase gas cell extensibility to yield higher oven spring.

While low levels of α-amylase are beneficial and increase bread quality, high levels may cause issues, especially during long fermentation periods. If α-amylase is allowed to digest most of the swollen damaged starch granules, the starch will release their retained moisture, lowering viscosity and elasticity, and will no longer be able to support hydrogen bonds between gluten proteins. The resulting dough will be overly extensible and yield a loaf of bread with low volume and coarse, unpleasant grain.

Bibliography

"Sponge and Dough | Baking Processes." Bakerpedia, Dr. Lin Carson, bakerpedia.com/processes/sponge-and-dough/.

KSU BAKERY SCIENCE FORMULA

PRODUCT: White Pan Bread _ DATE OF ISSUE: 10/15/16

Sponge & Dough Method

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS
	SPONGE	
70	Bread Flour	490
61	Water	299
1.7	Yeast (Instant)	12.0
0.043	Ammonium Sulfate	0.30
	FINAL DOUGH	
30	Bread Flour	210
18.3	Water	**128**
6	Sugar	42
3	NFDM	21
2	Salt	14
3	Shortening	21

NOTES: Final Dough water temp calculation:
WT = (**4** * DFDT) – (FT + RT + SpT + FF)

Desired Final Dough Temp: 79-81°F

Sponge water is equal to 490 times 61%

Dough side water is equal to (700 * 61%) – Sponge water amount.

INSTRUCTIONS

SPONGE HAS ALREADY BEEN MIXED FOR YOU!

1^{st} speed: 30 sec. 2^{nd} speed: 2 min

Desired Sponge Temp: 76-78°F

Sponge Fermentation time: 3 hours.

Use 800 grams of sponge.

Final Dough

1. Pre-mix all final dough ingredients including the water. 1^{st} Speed: 30 sec.
2. Add sponge to mixer in 4 or 5 pieces.
3. Mix sponge pieces and dough side ingredients on 1^{st} speed for 30 seconds.
4. Mix on 2^{nd} speed to optimum dough development.
5. **Record time on 2^{nd} speed: ______**
6. **Final Dough temperature: ______**

Post Mixing Procedures:

Scale: Scale dough into 2 540 gram pieces and lightly round up.

Rest: Rest 15 minutes on bench, covered with plastic.

Shape: Place dough ball seam down on the molder. Then place the molded dough piece into a lightly greased bread pan, again placing the seam against the bottom of the pan.

Proof: Proof to template (2 cm in height) for approximately 60 min. @ 100°F, 95% RH

Bake: Bake at 425°F/218°C for 22 minutes

Test and Score: After the loaves have cooled for 20 minutes, weigh your bread and perform volumetric tests on both loaves. Score each loaf. Record your data on the attached sheet as well as the computer.

KSU BAKERY SCIENCE FORMULA

PRODUCT: White Pan Bread _ DATE OF ISSUE: 10/15/16

Liquid Brew Method

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS	INSTRUCTIONS
	LIQUID BREW		**Liquid Brew has already been mixed for you!** **The liquid brew fermented for 2 hours.** **Use 732 grams of liquid brew.**
40	Bread Flour	280	
61	Water	**427**	
1.7	Instant Yeast	12.0	
2	Sugar	14	
0.043	Ammonium Sulfate	0.3	
	FINAL DOUGH		**Final Dough** 1. Scrape all brew out of SS bowl into McDuffie mixing bowl. 2. Add all additional ingredients. 3. Mix 1st speed: 30 sec. 4. Mix on 2nd speed to optimum dough development. **5. Record time on 2nd speed: ______** **6. Final Dough temperature: ______**
60	Bread Flour	420	
4	Sugar	28	
3	NFDM	21	
2	Salt	14	
3	Shortening	21	
NOTES: Desired Final Dough Temp: 79 - 81°F **Note:** All the water has been added to the liquid brew.			

Post Mixing Procedures:

Scale: Scale dough into 2 540 gram pieces and lightly round up.

Rest: Rest 15 minutes on bench, covered with plastic.

Shape: Place dough ball seam down on the molder. Then place the molded dough piece into a lightly greased bread pan, again placing the seam against the bottom of the pan.

Proof: Proof to template (2 cm in height) for approximately 60 min. @ 100°F, 95% RH

Bake: Bake at 425°F/218°C for 22 minutes

Test and Score: After the loaves have cooled for 20 minutes, weigh your bread and perform volumetric tests on both loaves. Score each loaf. Record your data on the attached sheet as well as the computer.

KSU BAKERY SCIENCE FORMULA

PRODUCT: White Pan Bread DATE OF ISSUE: 10/15/16
Straight Dough, Delayed salt

BAKER'S%	INGREDIENTS	WEIGHT/GRAMS
100	Bread Flour	700
62.5	Water	**438**
1.8	Yeast (Instant)	12.6
1.6	NFDM	11.2
3.0	A.P. Shortening	21.0
6.0	Gran. Sugar	42.0
1.57	Dough Conditioner	11.0
2.0	Salt	14.0
	Total Weight	**1,249.80**

NOTES:
Once optimum mixing time on speed 2 for stage 2 is determined, all remaining dough should be mixed using the same optimum mixing time.

INSTRUCTIONS

15. Place all ingredients (except salt) in McDuffie bowl
16. While mixing on 1st speed for 30 seconds add the water to the dough.
17. Mix 3:30 on speed 2
18. Add Salt and mix 30 seconds on speed 1
19. Continue mixing on 2nd speed to optimum gluten development

Optimum mix time on speed 2nd speed: ____________

Desired Dough temp: 79-81°F
26-27°C

Friction Factor: 45

Final dough temp: _____________

Post Mixing Procedures

Ferment: Place dough in greased stainless steel bowl. Ferment for 60 minutes @ 81°F, 90% RH

Scale: Scale dough into 2 540 gram pieces and lightly round up.

Rest: Rest 15 minutes on bench, covered with plastic.

Shape: Place dough ball seam down on the molder. Then place the molded dough piece into a lightly greased bread pan, again placing the seam against the bottom of the pan.

Proof: Proof to template (2 cm in height) for approximately 60 min. @ 100°F, 95% RH

Bake: Bake at 425°F/218°C for 22 minutes

Test and Score: After the loaves have cooled for 20 minutes, weigh your bread and perform volumetric tests on both loaves. Score each loaf. Record your data on the attached sheet as well as the computer.

KSU BAKERY SCIENCE FORMULA

PRODUCT: White Pan Bread — DATE OF ISSUE: 10/15/16

Remix Straight Dough, Delayed salt

BAKER'S%	INGREDIENTS	WEIGHT/GRAMS
100	Bread Flour	700
62.5	Water	**438**
1.8	Yeast (Instant)	12.60
1.6	NFDM	11.2
3.0	A.P. Shortening	21.0
6.0	Gran. Sugar	42.0
1.57	Dough Conditioner	11.0
2.0	Salt	14.0
	Total Weight	**1,249.80 Grams**

NOTES: Desired Dough temp:79-81°F

INSTRUCTIONS

1. Place all ingredients (except salt) in McDuffie bowl
2. Add the water while mixing on 1^{st} speed for 30 seconds.
3. Mix 3:30 on speed 2
4. Add salt. Mix on 1^{st} speed for 30 seconds
5. Mix on 2^{nd} speed for **1.5 min.** (This dough will be undermixed intentionally).
6. **Place the dough in a greased stainless steel bowl. Ferment for 60 minutes @ 81ºF, 90% RH**
7. **Place dough back into the mixer and mix to development on 2^{nd} speed.**

Final dough temperature: _______

Post-mixing procedures:

Scale: Scale dough into 2 - 540 gram pieces and lightly round up

Rest: Rest 15 minutes on bench, covered with plastic

Shape: Place dough ball seam down on the molder. Then place the molded dough piece into a lightly greased bread pan, again placing the seam against the bottom of the pan.

Proof: Proof to template (2 cm in height) for approximately 60 min. @ 100°F, 95% RH

Bake: Bake at 425°F/218°C for 22 minutes

Test and Score: After the loaves have cooled for 20 minutes, weight your bread and perform volumetric tests on both loaves. Score each loaf.

Post-Lab Discussion Questions

1. Construct a data table showing the average volume, average weight, average specific volume, and the average subjective sums for the 4 dough systems.

2. Construct two graphs illustrating the following:

    - The specific volumes of the four dough systems
    - The subjective sum of the four dough systems

3. Use your graphs to answer the following questions.

    - How does the sponge and dough compare with the liquid brew?
    - How does the straight dough compare to the remix straight dough?
    - How does the sponge and dough compare to the straight dough?
    - How does the liquid ferment compare to the straight dough?

4. Describe two advantages of the liquid ferment (brew) system over the sponge and dough system.
5. If you included all the formula salt in the sponge, how would this affect the total mix time required to reach optimum? How would rate of fermentation be affected?

GRSC 636 LAB DATA SHEET

Group# ______________________
Lab #________________________ **Today's Date**____________

Variation #						
Water temp. (F°)						
Mixing time (2nd Stage)						
1st Speed						
2nd Speed (post-salt)						
F.D.T. (F°)						
Processing Times						
Ferment: Time in (1hr)						
Ferment: Time out						
Rest (15 min)						
Proof: Time in						
Proof: Time out						
Oven: Time in						
Oven: time out						
Internal loaf temperature:						
Wt. (g)						
Volume (cc)						
Specific Volume (vol./wt.)						
Bread Scoring						
Crust color (20pts)						
Break and Shred (10pts)						
Grain (20pts)						
Crumb Color (20pts)						
Texture (20pts)						
Symmetry (10pts)						
Total Points (100pts)						

COMMENTS:

Lab #5 – Fermentation

Bakers work to produce white pan bread with sufficient volume, light texture, and a fine and uniform grain. Ingredients and equipment are chosen to optimize the dough's flow properties and to support gas cell retention until oven entry with the goal of maximizing oven spring.

Dough Structure

Bread dough contains a 3D protein matrix in which individual proteins are entangled like a web. Many hydrogen bonds, a few covalent disulfide bonds and hydrophobic interactions, as well as the physical interactions of the protein themselves, serve to hold the matrix together.

The gluten network is the skeleton which supports other formula components such as sugar and starch. These materials fill the voids in between proteins; the main fillers are hydrated damaged starch granules and air cells incorporated during mixing. The starch granules are able to interact with the protein network through hydrogen bonds and provide additional structure through cross-linkage. Due to the small size of the incorporated gas cells, recently-mixed doughs are highly extensible.

After proofing, the dough's 3D structure has expanded; within are entrapped air cells, intact and damaged starch granules, and other minor ingredients. Upon exposure to the hot oven air, the dough's surface begins to dry out and harden. The oven's heat diffuses through the dough system – once it reaches the entrapped gas cells, internal pressure begins to build and the yeast will speed up generation of carbon dioxide gas (Pyler 102). Eventually, the increased pressure will cause the de-hydrated dough surface to break at the weakest point. Expansion then occurs rapidly! This expansion, called oven spring, may cause up to 25% in volume increase from the final proofing step.

The flow properties of the dough at oven entry control the amount of oven spring that is able to occur. To maximize volume increase but retain acceptable crumb/grain properties, the proofed dough piece must meet two criteria.

1. **The dough piece must have sufficiently high resistance to internal flow (elasticity) to retain gas cells and prevent coalescence.** Gas cells are inherently mobile and tend to coalesce, or clump together. Coalescence in large quantity lead to gas leakage, reducing internal pressure in the oven, and therefore reducing the final loaf volume. The final grain will also be coarse and irregular.
2. **The dough piece must possess sufficiently low resistance to internal flow (extensibility) to allow easy expansion of gas cells in the oven.**

These attributes are in direct opposition, which poses a challenge for the baker, who must create a dough system that is extensible *enough* to allow for sufficient gas cell expansion, and yet elastic enough to prevent coalescence and retain its shape in the oven.

Viscoelasticity

Dough is a complex material that resembles both a fluid and a solid; therefore its total resistance to flow is both viscous and elastic.

Viscous resistance to flow: When external energy is applied to dough, some of the supplied energy will be dissipated as heat.

Elastic resistance to flow: When external energy is applied to dough, the dough stores a portion of the applied energy, and then releases it as it attempts to reform itself into its original shape.

The remainder of the external applied energy that is neither dissipated as heat nor stored in the system will be expressed as dough flow and deformation.

Fermentation Modifies Dough Flow Properties

Recently-mixed yeast doughs are highly extensible and have very little resistance to flow. If an unfermented dough is molded, proofed, and placed in the oven directly after mixing, it will not be able to keep the gas cells from coalescing and will yield a coarse, open crumb. Gas pressure will be lost, reducing oven spring and creating a dense, short final product.

Yeast fermentation breaks down sugars and starches, produces organic acids and carbon dioxide gas, inflates air cells, and increases the dough's total resistance to flow.

During fermentation, yeast cells produce carbon dioxide gas, which dissolves into the dough's aqueous phase. As the aqueous phase becomes saturated with CO_2, the gas begins to diffuse into existing air bubbles, causing them to expand. Inflation causes the dough to gain increased frictional resistance, leading to increased viscous resistance to flow. Additionally, as the gas cells stretch the dough gains additional, delayed elasticity (Pyler 104).

As the fermentation process continues, the gluten protein fibrils are pushed further and further apart. If fermentation was allowed to continue indefinitely, the proteins would be pushed so far apart that the cells would no longer be entrapped within the gluten matrix. Gas cells would then coalesce and escape.

Shaping and manipulating the dough (punching down, rounding, sheeting, and molding) during fermentation further entangles the gluten proteins, and subdivides the inflated gas cells. Gluten entanglement increases system elasticity; gas cell subdivision creates a more even dispersion of CO_2 and O_2 throughout the loaf, leading to a finer, more uniform grain after baking. Dough manipulation forces some gas out of the system but increases the number of total gas cells. Continued fermentation will re-inflate the dough piece.

Optimizing Fermentation

As mentioned previously, the two goals that must be met to produce an "ideal" dough are in opposition. Because the fermentation process (including shaping) increases the dough's viscous resistance to flow, the total amount of fermentation time must be tailored specifically to attain desired dough flow properties.

Total fermentation is a function of both fermentation time and fermentation rate, which are directly related to dough temperature and yeast concentration. The effects of fermentation may be enhanced or reduced by altering any of these factors. For example, at a constant temperature, lengthening fermentation time will increase the changes due to fermentation. Alternatively, if fermentation time is held constant, increasing the dough temperature will speed up the rate of fermentation and increase the total effects produced by fermentation.

This is one of the reasons why calculating ingredient temperatures, desired water temperature, and desired final dough temperature is so important, particularly during test baking. If a dough is not held constant or temperature is not taken into account, it will be difficult to distinguish the effects of the changing variable (e.g. flour type, mix time, etc.) from the effects of increasing or decreasing dough temperatures. Test baking helps determine how long the optimum fermentation period should be.

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Pyler, E. J., and L. A. Gorton. "1.G.6. Dough Rheology". Baking Science & Technology, vol. 1, Sosland Pub., 2008, p. 104.

KSU BAKING SCIENCE FORMULA

PRODUCT: White Pan Bread

FORMULA NO: Control dough

DATE OF ISSUE: 7/1/2015

BAKER'S%	INGREDIENTS	WEIGHT/GRAMS
100	Bread Flour	700
62.5	Water	438
1.8	Yeast (instant)	12.6
1.6	NFDM	11.2
3.0	A.P. Shortening	21.0
6.0	Gran. Sugar	42.0
1.57	Dough Conditioner	11.0
2.0	Salt	14.0
	Total Weight	**1,249.80 grams**

NOTES:____

Scale two loaves each weighing 540 grams.

INSTRUCTIONS

20. Place **All DRY** ingredients (except salt) in McDuffie bowl
21. **Add water slowly.**
22. Mix 30 sec on 1st speed
23. Mix 3:30 on 2nd speed
24. Add Salt and mix 30 seconds on 1st speed.
25. Mix for 2 minutes on 2nd speed. Check for gluten development.
26. Continue mixing to optimum gluten development.

Total time of 2nd speed after the addition of the salt: ____________

Desired Dough temp: 79-81°F
26-27°C

Friction Factor: 45°

Final dough temp:__________

Premixing Notes:

7. The amount of water to be used was determined in a series of test bakes.

8. **Calculated Water Temperature =**

(**3** times Desired Dough Temp.) **--** (Room temp. + Flour temp. + Friction factor)

(**3** times ___________________) **--** (__________ + __________ + ____________)

= ________________________

9. The optimum mixing time is the amount of time in 2nd speed after the addition of the salt. **ALL** remaining doughs **will** be mixed using this optimum mixing time for the control dough.

Variations and Group Assignments

Doughs	Fermentation time (minutes)
1	5
2	30
3 (CONTROL)	**60**
4	90
5	120
6	150

Lab Procedure:

1. **Each group will be assigned a control dough and a variation. Mix the control dough first. The time spent mixing on second speed will be used for the variation dough as well.**
2. Using the formula given above, calculate the water temperature needed to achieve final dough temp of 79-81°F.
3. Mix both doughs the same amount of time after the addition of the salt.
4. **At the end of the fermentation time run a pH and TTA.**
5. The doughs will then be proofed in the proof box until they are 2 cm above the pan rim. Make sure to record the proof time.
6. The loaves will then be baked at 425° F for 22 minutes and cooled for 20 minutes.
7. The loaves will be weighed and their volume measured using the volumeter.

RESULTS

From the class data sheet construct the following graphs.

1. Construct the following **6** graphs:
   a. Mix time vs Fermentation Time
   b. Proof time vs Fermentation Time
   c. Specific Volume vs Fermentation Time
   d. Subjective sum vs Fermentation time
   e. pH vs Fermentation time
   f. TTA vs Fermentation time

   Under each graph explain what the graph depicts and why.

Post-Lab Discussion Questions:

2. What changes can be observed and/or measured in a dough as a consequence of fermentation?

3. What is TTA and what does it measure compared to pH?

4. Besides yeast what two formula ingredients influence the rate of fermentation the most?

5. A dough that is under fermented is sometimes referred to as a "young dough." List five characteristics of a "young dough."

6. A dough that is over fermented is sometimes referred to as an "old dough." List five characteristics of an "old dough."

7. After mixing a dough was placed in the fermentation cabinet. Instead of being fermented for 1 hour the dough was fermented for 1.5 hours by mistake. What would can be done to make the fermented dough useable?

Make sure your group data sheet and the class data sheet is attached to your lab report.

GRSC 636 LAB DATA SHEET

Group# ______________________
Lab #________________________ **Today's Date**____________

Variation #						
Water temp. (F°)						
Mixing time (2nd Stage)						
1st Speed						
2nd Speed (post-salt)						
F.D.T. (F°)						
Processing Times						
Ferment: Time in (1hr)						
Ferment: Time out						
Rest (15 min)						
Proof: Time in						
Proof: Time out						
Oven: Time in						
Oven: time out						
Internal loaf temperature:						
Wt. (g)						
Volume (cc)						
Specific Volume (vol./wt.)						
Bread Scoring						
Crust color (20pts)						
Break and Shred (10pts)						
Grain (20pts)						
Crumb Color (20pts)						
Texture (20pts)						
Symmetry (10pts)						
Total Points (100pts)						

COMMENTS:

Lab # 6 – Artisan Breads and Whole Wheat Bread

Intro

Ken Forkish, author of *Flour, Water, Salt, Yeast* says "the most important ingredient for making good bread is plenty of time (25)." This lab and the following lab will encompass artisan breads made with starters like a poolish or biga, as well as a traditional sourdough starter process. Although it may seem like it takes a lot longer (or at least a little more preparation) to make artisan breads instead of white pan bread, it is evident that the level of flavor and texture found in handmade, artisan breads is completely worth the time investment.

Pre-Ferments and Dough Systems

Pre-ferments are used to enhance favor and improve structure, dough handling characteristics, and shelf life. By using a pre-ferment, the dough contains higher initial concentration of organic acids that promote dough maturation and flavor development. During the straight dough procedure, organic acids are produced during long periods of fermentation; pre-ferments are made before processing even begins, reducing the amount of floor time needed.

Types of Pre-Ferments

Yeasted (limited life – must be remade each day)

Poolish

Biga

Sponge

Pate Fermentée

Naturally Leavened Sourdough

Liquid

Dough/Stiff

Naturally Leavened Rye/WW Sourdough

Liquid

Dough/Stiff

Sourdough and Levain

Although the terms sourdough and levain are used interchangeably in the United States, they do not have the same meaning in Europe. For example, in Germany, sourdough (*sauerteig*) always refers to a culture made with rye flour and water. Sourdough starters are usually fairly stiff in texture. In France, levain signifies a culture made with white flour, although it may contain some rye flour as well. Levain starters may have hydration levels starting at 50% and reaching up to 125%.

While the ingredients in these two starters may differ, the techniques used are similar. Both support cultures of naturally occurring yeasts and bacteria that have the capability to both leaven and flavor bread. Both are created by mixing a paste of flour and water and sustained through scheduled feeding. In order to retain the purity of the culture and perpetuate the starter for further use, the baker retains a portion of the sourdough starter or levain before mixing the rest with additional flour, salt, and other dough ingredients. Sourdough starters and levain can be kept alive and utilized for decades.

A biga is similar to a levain or sourdough starter, but is closer in nature to a poolish or paté fermentée – it can't be sustained indefinitely. Biga is a term originally used by Italian bakers for a stiff pre-ferment with 50-55% hydration. However, unlike poolish or a sponge, the quantity of yeast, fermentation temperature, and fermentation time are held constant throughout the process. It is traditionally fermented at 60° F for 18 hours, which adds a richness of flavor and maintains the strength of the starter.

During the initial stages of starter development, some bakers add extra ingredients like grapes, potato water, or grated onions, believing these additions provide additional nutrients for the desired yeast and bacterial colonies. While they may boost the nutritional content somewhat, the flour should be able to supply the necessary nutrients by itself. However, if white flour is used it must be unbleached and unbromated – vital nutrients are lost during the bleaching process, reducing the ability of the flour to successfully support a starter culture.

Additionally, sourdough starters allow the bakery to utilize rye flour in a stable form. If rye flour is simply used as the main baking flour and not prefermented, the high amylase levels present in rye will cause the crumb to be unpleasantly gummy (Pyler 169). The acidification from the sourdough process reduces enzyme activity, promoting good crumb structure and final product texture.

There are several signs that help the baker decide when the preferment is ready. First, the preferment should have risen. If it is dense and sluggish, it most likely has not fully ripened. (This problem may be due to several factors: insufficient rising time, poor temperature controls, or a starter that has lost its viability). A sufficiently ripened starter will be fully risen and covered with small bubbles. The starter should also have a sharply tangy aroma and a more mellowed tangy flavor. Starters also may have a subtly sweet taste underneath the tang. Proper development of the starter is critical to producing quality finished product – under- or over-developed starter will yield bread that is low in flavor and in volume.

Preferment Benefits

- Increased dough strength. The long, slow fermentation increases acidity, which has a strengthening effect on gluten structure.
- Reduction in production time. Extended bulk fermentation time may be reduced or skipped through the use of a preferment, since the starter will immediately incorporate organic acids in to the dough. Division and shaping can be started more quickly.
- Improved flavor. Due to the aforementioned incorporation of organic acids, as well as esters, preferments provide a pleasing depth of flavor, including increased "cereal/grain" flavors and a sour tang.
- Extended shelf life. Breads with a higher acidity resist staling and mold growth longer. The levain or sourdough provides this necessary reduction in pH.

Whole Wheat

Whole wheat flour contains all parts of the wheat kernel (bran, germ and endosperm) in the same proportions as they would be present in the intact wheat kernel. Consumers are drawn to whole wheat and whole grain breads due to their high quantities of fiber, which is believed to promote better digestion, lower cholesterol levels, and help maintain weight loss (Mayo Clinic).

Unfortunately, baking with whole wheat flour can be tricky. Red wheat's bran layer contains tannins, making it bitter and unpalatable. White whole wheat flour does not contain the same tannins as hard red wheat flour, so products produced with hard white wheat flour may be considered tastier by the consumer. Additionally, the lighter-colored bran will not discolor the baked product, which may also be more appealing to those purchasing whole-grain baked goods. Another downside of whole wheat flours is the reality that increased fiber levels are able to absorb and bind more water than white flour, making whole wheat products dense and dry. Bakers have several tricks and tips to combat bitterness and formulation challenges, including the addition of sweeteners, vital wheat gluten, mixing agents, or soaked grains (Meyer, qtd. in Pyler 165). The use of a pre-ferment such as the sponge and dough technique also helps soften the sharp corners of the bran, adds moisture, and provides additional flavor to mask bran's bitter taste.

Bibliography

"Eight Details for Great Bread and Pizza." Flour Water Salt Yeast: the Fundamentals of Artisan Bread and Pizza, by Ken Forkish, Ten Speed Press, 2012, p. 25.

"How to Add More Fiber to Your Diet." Mayo Clinic, Mayo Foundation for Medical Education and Research, 22 Sept. 2015, www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/in-depth/fiber/art-20043983.

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Pyler, E. J., and L. A. Gorton. "2.A.2.d.ii. "Whole-grain functionality". Baking Science & Technology, vol. 1, Sosland Pub., 2008, p. 169.

GRSC 636 LAB DATA SHEET

Group# ______________________
Lab #________________________ **Today's Date**____________

Variation #						
Water temp. (F°)						
Mixing time (2nd Stage)						
1st Speed						
2nd Speed (post-salt)						
F.D.T. (F°)						
Processing Times						
Ferment: Time in (1hr)						
Ferment: Time out						
Rest (15 min)						
Proof: Time in						
Proof: Time out						
Oven: Time in						
Oven: time out						
Internal loaf temperature:						
Wt. (g)						
Volume (cc)						
Specific Volume (vol./wt.)						
Bread Scoring						
Crust color (20pts)						
Break and Shred (10pts)						
Grain (20pts)						
Crumb Color (20pts)						
Texture (20pts)						
Symmetry (10pts)						
Total Points (100pts)						

COMMENTS:

KSU BAKERY SCIENCE FORMULA

FORMULA NO:__________

PRODUCT: Pain Au Levain (Sourdough)
With the McDuffee Bowl

DATE OF ISSUE: 9/21/201

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS
	King Arthur Sir Galahad Flour	1100
	Whole Wheat Flour	100
	Water at 72°F	780
	Salt	28
	Starter (Levain)	377
	Total weight	2,400

INSTRUCTIONS

27. Mix flours and water until you have a shaggy mass. Cover and autolyze for 20-30 minutes.
28. Add the salt and starter.
29. Mix on 1st speed for 1-2 min. then on 2nd speed for 2 min.
30. Place in oiled steel bowl, cover and bulk ferment at room temperature for 45 minutes.
31. Fold.
32. Bulk ferment for another 45 minutes, covered, at room temperature.
33. Divide the dough into 3 pieces (approx. 800g each); lightly round, cover and allow to relax on bench for 20-30 min.
34. Final Shaping with all 3 pieces on the BACKSIDE of a pan, with a liner. Sprinkle a little cornmeal on top of the liner.
35. Place your pan of sourdough on the covered rack where it will proof approx. 2-3 hours before baking.
36. Score (cut) the top of the sourdough loaves.
37. Bake at 440°F with 25 seconds of steam for 10 min.
38. Reduce oven temperature to 420°F for completion of the bake.

NOTES: *This dough will NOT go to full development

****** The master dough of Sourdough produced in today's lab used the same % as this formula. This will be the base formula you will use in next week's lab to produce sourdough bread from your personal starter.***

KSU BAKERY SCIENCE FORMULA

PRODUCT: Ciabatta (Biga) DATE OF ISSUE: 7/18/2017

BAKER'S %	INGREDIENTS	WEIGHT/ GRAMS
	Biga	
100	Bread flour	560
85.71	Water	480
1.79	Yeast	10
	The Total:	1,050
	Dough side ingredients	
100	Bread flour	320
31.25	Water	100
300	**Biga**	960
3.75	Salt (Delayed Addition)	12
	Total Weight	1,392

NOTES: DDT post- mixing is 73- 76^{o} F.
The total weight for the Biga is 1,050 grams, however the biga weight on the dough side is only 960 grams. The 90 gram difference is to allow for the fermentation loss.

INSTRUCTIONS

BIGA:

1. Mix all the ingredients, including 70^{o} water, on 1^{st} speed for 3 minutes.
2. Allow the biga to ferment for 12- 18 hours in a 60^{o} environment.

START HERE

3. Blend all the dough side ingredients, except the salt and the water, for 30 seconds on 1^{st} speed.
4. With mixer in 2^{nd} speed slowly add the water and mix for 6 minutes. Add salt to the bowl and mix for 2 more minutes.
5. Ferment the dough in a greased stainless steel bowl for 60-120 minutes.
6. Divide the dough ball into **two** 625 gram pieces.
7. Lightly round the dough ball into an oval shape and place on a baking pan covered with cornmeal.
8. Score the top of the dough 3 times at a 45 degree angle.
9. Bake at 450 degrees F with a little steam for 30-45 minutes. Crust should appear lightly caramelized.

KSU BAKERY SCIENCE FORMULA

PRODUCT: DATE OF ISSUE: 9/21/2016

Wheat Bread – Straight Dough Method

BAKER'S %	INGREDIENTS	WEIGHT/ GRAMS
51	**Treatment flour***	435
49	King Arthur Flour Special (12.70% protein) Bread Flour	418
6.00	Honey	51
1.75	A.P. Shortening	15
1.75	Non Fat Dry Milk	15
0.25	Diastatic Malt Powder	2
1.0	Vital Wheat Gluten	9
2.0	Salt **(Not Delayed)**	18
1.25	Yeast (Instant)	11
62	Water	528
	Total Weight	1,502

NOTES: The instructor will determine ahead of lab which groups use HRW flour as their variation, and which groups use HWW flour. He or she will also demonstrate the hand-molding technique for whole wheat loaves.

INSTRUCTIONS

1. Combine all ingredients.
2. Mix to full development.
3. Desired Final Dough Temperature is 80-82 °F.
4. Place dough in a greased bowl and then cover the bowl with plastic wrap. Place the bowl in the fermentation cabinet.
5. Ferment the dough for 60 minutes.
6. Divide the dough ball into **two** 625 gram pieces; lightly round.
7. Place the dough balls on the bench and cover them with plastic for 15 minutes.
8. Mold the dough pieces by hand. Place the loaves seam down in the pan. Make sure to label the loaves.
9. Proof at 100˚F and at a relative humidity of 95% until the dough is 2 cm above the rim of the pan.
10. Bake for 22 minutes at 425 ºF.

KSU BAKERY SCIENCE FORMULA

PRODUCT: DATE OF ISSUE: 9/21/2016

Wheat Bread -- Sponge and Dough Formula

BAKER'S %	INGREDIENTS	WEIGHT/ GRAMS
SPONGE		
100	**Treatment Flour**	480
1.6	Yeast	8
7.1	Vital Wheat Gluten	34
67	Water	320
	Total Weight	**842**
DOUGH		
50	**Treatment Flour**	141
50	Sir Galahad Bread Flour	141
1.9	Yeast (Instant)	6
9.9	NFDM	28
0.37	Ascorbic Acid	1
5.5	Salt **NOT DELAYED**	16
12.3	AP Shortening	35
12.3	Honey	35
73.4	Water	208
272	**Sponge**	780
	Total	**1,391**

INSTRUCTIONS

1. Mix sponge ingredients together until well incorporated. The Desired Sponge Temperature (D.Sp.T.) is 74-77˚F
2. Ferment for 3 hours at room temp.
3. ***Sponge has been mixed for you ahead of lab time.***

START HERE

4. Combine all final dough ingredients into the horizontal mixer.
5. Add the sponge to the mixer in 4 or 5 pieces.
6. Mix on 1st speed for 30 seconds.
7. Mix on **Second** for 2 minutes.
8. Evaluate gluten window and continue mixing to full development if necessary.
9. Place dough in a greased bowl. Cover the bowl with plastic wrap and place in the fermentation cabinet.
10. Ferment the dough for 60 minutes.
11. Divide the dough ball into **two** 625 gram pieces; lightly round.
12. Rest the dough, covered, on the bench for 15 minutes.
13. Mold the dough pieces by hand. Place the loaves seam down in the pan. Make sure to label the loaves.

NOTES: FDT is 80-82 °F

Continued Instructions:

14. Proof at 100˚F and at a relative humidity of 95% until the dough is 2 cm above the rim of the pan.
15. Bake for 22 minutes at 425 ºF.

Post-lab Discussion Questions

6. Briefly discuss the advantages and disadvantages of using pre-ferments such as sponge and dough and sourdough starters. Include the scientific names of the two most common microorganisms involved in the sourdough process. How do they affect the finished product?

7. How did your starter change over the seven days of maturation?

8. When does the sourdough starter officially become a levain?

9. Loaves that are shaped properly will appear different after baking than loaves that are under-shaped. How?

10. Would a under proofed loaf of sour dough be given a deeper or shallower cut then a loaf that is properly proofed? Why?

11. Why is a biga not often used in today's artisan market?

12. The mixing of wheat bread and multigrain doughs often proves more difficult when using 100% whole wheat bread flour. Why?
13. Why are whole wheat and multi-grain flours typically added to the sponge side of a sponge and dough system?

Lab #7 – Sweet Roll and Laminated Yeast Dough

Sweet Dough Background

Sweet roll doughs are a rich, yeast-leavened dough containing fat, eggs, and lots of sugar and are most often used to produce cinnamon rolls, coffeecakes, and the like. Ingredient types and quantities may vary depending on the final product desired.

Many older sweet dough formulas list sugar at a 20-25% level. Such high amounts of sucrose were thought to add tenderness, moisture retention, and a fine, compact grain. However, extremely high sugar levels can cause problems when producing yeast doughs.

High sugar levels extend the total amount of mix time because the sucrose molecules bond with the polar water molecules, creating bulky clusters. It is challenging for this larger molecule to hydrate the flour granules and abrade the dry surface, so the total rate of hydration and the development of the gluten matrix is slowed down.

Since salt causes water to behave similarly, salt addition is often delayed in the commercial dough mixing process. Many bakers now also delay the addition of sugar until after dough development has begun to reduce the total mix time and enable the water to penetrate the flour particles more quickly. Additionally, salt and sugar raise the osmotic pressure in yeast cells, so their delayed addition enables yeast to begin fermenting more quickly.

If sugar and salt are added at the beginning of mixing, the yeast cells are under increased osmotic pressure, slowing their rate of fermentation. This slow fermentation causes a decrease in gas production, requiring longer proof times or the addition of extra yeast. It also takes longer for the dough to mature during fermentation, causing a need for extended bulk fermentation or addition of oxidizers to attain the desired properties of dough flow and elasticity.

Industry production of sweet doughs most often use a sponge and dough or remix straight dough procedure to reduce fermentation time and avoid many of the issues caused by high sugar levels. Sweet roll doughs are transferred directly from the mixer to the depositor or divider to avoid the development of unwanted elasticity that could make the finished buns tough and unpalatable.

Sucrose in Sweet Doughs

Again due to the interaction of sugars with bulky water molecule clusters, high sugar levels delay the onset of starch gelatinization. The structured molecules need more kinetic energy to hydrate intact starch granules, requiring a higher temperature to be reached before gelatinization occurs. Because increased temperatures speed the process of oven-spring and protein dehydration, there may be fewer swollen gelatinized starch granules when the structure of the finished product “sets”.

Sucrose addition helps maintain one of the desired attributes of a sweet roll - a close grain and slightly gummy texture – by delaying gelatinization. Higher sugar levels cause doughs to gain color quickly in the oven, which may lead bakers to underbake sweet rolls. However, fully baked, darkly colored product may be considered undesirable by consumers. One way to combat this issue is by reducing the oven temperature but increasing the total amount of time the product spends in the oven.

Texture and Mouthfeel in Sweet Doughs

The amount of gluten development present in the dough determines much of the final texture, bite, and mouthfeel. Since desired final product attributes vary by product (coffee cake, cinnamon roll, orange roll, etc) and by region, the flour used in sweet dough production varioes widely. If a sponge and dough procedure is used, hard wheat flour is often predominant, since the long period of chemical development and short mix time allows the creation of the desired tender texture without overdevelopment of the gluten. If a straight dough procedure is used, soft wheat pastry flour (usually used in combination with hard wheat flours up to 40%) is used to decrease toughness and bite tenacity, while still maintaining gas retention and oven spring.

In products with extremely high sugar levels or the addition of malt, chlorinated cake flour is blended with the hard wheat flour instead of pastry flour. Large amounts of sugar delay gelatinization; the starch in cake flour is able to swell more quickly than non-chlorinated starch and provide a larger quantity of filler material, preventing collapse and maintaining tenderness.

Sweet doughs usually contain high levels of fat to interrupt the gluten structure, provide richness, and lend a tender "shortness" to the bite. Egg or egg yolk solids may be added to increase depth of flavor, support dough structure, and improve finished product texture. On the commercial scale, manufacturers may use plastic shortenings, SSL, emulsifiers, and artificial flavors and colors to obtain these goals while keeping costs low.

Laminated Yeast Doughs

Laminated yeast dough formulas differ widely depending on product, manufacturer, and even country of origin. Basically, laminated doughs are yeast-leavened and layered with fat; a cross between bread dough and puff pastry.

Generally, doughs that are intended for lamination are mixed only until all the ingredients are incorporated and a smooth dough forms. Doughs are undermixed because the sheeting and folding process completes mechanical development and takes the place of further mixing. If the dough was mixed to full development and then spotted, sheeted, and folded, the dough would become highly elastic, causing tearing. Elasticity not only causes unsightly tears during sheeting, makeup, and baking, but also adds toughness and reduces flakiness.

The dough is then bulk fermented in slabs for as little as 30 minutes, or up to 12 hours. A layer of chilled butter equivalent to approximately 25% of the dough's weight, known as the **spot**, is centered on the fermented dough slab. The baker pulls the edges of the dough around the spot, enclosing it. After spotting, the dough is sheeted, folded into 3-4 layers, and allowed to rest in a chilled area for 15-30 minutes. The dough slab is then sheeted again, re-folded, and chilled (1 hour to overnight) until it is shaped into the final product.

This final retardation period allows the dough to relax and regain extensibility, facilitating sheeting during the makeup process. The chilled resting periods also keep the butter layers solid, preventing the dough from absorbing the thin layers of fat and promoting flakiness. Once the final rest is complete, the dough is sheeted out to 3-4 mm and cut into the desired shape. The shaped dough pieces are then proofed for 30-45 minutes in a moist environment. Proof temperatures should not exceed 90^{o} F in order to prevent the butter from melting.

Like traditional yeasted doughs, laminated products undergo oven spring when baked. Additionally, each "layer" lifts and puffs, separating as internal pressures rise. Each layer of fat serves as a moisture barrier and entraps water vapor at the dough/fat interface, allowing this distinct layered structure to expand. The final product should have a flaky, buttery texture and retain the puffed laminated structure characteristic of products such as croissants and traditional Danishes.

The simplest laminated dough is **croissant** dough, which is in essence an underdeveloped white pan bread dough laminated shortly after mixing. Butter is traditionally used as the spot, giving these pastries a rich, decadent flavor.

Danish pastries may be found in two forms – traditional Scandinavian/Viennese pastries, and the American-style sweet good found in grocery stores and retail bakeries. The traditional Danish is made from a rich yeast dough, similar to doughs used for croissants, but containing higher levels of sugar and potentially whole eggs or egg yolks. The end product should be delicate and flaky with a buttery, crisp texture. Traditional Danishes may contain a spot weighing up to 50% of the total dough weight.

American-style Danishes are made with a lean sweet dough containing little sugar and no eggs, laminated with "roll-in fat". Because these products are frequently sold in stores, the final product goal is a rich, flaky pastry with a long shelf life. However, the products marketed as "Danishes" are often difficult to distinguish from sweet rolls, and may contain no laminations whatsoever! This is in part because many large-scale manufacturers use inexpensive margarine or shortening as the laminating fat, reducing flakiness and richness of flavor. Additionally, the term "Danish" has been mistakenly used to refer to sweet rolls containing jam or cream cheese, further blurring the lines between the American Danish and other sweet rolls.

Laminating Material Functions and Desired Attributes

As mentioned above, laminations must be performed carefully to maintain the integrity of the internal layers. Hydrophilic dough is separated by thin layers of hydrophobic fat, so when the product is placed in the oven, the water contained in the dough undergoes a phase transition and turns in to steam, expanding the "pocket" created in between the layers of dough and fat. The fat layer prevents the steam from exiting the pastry, increasing the total amount of expansion and creating the expected puffy, flaky layers.

The laminating material used is crucial to obtain the desired final product! The fat must be able to form thin, continuous layers, must spread evenly, must withstand sheeting and shaping, and must have a low enough melting temperature to reduce waxy mouthfeel during consumption.

Butter is ideal, meeting all of the above conditions provided the working area is kept cool during lamination and shaping. Butter is about 81% fat and 19% water, providing adequate moisture to produce ample amounts of steam, increasing lift and separation between the flaky, delicate layers.

Vegetable Shortening

Vegetable shortening contains no water and is therefore 100% fat. Shortening is fairly "plastic" and withholds the stress of lamination well, spreading thinly without breaking or melting. However, the melting point of vegetable shortening is higher than butter; shortening retains much of the crystalline phase of fat formation at higher temperatures. Because the melting temperature of shortening is higher than body temperature, the fat provides a waxy, unpleasant mouthfeel and an undesirable eating temperature.

Pastry Margarine

Pastry margarine is formulated specifically for use in laminated products and contains 80% triglycerides to maintain practical working temperatures. Pastry margarine has a higher melting point than butter and is more easily workable during the lamination and shaping steps, but also has a *lower* melting point than shortening to reduce unpleasant palate cling. Additionally, pastry margarine maintains a homogenized aqueous phase evenly distributed within the fat phase to aid vapor pressure and total "lift" during baking. The majority of oven spring comes from the lifting and separation of the laminated layers, so gas cell retention is not as crucial to pastries like croissants and Danishes as it is in yeasted sweet doughs or breads.

Elasticity and Extensibility in Laminated Doughs

Since the lamination process is complex, requiring a dough to be rolled out, sheeted, and folded numerous times without tearing, doughs intended for lamination must be highly extensible. Such doughs are undermixed to minimize gluten development and reduce the amount of cross-linkages created, reducing the total amount of elastic resistance to flow. The lamination process completes dough development.

Additionally, the dough layers must remain separated by distinct fat layers during the lamination process, requiring a relatively high dough viscosity. Soft doughs will absorb the laminating fat and reduce or even eliminate puffing in the oven. Therefore, water levels must be as low as possible to create a stiff, viscous dough. Small retail bakers may obtain additional stiffness by mixing doughs the day before they are required for use, and fermenting them overnight in a 40° retarder. Cold dough temperatures help maintain the integrity of the fat layers and reduce the dough's ability to absorb fat.

Bibliography (general reference)

Pyler, E. J., and L. A. Gorton. "8.H.1 Sweet Goods" Baking Science & Technology, vol. 2, Sosland Pub., 2008, p. 258.

KSU BAKERY SCIENCE FORMULA

FORMULA NO:______________

PRODUCT: Flat Roll Icing (Wholesale)

DATE OF ISSUE: 9/15/16

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS
15.3	Water	695
6.1	Icing Stabilizer	278
15.3	Granulated Sugar	695
1.9	Hard Fat Flakes	84
61.2	Powdered Sugar (Sifted twice)	2,780
0.1	Salt	6
	Flavor	Variable
	Total Weight	4,538 g

NOTES:____

INSTRUCTIONS

1. Bring water and stabilizer to a boil. Boil for 2 minutes.
2. Add sugar and fat flakes to boiling water. Bring back to boil. Should become syrupy.
3. Add 60% of above syrup to powdered sugar in a 20 Qt. bowl with paddle.
4. Mix until smooth on low, scrap sides of bowl.
5. Add remaining syrup slowly while mixing on low speed. Mix smoothly.

   Final temp: 110-115°F

   Application temp to cool roll: 115-120°F

KSU BAKERY SCIENCE FORMULA

FORMULA NO:______________

PRODUCT: Yellow Streusel

DATE OF ISSUE: 4/15/14

BAKER'S %	INGREDIENTS	WEIGHT/ GRAMS	INSTRUCTIONS
	Step 1		
43	Granulated Sugar	1,040	1. Use 12 Qt. bowl with paddle.
19	A.P. Shortening	472	2. Cream lightly on 2nd speed.
23	Butter (room temp)	568	
0.66	Salt	16	
	Step Two		
0.25	Yellow Color	3-4 drops	**3. Add to above in 1st speed**
0.66	Liquid Vanilla	16	4. Scrape down bowl well until color is even.
0.17	Lemon Emulsion	4	
	Step Three		
100	Pastry Flour (Sifted once)	2,420	5. After sifting pastry flour, put the flour into a bus tub.
			6. Place creamed mixture from above, **on top** of the flour.
	Total Weight	**4,536**	7. Using your hands, rub into the crumbs. Don't over mix. Looking for crumbs the size of peas.
			8. Place mixture into labeled storage container.

NOTES: This streusel will be used on the top of the sweet rolls.

KSU BAKERY SCIENCE FORMULA

FORMULA NO:______________

PRODUCT: Cinnamon Smear

DATE OF ISSUE: 9/10/16

TRUE %	INGREDIENTS	WEIGHT/ GRAMS
	Step 1	
16	Granulated Sugar	800
16	Brown Sugar	800
11.3	Butter (room temp)	568
8.6	A.P. Shortening	432
8	Cinnamon	400
	Step Two	
20	Dried Cake Crumbs	1000
	Step Three	
20	Liquid Egg Whites	1,000
100	**Total Weight**	**5,000**

NOTES: This cinnamon smear will be used in the sweet rolls.

INSTRUCTIONS

1. Use 20 Qt. bowl with paddle.
2. Cream lightly on 2nd speed.
3. **Add to above in 1st speed until no big chunks remain.**
4. Scrape down bowl well to incorporate.
5. Add slowly on 1st speed.
6. Now cream on 2nd speed for 10 minutes. More water may need to be added for proper spreading consistency.
7. Place the finished product in storage container.

RICH SWEET ROLL DOUGH- Straight Dough Format
Sugar & salt delayed mixing method

High sugar level (1) structures water, which increases required mixing times, and (2) exerts high osmotic pressure on yeast cells, which slows their rate of acclimation to their environment and inhibits fermentation rate.

Note use of: (1) a staged mixing method that delays sugar & salt additions until after flour proteins are hydrated and yeast cells are somewhat acclimated, and (2) a high % yeast level. This allows much shorter mixing times with less frictional heat build-up, and faster take-off by the yeast cells.

	Bakers %	**1**	**2**	**3**
Water * (°F)	VAR	580	560	550
Bread flour, HRW	EXPER	1000	750	650
Pastry flour, SRW	EXPER	-	250	350
Cake flour, chlorinated	EXPER	-	-	-
Yeast, SAF instant	2.0		20	
NFDM	4.0		40	
Dry eggs (≡ 16% liquid)	4.0		40	
Shortening	20.0		200	
43 DE corn syrup	3.0		30	
	1st:	:30	:30	:30
	2nd:	3:30	3:00	3:00
Sugar	20.0		200	
Salt	1.5		15	
	1st:		:30	
	2nd:		2:00	

FERMENT: 60 minutes at 81°F

BALE: (large semi-loaf)

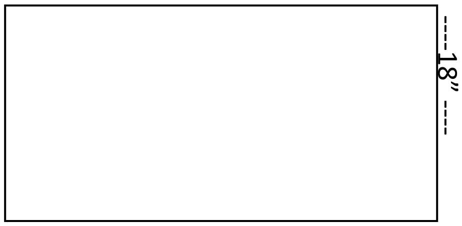
REST: 30+ min in retarder

MAKEUP: **Sheet to 18" wide rectangle. See makeup instructions.**

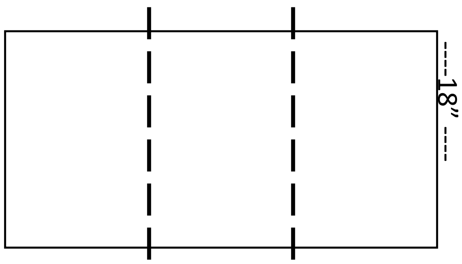
PROOF: ≈ 50 min. (100°F, 90% relative humidity)
BAKE: 385°F for 18-22 minutes. Cool, glace, and string ice.

SWEET DOUGH UNITS MAKEUP

SHEETING:



Gradually sheet down to 4 mm.
Rectangle should be 18” wide.



Next cut the dough into thirds.

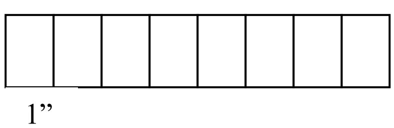
MAKEUP:

1. **Cinnamon Rolls and Cinnamon Roll-based Coffeecakes**
   Spray-grease (2) ALUMINUM cake pans. Using larger half of sheeted dough rectangle:

   Spread cinnamon smear across dough piece. (Leave the border un-smeared.)

   Sprinkle with raisins or nuts (optional), then with streusel.

   Roll up (not too tightly) starting at top and working toward bottom to form a long cylinder ≈ 1 ¼ -1 ½”

   Cinnamon rolls: With a bench knife, cut (8) pieces 1” thick. Place these in grease cake pan.

   Coffeecake: Orient remaining dough cylinder vertically before you on the bench, then fold in half i.e. grasp bottom end and fold it up and over to meet top end.

   With a bench knife, make a vertical cut in this folded piece that extends from the base to within “1 of the top.

   Open this cut, turn piece and place it in a cake pan so that cut sections face upward, loosen piece in pan. Water spritz, then sprinkle streusel on top. Proof.

Post-Lab Questions

1. Explain briefly the specific differences between the five different fats used in today's lab. Specifically, indicate the different melting points and explain why one fat may be more suitable for a baked product than another. You'll probably find it necessary to do some research on this question – Pyler is a good resource.

2. Why must sweet roll doughs (straight dough procedure) contain higher levels of yeast than typical bread formulas?

3. Describe considerations one would make in selecting a flour or flour blend to use in a sweet dough. Some sweet roll doughs use a blend of hard and soft wheat flours. Why?

Lab #8 – Commercial Pizza Production

In essence, pizza crusts are a lean bread dough containing flour, water, salt, and yeast. However, there are many variations in pizza dough production depending upon the needs and structure of the company producing pizzas and the characteristics desired from the final product. Some pizza joints mix up the dough in-house and bake it off almost immediately, while others receive dough from a commissary or fresh/frozen dough facility, which may be refrigerated or frozen for a period of time. Other companies utilize pre-fried dough rounds to create take-and-bake pizzas for at home baking.

Methods of pizza crust production include:

- Short ferment, high yeast
- Long ferment, low yeast
- Retarded dough, extended ferment (may contain lower levels of yeast)
- Short ferment, proofed
- Chemically leavened (may or may not contain yeast), no ferment
- Par-baked
- Frozen dough distribution
- Fried crust

Since flour is the primary ingredient in pizza crust, variations in strength and protein content will majorly affect crust attributes. Generally, 11-14% protein is desired, depending on the flour variety used and the final product desired. Thicker crusts will require less protein to increase fluffiness and provide a more "bready" texture, while a thin crust should be made with a higher-protein flour to increase chewiness and crispiness. (Pyler 234).

Yeast quantity varies widely depending upon the production method and the product's intended use. If an extended ferment or refrigerated dough is produced, yeast levels will be low. The long ferment time allows flour enzymes to react and "mellow" the gluten structure, increasing dough development; under these circumstances, high levels of yeast would cause over-fermentation. On the other hand, pizza doughs mixed in a pizzeria may contain large quantities of yeast to allow for short fermentation times, speeding pizza production along.

Other ingredients, such as salt and sugar, affect flavor and water activity. Sugar also provides tenderness (as does shortening), darkens crust color and provides an easily accessible source of food to the yeast, increasing the rate of fermentation. As mentioned in Lab 4, salt reduces enzymatic activity and strengthens the gluten matrix.

Production

Mixing time is short compared to bread doughs and the amount of development is much less. Pizza doughs are often mixed on low speeds for the entire time because long fermentation will provide additional chemical development. Discretion must be used to determine the desired amount of mixing time and total development. For example, frozen doughs require more strength than fresh doughs to withstand freezing and thawing. Desired dough temperatures for a "typical" fresh dough are often around 75-80^{o}F; however, doughs produced for immediate use may have temperatures closer to 80-90^{o}F.

After mixing, doughs are rounded into a ball, lightly coated with vegetable or olive oil, and allowed to ferment. As touched on above, fermentation varies depending on the desired end use. An appropriate balance must be achieved between the fermentation time, yeast level, and dough temperature to meet fermentation needs. Once the fermentation process is finished, dough balls are shaped to the desired thickness. Thin crusts are usually topped and baked immediately after shaping, but thick crusts may undergo a proof step. Doughs may be shaped by hand, by using a dough sheeter, or by using a dough stamper.

Baking takes place at much higher temperatures (and potentially increased air flow) than other baked products, reaching temperatures of 400-600^{o}F. Impingement ovens or convection ovens are commonly used to increase the heat on the bottom of the pizza. Bake times are quick at 5-8 minutes per pizza. A variety of factors including air flow, temperature, and pan style may be adjusted to achieve various characteristics in the final crust.

Refrigerated Doughs

As the temperature of the dough declines, the rate of fermentation also declines. Controlling the finished dough temperature and the cooling rate is crucial to achieve the desired amount of fermentation in the finished dough. The container in which the dough is stored is a major factor, as is the amount of air flow the dough receives. Some refrigerated dough manufacturers stack dough in trays for a few hours to allow increased air flow and then re-stack or cover doughs to restrict air movement and reduce the cooling rate. Refrigerated doughs generally have a shelf life of 4-7 days.

Frozen Doughs

Minimal fermentation must take place before freezing to reduce yeast activation since yeast can be killed by cold temperatures. Therefore, finished dough temperatures must be lower (68-72^{o}F) and doughs must be placed in the freezer within 25 minutes post-mixing. Oxidative agents may also be added to strengthen the dough and counter the negative effects of freezing. Fermentation takes place during the thaw and proof stages and must be carefully monitored to avoid either doughs of excessively low volume or over-fermented, discolored doughs with a sour, unpleasant taste.

Bibliography

Pyler, E. J., and L. A. Gorton. “8.E.2. Pizza Crust” Baking Science & Technology, vol. 2, Sosland Pub., 2008, p. 234.

Note: The first two formulas will be prepared ahead of time by the instructor and TAs and then processed in the bake lab by students. The third and fourth formulas will be prepared and processed by students during the lab period. Students should begin at the stages marked "PROCESSING".

Dough #1: SHORT Fermentation

	Bakers %	***Exp. 1 (g)***	***Exp. 2 (g)***	***Exp.3 (g)***
Ingredients				
Flour Protein	100			
Weak: 100% Pastry-8.5%		700		
Intermed.: 100% White Wheat			700	
Strong: 98% Bread flour - 11.7%				686 +
2% Vital Wheat Gluten				14g VWG
Sugar	3.0	21	21	21
Salt	1.5	10.5	10.5	10.5
Vegetable Oil	3.0	21	21	21
Yeast, Instant	1.0	7.0	7.0	7.0
Water, Variable	60-65	420	420	420

MIX: Mix the dough for 10 minutes on 1st speed. Desired dough temperature is 78-80° F.

FERMENTATION: Ferment the dough in a lightly greased, covered stainless steel bowl for 60 minutes.

DIVIDE: Scale 2 – 250 gram dough balls, and lightly round. The remaining dough may be used to make additional pizzas for topping and eating.

BENCH REST: The two dough balls will rest on your bench for 15 minutes, covered with plastic.

PROCESSING:

SHEET: One 250 gram dough ball will be sheeted down to 4 mm on the Rondo sheeter. Place on ***pre- labeled*** parchment lined sheet pan.

HAND STRETCH: One 250 gram dough ball will be hand stretched to comparable size.

DOCKING: Make sure to dock the sheeted and the hand stretched dough pieces.

TOP: Do not top the first sheeted and hand-stretched crusts – they will be needed for comparison and scoring. Additional crusts may be topped and eaten.

BAKE: at 440°F until golden brown crisp crust is developed.
Sheeted pizza ≈ 14 minutes **Pan Pizza ≈ 16 minutes**

Dough #2: Refrigerated Fermentation

Ingredients	*Grams*	*Bakers %*
Bread Flour (12.7% protein)	700	100.0
Sugar	21	3.0
Salt	10.5	1.5
Vegetable Oil	21	3.0
Instant Yeast	5	0.75
Water	420	60.0

MIX for 6 minutes on low speed. Desired final dough temperature should be 75-78° F

DIVIDE and round into **three** dough balls, 250 grams each. Two of the three dough balls will be used for evaluation purposes and must be left untopped! The third dough ball is for you to process how you'd like and then eat.

AFTER DIVIDING, RETARD OVERNIGHT.
Remove the dough from the retarder 90 minutes before class begins and warm at room temperature for 60-90 minutes.

PROCESSING:

SHEET SHEET: One 250 gram dough ball will be sheeted down to 4 mm on the Rondo sheeter. Place on ***pre- labeled*** parchment lined sheet pan.

HAND STRETCH: One 250 gram dough ball will be hand stretched to the diameter of the cake pan on your bench. Spray the pan and place the stretched dough sheet in the bottom of the pan.

DOCKING: Make sure to dock the sheeted and the hand stretched dough pieces.

THE THIRD DOUGH ball is yours to top how you wish, bake and then eat.

PROOF: There is NO PROOFING.

BAKE: The pizzas are to be baked immediately. The plain and topped pizzas will be baked at 450°F, or until golden brown crisp crust has developed.
Sheeted pizzas ≈ 14 minutes **Panned pizza ≈ 16 minutes**

Dough #3 - Thick Crust with Proof Step

Ingredients	*Grams*	*Bakers %*
Bread Flour (12.7% protein)	700	100.0
Sugar	28	4.0
Salt	14	2.0
Vegetable Oil	28	4.0
Instant Yeast	9	1.3
Water	420	60.0

MIX: Dough 6 minutes on low speed. Desired dough temperature is 75-78° F

DIVIDE: Round dough into three 250 gram dough balls. Two of the three dough balls you will use for scoring and evaluation and will be baked without toppings. The third dough ball is for you to process how you'd like and then eat.

REST: The dough pieces will rest on your bench covered with plastic for 15 minutes.

SHEETING: One of the 250 gram dough balls wills be sheeted to 6 mm on the sheeter.

HAND STRETCH: one of the 250 gram dough balls then place it into a lightly greased 8" cake pans. Decide what you want to do with your third dough ball.

DOCKING: Use the dough docker to thoroughly dock your sheeted crusts.

PROOF: All three dough pieces will be covered with plastic, and will proof on your bench for 1 hour at room temperature.

TOPPING: There will be **NO CHEESE and NO SAUCE** on the two pizzas you will bake and compare to others. The third pizza dough ball is yours to "top" and eat.

BAKE: at 450°F, with all cake pans placed on a sheet tray for baking. Bake until golden brown crisp crust is developed.

Sheeted pizza ≈ 14 minutes **Panned pizza ≈ 16 minutes**

Dough #4: Chemically Leavened Thin Crust Pizza

Ingredients	***Grams***	***Bakers %***
Bread Flour (12.7% protein)	700	100.0
Sugar	14	2.0
Salt	10.5	1.5
A.P. Shortening	21	3.0
Baking Powder	21	3.0
L-Cysteine***	45 ppm (0.001 grams)	45 ppm
Water	420	60.0

MIX: Mix the dough for 10 minutes on low speed. The desired final dough temperature is 75-78° F

MAKEUP: You will need 3 dough balls at 250 grams; two for evaluations purposes; the third for you to make up and eat.

BENCH REST: **NONE**

SHEET: One dough ball (250 grams) to 3.5 mm and hand stretch the other dough ball to the same thickness.

PLACE: Place both dough pieces on a parchment lined sheet pan that is labeled with your group's number. **DO NOT top either of these pieces!**

DOCKING: Make sure to dock the sheeted and the hand stretched dough pieces.

PROOF: There is NO proofing of the dough pieces.

BAKE: Bake at 450°F, or until a golden brown crisp crust has developed.

Sheeted pizza ≈ 14 minutes

Pizza Score Sheet

Attributes	Short Fermentation	Refrigerated Dough	Thick Crust	Chemically Leavened
Crust color and appearance (0 – 20 points)				
Grain (0 – 20 points)				
Blisters (0 – 10 points)				
Gel layer (0 – 10 points)				
Toughness and tenderness (0 – 20 points)				
Flavor (0 – 20 points)				
Total points:				

Post-Lab Discussion Questions

1) Why was vegetable oil used in most of the pizzas today and not AP Shortening?

2) Why was AP shortening used in the chemically leavened pizza, not vegetable oil like the other pizzas?

3) Suppose you are the product development technician for a company producing a pizza crust with a short time fermentation system. Your manager requests that you develop a pizza with added flavor in the crust and greater tolerance to variation in time between production of the dough and use in pizza production. What changes in formulation and fermentation process would you evaluate?

4) You are producing pizza crust dough and distributing the dough to individual stores in a refrigerated form. The current dough will last 3 days before becoming over-fermented and unacceptable for use in the pizza store. How would you adjust the formula and process to increase the refrigerated shelf-life and tolerance to refrigerated distribution?

5) The pizza that you are producing using a short fermentation process is quite tough and chewy. You want to add another product to the line that is tenderer and less chewy. What changes in formulation ingredients would you make to meet this new product definition? Why?

Lab #9 – Yeast-raised Doughnuts

Background

According to the Smithsonian Magazine, doughnuts have a long and complicated history – no one is certain how they originated or who punched a hole right through the center. Deeply beloved by many, doughnut shops are both a big-city and a small town staple; shops like Varsity Doughnuts here in Aggieville or Voodoo Doughnuts in Portland, Oregon inspire pilgrimages by doughnut devotees.

"Doughnut" is simply a catch-all term for any bakery product that is cooked through deep-fat frying rather than by baking in the oven. Two major categories exist: chemically leavened cake doughnuts, and yeast-raised doughnuts (some prepared mixes include yeast and chemical leavening to provide dual-leavening and increase volume expansion during frying). Doughnuts may be deposited, machine cut, or hand cut in numerous shapes and sizes. Traditional yeast-raised doughnuts are the main focus of today's lab.

Fried doughs have existed for many years in an abundance of forms – *oliebollen,* churros, and fry-bread, for example. It is believed that bakers began by frying leftover scraps of bread dough. To improve taste, they added sugar, creating a sweet dough, but these high levels of sweetener delayed starch gelatinization and caused doughy, unpalatable products. The addition of the hole allowed more surface area to be exposed to the frying fat, reducing doughiness, but the final products were still darkly colored, misshapen, and overly greasy. Eventually, bakers began developing formulas specifically to optimize frying characteristics. For ideal frying performance, a doughnut must strike the middle ground between lean white pan breads and rich sweet doughs. Formulas vary widely depending on the desired final attributes and desired final shelf life of the finished product. Richer doughs have longer shelf life and increased tenderness, but they tend to absorb too much fat during frying if conditions are less than perfect. It can be difficult to fully optimize the entire production process to reduce unwanted fat absorption, particularly due to the conflicting goals of doughnut production.

Doughnut Production Goals:

- **Maximize volume**
- **Maximize tenderness, softness, and moistness**
- **Minimize drooping during proof**
- **Minimize frying fat absorption**
- **Minimize collapse during cooling**

Ingredient choice, optimizing mixing time to maintain structure but reduce gluten development, and heating the frying fat completely before beginning the frying process all have a positive effect on attaining the goals above.

Ingredient Functionality in Doughnuts

Flour

Doughnuts made for commercial sale on grocery store shelves prioritize processing tolerance and extended shelf life. Hard wheat flours (11-13% protein) help maximize gas retention and dough workability during machining and cutting due to the strength of the gluten matrix. Unfortunately, doughnuts made solely from hard wheat flours may be soft and moist, but still lack tenderness. The stronger flour increases the amount of starch-protein interaction and cross-linking and yields a product with the texture and tenacity of white pan bread.

Smaller retail operations have first-day tenderness as their primary goal and use a flour blend consisting of 20-45% soft wheat to attain this attribute as well as a fine, compact grain. This flour blend often also contains small amounts of soy, corn, or potato flour to gain additional moisture retention, minimize frying fat absorption, and to improve the grain of the finished doughnut (Pyler 300). Chlorinated cake flours may also be used as the soft wheat portion of the flour blend if a richer formula (i.e. increased sugar level) is chosen. The rapid starch gelatinization helps prevent sagging during the cooling process.

Water

Water level must be maximized for workability, fryer expansion, and appropriate starch gelatinization. However, levels must also be limited in order to maintain straight side walls during proofing and to reduce excess spread.

Since doughnuts are proofed on a screen, excess water will cause the doughnuts to spread too much and droop. Lower water levels help maintain uniform shape and straight side walls. Care must be taken to keep water levels at an optimum level (about 54-62% of the total flour weight), however, or the finished doughnuts will have delayed starch gelatinization and a dense, gummy texture and grain.

Shortening

The use of shortening as well as additional mono- and di-glycerides provide “shortness” by interrupting the gluten matrix, tenderizing the bite. 10-12% is the most common usage level in yeast-leavened doughnuts. Dually-leavened doughnuts may use up to 20% shortening. Additional fat will be absorbed during the frying process.

Sugar

Sugar primarily adds sweetness and contributes to crust color. At higher levels (8-12%), sugar also provides tenderness. Dextrose may be used to increase crust color if a darker product is desired. This percentage of sugar is very low compared to cake doughnuts, which clock in at a whopping 40% sucrose. It is the filling, frosting, or glaze which gives the yeast doughnut its characteristic sugary flavor.

Malt

α-amylase in the form of malt or malted flours is used to break down starch and increase the tenderness of the doughnut. Shortening the polysaccharide chains provides a rich texture while reducing the total amount of fat and sugar necessary.

Processing

Raised doughnut dough is extremely versatile and may be formed into a variety of products, including shells, rings, long johns, twists, pershings, elephant ears, apple fritters, and strudel. They may be filled with fruit, jam, cream, cinnamon sugar, and glazed, frosted, or topped with nuts, sprinkles, sugar, or candy. This flexibility allows the retail baker creativity in the bakery and to create a number of cute, innovative products!

To produce a quality finished product, both dough structure and the structure of the final product must be optimized.

Mixing & Proofing

Yeast-raised doughnuts are typically made using the straight dough or sponge-and-dough procedures discussed in Lab 5. For optimum processing capabilities, doughs should be fully mixed and fermented for 45-90 minutes (Pyler 304). After bulk fermentation, doughs are then sheeted, cut out, and proofed. Proofing should take place at 95-100°F and proceed until the doughnut is able to retain a mark from the baker's finger without de-gassing or falling apart. Once proofing is complete, doughnuts are removed from the proof box and allowed to sit uncovered for 5 minutes. This allows the surface to form a skin which helps maintain the doughnut's shape during frying.

Frying

When doughnuts are placed in the hot frying fat, the internal pressure of the gas cells rises due to the increased temperature, causing rapid expansion. The side immersed in oil begins to brown and a golden crust forms. Since rising occurs before the doughnut is flipped, the "equator" of the doughnut floats above the surface of the oil and will never be fully submerged in oil. It will cook due to heat transfer throughout the product, but will remain pale in color. This ring is known as the "skunk line".

As doughnuts cool, the fried crust supports the shape of the doughnut and keeps it from collapsing. Doughnuts must be handled gently as they cool to keep their characteristic shape intact.

Potential Problems

- **Collapse –** Excessive volume may lead to inadequate starch gelatinization, leading to a lack of "filler" material and a net decrease in volume once doughnuts are removed from the hot oil. Overproofing will weaken dough structure and may also cause collapse.

- **Blistering –** Small bubbles marring the surface of the dough are common in ring-shaped doughnuts, particularly if the dough is overproofed and if the formula is too high in protein or too low in fat.
- **Capping** – Capping is more common in larger doughnuts like bismarks and long johns. Single, large blisters may form immediately under the crust and cause cracking and flaking. Capping and blistering are caused by the same factors – the terms simply refer to flaws in the surface of the doughnut.

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<u>Yeast Raised Donuts</u>

Straight Dough Procedure
REFERENCE ONLY
Using the McDuffie Bowl.

	100:0	**85:15**	**75:25**	**65:35**	**65:35cake**	**Bakers%**
Water (72°F)	595 g	580 g	565 g	550 g	560 g	VAR
HRW bread flour	1000 g	850 g	750 g	650 g	650 g	
SRW pastry flour	0	150 g	250 g	350 g	0	100
Chlorinated Cake Flour	0	0	0	0	350 g	
NH_4Cl	0.5 grams					0.05
MCP-mono	3.0 grams					0.3
No-bromate dough conditioner	2.5 grams					0.25
instant yeast	15 grams					1.5
NFDM	40 grams					4
soy flour	5.0 grams					0.5
dry egg yolks	16 grams					2
shortening, emulsified	120 grams					12
sucrose	60 grams					6
1st:	***30 s***					
2nd:	***3min 30s***	***3min15s***	***3min***	***2min45s***	***3min***	
Salt	14g					1.4
1st:	***30sec***	***30sec***	***30sec***	***30sec***	***30sec***	
2nd:	***optimum***	***optimum***	***optimum***	***optimum***	***optimum***	

FERMENT: 60 min at 81°F in fermentation cabinet, FDT = 78-80°F.

BALE: This technique will be demonstrated by the instructor.

REST: 30 min on bench, covered with plastic.

MAKEUP: Turn out the dough bale onto the sheeter, aligned parallel with the belt.

PROOF ≈ 100°F, ≈ 70% RH.: Allow the doughnuts to proof for approximately 25-40 min. (check by touch test) *When surface of doughnut is touched, an indention will stay without springing back. When the doughnut reaches this point, it is finished proofing. Allow the doughnuts to sit on a rack or on the bench uncovered for 3-5 minutes – this will create the dried “skin”.

FRY: 375°F, 60 seconds per side.

WEIGH: Weigh 6 of the fried doughnuts at the same time. Determine oil absorption by finding the difference between the total weight of the unfried dough rings and the total weight of the fried doughnuts. Use this figure to find the percentage of oil absorbed during frying.

FINISHING: Bismarks may be filled with a piping bag (fruit or crème fillings) and sugared or glazed. All other shapes may be iced or glazed.

KSU BAKING SCIENCE FORMULA

PRODUCT: Yeast Raised Donuts (Sponge and Dough) - control DATE OF ISSUE: 11/02/15

BAKER'S%	INGREDIENTS	WEIGHT/GRAMS
	FINAL DOUGH	
44	Water	155
T.B.D.	HRW Bread Flour	**check handout**
T.B.D.	SRW Pastry Flour	**check handout**
T.B.D.	SRW Cake Flour	**check handout**
1.58	Yeast (Instant)	15
4.21	Sucrose	40
2.11	Dextrose	20
4.21	NFDM	40
0.21	Soy Flour	2
1.47	Salt	14
12.63	Shortening (Emulsified)	120
	All the Sponge	1015 (approx.)
	TOTAL WEIGHT	**1,771 grams**

NOTES: The total dough side flour weight is 350 grams. The Bakers Percent is based on a total flour weight of 950 grams.

The sponge has fermented at 81°F for 3 hours prior to the start of lab. Add all the sponge as indicated in step #6.

****

SPONGE FORMULA

Baker%	***Ingredients***	***Wt. (g)***	
T.B.D.	Bread Flour	**T.B.D**	Flour wt. is
T.B.D.	Pastry Flour	**T.B.D**	600 grams

INSTRUCTIONS

39. Calculate the desired water temp., then add the water to the McDuffie bowl.
40. Add the flour and yeast
41. After sifting the sucrose, NFDM, Soy flour, and salt **twice**, scale the shortening on top.
42. Then add all the ingredients to the McDuffie bowl
43. Mix for 30 sec. on speed 1
44. **Add all the sponge**
45. Mix 30 sec. on speed 1
46. Mix 2 min. on speed 2
47. Bale (form into a seamless rectangle) and allow to rest on a lightly floured bench, (Make sure to cover with plastic) for 15 min.
48. Make-up: Sheet bale down gradually to 16 mm, rotate 90° and continue to sheet down to ≈ 12 mm. At this point, total donut weight will determine how far to sheet the dough down.
49. Use small doughnut cutter. Cut 6 rings (weight of rings should be 38-42g each).
50. Space 6 cut donut screen
51. Determine net dough weight of your 6 rings
52. Remaining Dough can be made into: rings or Bismarks: cut at 7 mm. Space these units on screens.
53. **PROOF** ≈100 °F, ≈ 60-70% Rh. Place screen in proof box for 25-35 min. Pull panel out of proofer, allow to sit in open air for 5 minutes so that units may form a skin.
54. **FRY** 375 °F, 60 sec. per side

KSU BAKERY SCIENCE FORMULA

PRODUCT: **Dawn Yeast Raised Donut premix** DATE OF ISSUE: 11/02/15

Straight Dough Process

BAKER'S%	INGREDIENTS	WEIGHT/GRAMS
100	Dawn Bag Mix	1361
47.06	Water (48-50° F)	640
1.48	Yeast (Instant)	21
	Total Weight	**2,022 grams**

NOTES: D.F.D.T. = 78-80° F

INSTRUCTIONS

1. In the McDuffie bowl, combine donut mix and yeast.
2. Mix on 1st speed for 1 minute.
3. Add water and mix on 1st speed for 1 minute.
4. Continue mixing on 2nd speed for 7-8 minutes; take to full development.
5. **Ferment 45 min. at room temp,** covered with plastic.
6. Bale and let rest 15 minutes, covered.
7. Make-up: Sheet bale down gradually to 16 mm, rotate 90° and continue to sheet down to 12 mm. At this point, total donut weight will determine how far to sheet the dough down.
8. Using small doughnut cutter, cut 6 rings (weight of rings should be 38-42g each).
9. Space the rings on a doughnut screen. Determine net dough weight of your 6 rings (TARE the screen).
10. Proof for 45 minutes.
11. Fry at 375°F, 60 seconds per side.

Doughnut Glaze

Simple Donut Glaze

Hot water, variable	25 %
Powdered sugar	100 %

Maintain glaze at slightly heated temperature, 100 – 120°F.
Glaze donuts about 60 seconds after frying.

White Roll Icing /Dipping

Hot water	250 grams
BLV (liquid)	11 grams
Powdered sugar	1500 grams
Corn syrup solids	20 grams
Emulsified shortening	60 g

Cream until smooth. Heat slightly to lower viscosity, dip one side of donuts into the icing, turn to drain.

Sugar coating

Corn syrup powder (42 D.E.)	60-85%
Shortening	7-10%
Starch	5-20%
Salt	5-1%
Flavoring	variable

Glaze-commercial

Sugar, powdered	70%
Sugar, granulated	20%
Corn syrup (42 D.E.)	10%
Gelatin	1-1½%
Water	20-22%
Hard fat flakes	2% (melt point = 130-140°F)

Glaze temp. 100 – 120°F

YEAST RAISED DOUGHNUTS data sheet	**DOUGH:**
(Height of 6 doughnuts) divided by **6** =’s The **radius** of one yeast raised doughnut	
Prior to Proofing Weight of six doughnut rings + the frying screen Weight of the Frying screen Difference is the weight of the 6 doughnuts **(A)**	
After Proofing and prior to frying Weight of six doughnut rings + the frying screen Weight of the Frying screen Difference is the weight of the 6 doughnuts after proofing **(B)** Percent loss caused by proofing: **((A – B) / A) times 100**	
After Frying Weight of six doughnut rings + the frying screen Weight of the Frying screen Difference is the weight of the 6 doughnuts: **(C)** Percent fat absorption: **((C – B) / B) times 100**	
Score Subjective: Color (20 points) Symmetry, uniformity (20 points) Tenderness (20 points) Grain (20 points) Flavor (20 points)	
Total subjective score: 100 points	

Post Lab Discussion Questions

1. Why does soy flour inhibit oil absorption? Explain.

2. Why would a baker choose to use chlorinated cake flour in his/her doughnut formula?

3. Compare and contrast the straight dough and sponge and dough processes for doughnut production. Please list advantages and disadvantages.

4. What are the advantages of using a bagged mix when producing doughnuts? Disadvantages?

Addendum – pH and TTA

pH = - log [H+]. pH measures the concentration of dissociated hydrogen ions in a solution - it is a measure of the 'strength' of acidity of a substance. With pH 7.0 being the neutral point on this scale, or the pH of pure water, numbers decreasingly less than 7.0 express increasing acid strength, while numbers increasingly greater than 7.0 express increasing alkalinity. Since pH is on a logarithmic scale, note that a unit change in pH represents a 10-fold change in acid strength. (A pH 5.0 solution is ten times as acidic as a pH 6.0 solution. And a pH of 8 is 1,000 times more alkaline then a pH of 5.)

pH <u>0 1 2 3 4 5 6 7 8 9 10 11 12 13 14</u>

*-----acidic neutral alkaline---+

Total Titratable Acidity (TTA) is a measure of the total amount of acid in a substance, both dissociated and non-dissociated. TTA equals the number of ml of 0.1 M sodium hydroxide needed to neutralize a specified amount of an acid solution to a near-neutral pH of 6.6 (if you aim for pH 7.0, you will overshoot).

<u>Determination of pH and TTA</u>

Take dough sample after fermentation time.

A. Procedure to set up each pH sample:

1) Weigh 15 grams of the dough (or sponge) and place in plastic Nalgene container.
2) Fill container to black line with distilled water (this will be approx. 80 mL).
3) Place magnetic stir bar in the bottom of the jar.
4) Seal the jar and shake vigorously to break up the dough piece.
5) Take the top off the jar and place the jar on top of the stirring unit.

B. Determine pH of sample mixture:

1) Make sure the plastic guard of the electrode is covering the ball at the bottom of the electrode.
2) Place pH meter electrodes into beaker (set to pH/mV).
3) Record the pH reading while constantly stirring.
4) When done, rinse off electrode with distilled water.
5) Return clean container and clean stir bar back to counter.

C. Determine TTA of that same sample mixture:

1) Titrate sample with 0.1 N NaOH, continuing to stir constantly, until you reach a meter reading of pH 6.6. Record number of mL of NaOH solution needed to titrate as the TTA of the sample.

Make sure when adding NaOH solution you observe the starting measurement of the solution to maintain accurate calculations.

GRSC 638
Baking Science II
Lab Manual

Spring 2018

The Effects of Ingredient and Process Variation in Chemically-leavened Bakery Products

Edited by Chloe Shearon

Fall 2017

Lab #1 - Intro to Specific Gravity and Desired Batter Temperature

Specific Gravity

Specific gravity (SG) is a ratio that allows density to be measured in a consistent and quantifiable manner. In the context of cake production, it displays the quantity of air that has been incorporated into the batter system. Water has a specific gravity of 1 and serves as the standard against which all other specific gravities are measured. Because water always serves as the denominator, it's easy to visually recognize whether a substance is more or less dense than H2O.

$$Specific\ Gravity = \frac{weight\ of\ sample\ volume\ (g)}{weight\ of\ the\ same\ volume\ of\ water\ (g)}$$

As more air is incorporated, the batter becomes less dense; therefore the specific gravity of the batter decreases. The level of air incorporation is a major contributing factor to the texture, appearance, and volume of the finished cake (Pyler, *Volume II* 144).

Recommended Temperature and Specific Gravities: Cakes

Batter	***Temp.(°F)***	***Specific gravity****
Angel food	*70-72*	*0.30-0.40*
Sponge	*92-94*	*0.50-0.60*
Chiffon	*70-72*	*0.40-0.45*
Pound	*58-60*	*0.80-0.84*
Yellow layer	*70-72*	*0.88-0.94*
White layer	*70-72*	*0.88-0.94*
Chocolate Layer	*70-72*	*0.90-0.95*
Devil's food	*70-72*	*0.90-0.95*

****SG ranges given apply to vertical mixers (ex. Hobart) and may vary for continuous mixing operations.***

Batter Temperature

Batter temperature has a large impact on a variety of factors, including specific gravity, viscosity, and the timing of leavening gas production. Temperature affects how much resistance to flow (viscosity) the batter possesses, which also affects air incorporation and specific gravity. High temperatures will cause the batter to be too fluid by melting incorporated fats, while extremely cold batters will be stiff and difficult to mix (Pyler, *Volume II* 144).

The most common way to control the desired batter temperature (DBT) is by determining the temperatures of the ingredients and varying the temperature of the water added to the formula. The equation given below is useful in this endeavor.

$$Water\ Temperature = (6 * DBT) - (RT\ + flour\ T + sugar\ T\ + shortening\ T + egg\ T + FF)$$

RT= room temperature
FF= friction factor

Friction factor will be provided in each KSU Baking Science formula and may vary depending upon the product being made and the mixer in use. Friction factor can be defined as as "the frictional resistance to motion between surfaces that are subject to a load" (BakingBusiness). Basically, the mixer must overcome the friction between the dough, the hook or whisk, and the bowl to incorporate the ingredients. This uses energy and as such, increases the dough temperature and must be accounted for when calculating the best water temperature for use.

AACCI Cake Scoring Template

The cake scoring template on the next page is provided by the American Association of Cereal Chemists and represents the industry standard for measuring and scoring the volume, symmetry, and uniformity of high-ratio layer cakes. Templates will be provided by the lab instructor and used once the cake has been removed from the oven and cooled. The cake should then be carefully cut in half (on a cutting board, not directly on the bench) and the template placed against the cut side.

Record the measurements of points A-E and use them to calculate the volume, symmetry, and uniformity indices.

Use of Layer Cake Measuring Template

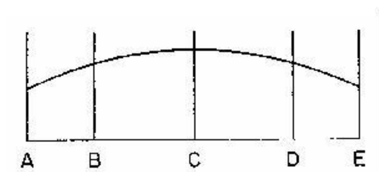
Final approval October 15, 1997, Reapproval November 3, 1999

Objective

To obtain indices for cake volume, symmetry, and uniformity of 20-cm (8-in.) diameter layer cake, using the template. Method **10-90.01** produces 20-cm (8-in.) layer cakes, for which volume is a primary quality measurement. The liquid level is optimized to produce good symmetry, i.e., not peaked nor dipped in the center.

Procedure

1. Carefully cut cake vertically through center. Place cake with cut surface down on template, center, and align with baseline of template. (Alternatively, place cut section of cake on shelf, hold template in front of and against cake, line up as above, and make necessary readings.)
2. Read diameter (A to E) to nearest 0.1 mm. Subtract diameter from 20.3 mm to obtain shrinkage value.
3. Read off height of cake to nearest 0.1 mm at vertical lines B, C, and D. These lines are designated for calculations as illustrated in diagram below:



Calculations

Volume index = $B + C + D$. See Note 1.
Symmetry index = $2C - B - D$. See Note 2
Uniformity index = $B - D$. See Note 3.

Notes

1. Refer to index value of cake from control flour.
2. The term “symmetry” has traditionally been used in the cake industry to indicate contour.
3. The term “uniformity” has been applied for a number of years to the measurement of cake symmetry.

doi: 10.1094/AACCIntMethod-10-91.01

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KSU Bakery Science Lab High-Ratio Cake Procedure

Scaling: Weigh all dry ingredients first. **Use one bowl to weigh individual ingredients; transfer them to another bowl before continuing to weigh.** Don't zero the scale and add ingredients on top of others – it's easy to make scaling errors that way. Weigh the water immediately prior to mixing.

Mix: Mix the cake according to the appropriate formula.

Measure: FBT and SG, using the provided SG cup for the weights of both water and batter.

Record: Using the Excel spreadsheet in SH 109, record the SG and temperature measurements.

Sample: Using a # 20 disher, place a level scoop of the finished batter on the Specific Gravity sample tray. Record the corresponding SG and FBT on the pan liner.

Scale: Line each pan with a fluted cake liner. Scale 380 grams per 8" pan, ensuring the scale has been zeroed. Yields 4-5 cake layers. Make sure to label each cake using the provided KSU tags.

Bake: Double pan, 355°F/179°C for approximately 26 min.

The cake should be set (not jiggly) when touched, but not dry.

Cool: **Allow cakes to cool for 10 minutes.** Holding the pan in the right hand, support the top of the cake with the left. Invert the pan, then re-invert so the cake is right-side up. Keep label with proper product.

Score: Once the cake layers are cool to the touch, sensory and template scores can be taken and recorded.

KSU BAKING SCIENCE FORMULA

PRODUCT: YELLOW HIGH RATIO LAYER CAKE FORMULA NO: Control

BAKERS %	INGREDIENTS	WEIGHT/ GRAMS	INSTRUCTIONS
100	Cake flour, SRW chlorinated	500	Put all ingredients (except water) into mixing bowl and then:
125	Sugar	625	
10	Nonfat dry milk (NFDM)	50	
18.2	Dry whole eggs	91	
3.0	Salt	15	
2.4	Baking Soda	12	Mix 1st speed: 1 min Scrape down bowl and paddle
2.2	SALP	11	
0.25	MCP	1.2	
2	B.L.V.	10	Mix 1st speed: 4 min Scrape down bowl and paddle
46	Emulsified cake shortening	230	
1	Cake emulsifier (Vanlite brand)	5	
132	Water	660	Add 220g water Mix 1st speed: 1 min Scrape down bowl and paddle Cont. mixing 2 min., speed 1
	Total Weight	2210.2g	

NOTES:

Dry blend with paddle to stimulate cake mix finisher.

Friction Factor: 5

Desired Final Batter Temperature (DFBT) = 72°F/22°C

Final Desired Specific Gravity (S.G.) = 0.88 – 0.92

Instructions (continued):

Add 220g water
Mix 1st speed : 30 sec
Scrape down bowl and paddle
Mix 2nd speed: 2 min.
Check S.G. Target: 0.87- 0.90

Add 220g water
Mix 1st speed: 15 sec
Scrape down bowl and paddle
Mix 2nd speed: 1 min

Check S.G. & continue mixing on 2nd speed to reach desired S.G. in 30 second intervals.

Premixing Notes:

1. The amount of water to be used was determined in a series of test bakes.

2. **Calculated Water Temperature =**

(**6** times Desired Batter Temp.) **--** (Room temp. + Flour temp. + Sugar temp. + Shortening temp. + Egg temp. + Friction factor)

(6 times _______) **--** (______ + ______ + ______ + ______ + ______ + ______)

= ______________________

KSU Bakery Science Lab Cake Scoring Sheet **Batter #**

Batter temp (°F) wt (1 cup batter) / wt (1 cup water) = S.G. S.G. = specific gravity pH of batter			
pH of final product			
Template Measures A			
B			
C			
D			
E			
Volume Index = B+C+D			
Symmetry Index = 2C – B - D			
Uniformity Index = | B- D |			
Subjective Scores:			
Crust color (descriptive) Cells & Grain (40 pts) Texture (40 pts) Crumb color (10 pts) Flavor & Aroma (10 pts)			

Total Subjective Score (100 pts. possible)

Lab #2 - The effects of ingredient variation on starch gelatinization and structure in high ratio cakes

Mixing

The mixing process converts unincorporated ingredients into a structured oil-in-water emulsion filled with finely distributed air bubbles. Depending on the formula and mixing method, air bubbles may be entrapped into the fat stage or into the aqueous stage. The old-fashioned creaming technique incorporates air into shortening or butter; a time-consuming but stable process, while modern continuous mixing methods use mechanical processes to force air into the liquid batter.

For example, in the Oakes continuous mixing system, a batter slurry is mixed and transferred to a holding tank. Little to no air is incorporated into the slurry during the bulk mixing process. The slurry is then pumped to the Oakes mixing head, which contains a stationary and a revolving stator. The teeth interlock and use high shear at 200-300 rpms to aerate and emulsify the batter. Specific gravity can be controlled by adjusting the speed of slurry info, the air pressure, and the stator RPMs. Although an efficient process, air bubbles are physically more able to escape from the aqueous phase than the fat phase, so modern single-stage or continuous mixing operations often use emulsifiers and other interventions to help reduce bubble migration.

As discussed in Lab 1, as the specific gravity of a batter increases, so does the viscosity and resistance to flow. Entrapped gas bubbles create increased frictional resistance within the batter. Although the bubbles are more buoyant than the rest of the batter, they are prevented from coalescing or migrating outwards because surface forces and the high batter viscosity hold them in place. Logically, as more air is incorporated, the batter density decreases.

Batter Viscosity during Baking, Gas Cell Migration & Expansion

As batter temperature rises in the oven, shortening globules begin to melt. Small oil pools form and H-bonds between polymers weaken, reducing viscous resistance to flow. The batter now behaves like a fluid system; gas cells are able to move around more freely and may coalesce. Since larger bubbles have a lower surface area to volume ratio than smaller bubbles, the ratio of surface forces to buoyancy is also lower, contributing to their increased ability to migrate to the surface of the batter and escape. Batter complex viscosity must be kept at a sufficiently high value, particularly at the lowest point in the baking cycle (Vmin). If the Vmin drops too far, the bubbles will easily escape and the cake will fall. Cakes are at best a leaky system, so the use of multi-stage leavening acids to ensure gas production during this stage helps to maintain height and counter the decrease in viscosity.

Furthermore, if the minimum level of viscosity is allowed to decrease too much, heavy starch particles (specific gravity 1.0-1.6) will be able to sink to the bottom of the pan, creating a dense, rubbery layer and a cake with unpleasing texture and low volume.

Increasing batter temperatures also cause the activation of the chemical leavening, which begins to produce carbon dioxide gas accumulation in the air nuclei. Water vapor pressure also builds up in the nuclei. As the gas expands, the cake increases in size. This size increase is one of the main reasons why even and uniform incorporation of air bubbles is crucial to a high quality product; if the bubbles are uneven the cake will not expand at the same rate and may have a misshapen structure and rough grain.

Finally, the "inflated" volume of the cake is supported by the internal pressure of the heat-expanded gas cells. If the cake is removed from the oven before the structure is set, the cake will collapse during cooling due to the lowering internal pressure of the gas cells. Without a set structure, only the gas bubbles hold the cake's internal structure aloft. This is also why many home bakers will shoo everyone out of the kitchen while a cake is baking because they are afraid of jolting or disturbing the cake's wobbly structure and allowing the gas bubbles to escape.

Starch Gelatinization Onset (To) and the Effect of High Sugar Levels on Tg in High Ratio Cakes

Starch gelatinization occurs once the internal temperature of the cake reaches 90 degrees Celsius. The starch granules absorb the surrounding water and began to swell. The system's complex viscosity rises dramatically. The proteins become glassy and brittle as they are dehydrated, increasing the system's elasticity (G') and causing the system to resist further volume expansion from leavening gas production. Once this occurs, the system has "set".

As seen above, starch gelatinization requires both energy (heat) and water. If limited water is available, higher temperatures must be reached before the starch granules are able to gelatinize. Similarly, high levels of sucrose structure the water molecules into bulky "clumps" which are less able to penetrate and plasticize starch granules. In such cases, greater kinetic energy and higher temperatures must be realized before the starch will gelatinize. Therefore, in a high-ratio system, higher sugar levels delay To, the onset of starch gelatinization, so the cake has more time to expand in volume. Chlorinated cake flour must be used to yield successful results because the starch is better able to absorb water and swell at an accelerated rate. These swollen starch granules provide structure and occupy void space, providing support for the cake as the internal gas pressure decreases. If unmodified flours are used, the starch granules will not be able to swell quickly enough before gelatinization is completed, and the cake

Functional Properties of Cake Batter Ingredients

Flour

Hydrated flour proteins function as part of the skeletal framework for a cake by acting as polymeric skeletal members that loosely tie the batter together. Flours used for high ratio cake production are most often milled from soft red winter wheat and treated with chlorine gas to a pH of 4.4-4.9. Soft wheat is used to minimize the degree of protein-starch interaction that would otherwise give the cake a tough bite and undesirable texture. Cake flours tend to have lower water absorption, finer particle size, and less starch damage than bread flour, and should have a protein range of 7-9%.

As discussed in the previous section, flour used for high ratio cakes must be chlorinated in order to achieve high levels of gelatinization and avoid collapse. Chlorination partially de-polymerizes and oxidizes the starch present in flour, which creates a modified starch polymer that absorbs water easily and swells rapidly. Chlorination does not affect the onset temperature of starch gelatinization, it simply causes the water absorption and swelling process to occur more rapidly.

Sucrose and Other Sugars

The main function of sucrose in cake baking is to impart sweetness, bind water, and impart crust color through caramelization. “Binding” water lowers the water activity, aids in gelatinization onset and slows moisture migration once baked, preventing staling and preserving quality. High levels of sucrose also cause an increase in the temperature required for gelatinization onset, prolonging the time available for volume expansion. However, extremely high sucrose levels may prevent the cake from forming much structure and will cause collapse late in baking or upon cooling. Sucrose is a non-reducing sugar.

Sucrose is primarily used in cake baking, but corn syrup, high fructose corn syrup, or invert syrup may also be used at a 15-45 % on a total weight basis. Corn syrup is cheaper than sucrose and may be used to make production less expensive. However, it is not as sweet as sucrose and may be difficult to handle or pump due to its high viscosity. The monosaccharide present in corn syrup, glucose, is less able to increase To than sucrose. Corn syrup also contains reducing sugars, which may caramelize and impart an undesirable, dark color to white or yellow cakes. Reducing sugars react protein amino groups and are responsible for interior crumb color formation through the Maillard reaction.

High fructose corn syrup (HFCS) is functionally equivalent to invert sugar and may be easily used to replace sucrose in cake formulas. The addition of HFCS doesn’t affect batter specific gravity but may affect internal crumb color if used at high levels (>25%) because of its reducing sugar content. At even higher levels (>50%), HFCS will cause reduced volume, excess tenderness, thick outer crusts, limited shelf-life, and a sandy appearance during staling. HFCS also affects batter pH more than sucrose, which will affect the functionality of leavening acids in the formula.

When substituting corn or invert syrups for granulated sucrose, substitution must be done on the basis of % solids. The amount of water contributed by the syrup must be subtracted from the total amount of water called for in the formula.

Shortening and Emulsifiers

The primary function of shortening in high ratio cakes is to “shorten” and tenderize the cake’s bite by interrupting protein structures, as well as to lubricate and moisten the texture (Bakerpedia). Shortening also increases the batter’s viscosity and flow resistance, which helps air bubble incorporation and retention within the gas phase.

Cake shortenings may be liquid or plastic (solid) and usually contain an emulsifier. Shortening may be used from 50-60% in yellow layer cakes up to 75% in pound cakes.

Emulsifiers, whether added separately or present in shortening, help reduce interfacial tension between batter aqueous and lipid phases and prevent separation. Batter viscosity is better maintained and gas bubble coalescence and migration are minimized. Emulsifiers make two-stage blending and single-stage, all-in-one cake mixing methods possible. They also allow the use of higher water levels, allowing faster starch gelatinization and therefore successful production of high-ratio cakes. Before the widespread use of emulsifiers in the 1920s-1930s, high-ratio cakes couldn’t be produced without using multiple-stage creaming methods. Finally, emulsifiers also allow cake layers to retain moisture longer and reduce moisture migration, extending shelf life.

Eggs

Eggs lend their binding ability and foaming capacity to batter structure and help stabilize aerated batters. They are also able to leaven cake batter through foaming, steam expansion during baking, and air-fat emulsification (Indrani et. al 37). Egg white proteins bind together strongly and may toughen the final cake unless tenderizing ingredients are added. The fat and lecithin found in egg yolks are able to provide tenderizing and emulsifying functions. Eggs also contribute flavor, color, and additional proteins.

Whole eggs and egg yolks are used in layer and sponge cakes, while egg whites alone are used in white cakes and angel food cakes. Fresh or frozen eggs may be used; if frozen egg is chosen, it must be thawed for 5 to 6 hours in running water and mixed thoroughly before use. If unevenly mixed, the total soluble solids content will be inconsistently distributed throughout the product and the cake’s final structure will be negatively affected.

Milk Solids

Non-fat dry milk (NFDM) is the main type used in commercial cake production; it is mainly composed of casein, lactose, and various minerals. These components add richness, structure, and retain moisture. Lactose, a reducing disaccharide, is critical to crust color formation during baking.

Milk proteins such as casein interact with flour and egg proteins and form a polymeric skeleton which provides batter structure and contributes to batter viscosity. Casein and other milk proteins reduce surface tension between gas cell walls and water and provide surface reactive forces that hold gas bubbles in place. If NFDM is eliminated, formulas must be adjusted and emulsifiers added to replace these surfactant forces.

Leavening

During baking, cakes are leavened by carbon dioxide gases produced by chemical leavening products, by water vapor pressure generated in the oven, and by expansion of the batter's incorporated air bubbles.

Baking powder is the most common leavening agent used in cake production and always contains sodium bicarbonate (baking *soda*) as a source of carbon dioxide. Baking powders also contain at least one buffering acidic compound, which react with and neutralize NaOH produced during the mixing of baking soda and water, speeding up the production of CO_2 gas.

Baking powders are classified as fast, slow, or double-acting depending on the acids used. Double-acting powders are most common in cake production and contain at least 2 buffering acidic salts, the first one of which reacts at room temperature with liquid to produce CO_2. The second buffering acid produces gas when heated in the oven, which aids structural integrity and helps prevent collapse (Bakerpedia).

The amount of baking powder required in a cake depends on variety and formulation. Richer cakes that contain more sugar and fat have the capacity to retain more air during mixing and therefore need less chemical leavening. Large cakes with a lower surface-to-volume ratio may also require less baking powder than a cake with a larger surface-to-volume ratio.

Salt

Salt mainly functions as a flavor enhancer. It also helps "structure" water and reduce the amount of free water available, reducing moisture migration and helping to prevent spoilage.

Water

Water controls the onset and rate of starch gelatinization, the extent of gluten development, the disassociation of sodium bicarbonate to carbon dioxide and affects non-enzymatic browning. Water temperature is crucial when adjusting and controlling batter temperature.

Bibliography

"Double-Acting Baking Powder: Baking Ingredients." *Bakerpedia,* *http://bakerpedia.com/ingredients/double-acting-baking-powder*.

Indrani, Dasappa, and Gandham Venkateswara Rao. "Functions of Ingredients in the Baking of Sweet Goods." *Food Engineering Aspects of Baking Sweet Goods*, edited by Servet Gulum. Sommu and Serpil Sahin, CRC Press, 2008, p. 37.

"Shortening: Baking Ingredients." *Bakerpedia,* *http://bakerpedia.com/ingredients/shortening/*

Experimental Assignments

Mix and bake cakes from the CONTROL formula, following the formula alterations assigned to your team.

1. **CONTROL (in Bakers' %)** **Flour – 100; Sugar – 115; NFDM – 10**
Whole Dry Eggs – 18.1; Water -125

Water Level Variation

2.	105 % water	576 g total water; added in 3 stages (192 g, 192 g, 192 g)
3.	150 % water	825 g total water; added in 3 stages (275 g, 275 g, 275 g)

Sugar Level Variation

4.	95% sugar	522 g
5.	150% sugar	825 g
6.	150% sugar 155% **water** to compensate	825 g 852 g ; 3 stages, 284g, 284g, 284g)

Egg Solids Variation

7.	9% dry whole eggs	50 g
8.	5% dry egg white	28 g

This white layer cake contains the same level of egg white albumen protein as does the CONTROL with 15% dry whole eggs. Performance differences stem from the lack of yolk material.

Milk Solids Variation

9.	0% NFDM 113% water to compensate G"	**Zero g** 621g ; 3 stages, (207g, 207g, 207g)
10.	3% NFDM 112% water	16 g 615g ; 3 stages, (205g, 205g, 205g)

KSU Bakery Science Lab Cake Procedure

Scaling: Weigh all dry ingredients first. **Use one bowl to weigh individual ingredients; transfer them to another bowl before continuing to weigh.** Don't zero the scale and add ingredients on top of others – it's easy to make scaling errors that way. Weigh the water immediately prior to mixing.

Mix: Mix the cake according to the appropriate formula.

Measure: FBT and SG, using the provided SG cup for the weights of both water and batter.

Record: Using the Excel spreadsheet in SH 109, record the SG and temperature measurements.

Sample: Using a # 20 disher, place a level scoop of the finished batter on the Specific Gravity sample tray. Record the corresponding SG and FBT on the pan liner.

Scale: Line each pan with a fluted cake liner. Scale 380 grams per 8" pan, ensuring the scale has been zeroed. Yields 4-5 cake layers. Make sure to label each cake using the provided KSU tags.

Bake: Double pan, 355°F/179°C for approximately 26 min.
The cake should be set (not jiggly) when touched, but not dry.

Cool: **Allow cakes to cool for 10 minutes.** Holding the pan in the right hand, support the top of the cake with the left. Invert the pan, then re-invert so the cake is right-side up. Keep label with proper product.

Score: Once the cake layers are cool to the touch, sensory and template scores can be taken and recorded.

KSU BAKING SCIENCE FORMULA

PRODUCT: YELLOW HIGH RATIO LAYER CAKE FORMULA NO: **Control** 1/26/17

BAKERS %	INGREDIENTS	WEIGHT/ GRAMS
100	Cake flour, SRW chlorinated	550
115	Sugar	632
10	Nonfat dry milk (NFDM)	55
18.1	Dry whole eggs	100
2.9	Salt	16
5.5	Baking Powder (SALP, MCP)	30
2	B.L.V.	11
41	Emulsified cake shortening	225
1	Cake emulsifier (Vanlite brand)	11
125	Water	690
	Total Weight	**2320 g**

NOTES:

Dry blend with paddle to stimulate cake mix finisher.

Friction Factor: 5

Desired Final Batter Temperature (DFBT) = 72°F/22°C

Final Desired Specific Gravity (S.G.) = 0.88 – 0.92

INSTRUCTIONS

Put all ingredients (except water) into mixing bowl and then:

Mix 1st speed: 1 min
Scrape down bowl and paddle

Mix 1st speed: 4 min
Scrape down bowl and paddle

Add 230 g water
Mix 1st speed: 1 min
Scrape down bowl and paddle
Cont. mixing 2 min., speed 1

Add 230 g water
Mix 1st speed : 30 sec
Scrape down bowl and paddle
Mix 2nd speed: 1.5 min.
Check S.G. Target: 0.87- 0.90

Add 230 g water
Mix 1st speed: 15 sec
Scrape down bowl and paddle
Mix 2nd speed: 1 min

Check S.G. & continue mixing on 2nd speed to reach desired S.G. in 30 second intervals.

Results and Discussion

Construct a table for **EACH** independent variable listed below, Tables 1, 2 3 and 4. The dependent variable columns in each table should include:

* cake volume index
* cake contour index
* cake symmetry index
* weighted subjective scores

Explain the WHYs underlying these accumulated observations by referring to the underlying mechanisms in questions 1-4.

1. **Table 1. Effect of Varying Water Level** [2,1,3]

   Identify the optimum water level to use in this formula with this flour.

   Why do insufficient water levels yield uneven cakes with low volume?

2. Table 2. **Effect of Sugar Level Variation** [4,1,5, and 6]

   Increasing sugar levels increase T_o, the temperature required for the onset of starch gelatinization

   Why?

   How will this affect the volume of cooled cakes?

   Explain any marked differences between batters.

3. Table 3. **Effect of Egg Solids Variation** [7,8,1]

   Why is the volume of cakes produced from batter #8 less than that of the control?

4. Table 4. **Effect of Milk Solids variation** [9,10,1]

   Note and explain any major differences between batters. Are there any differences in crust or crumb color?

5. Consider the following baker's scenario. "My customers like the taste of our yellow cake layers, but they usually dip in the center, and occasionally they slightly collapse when they come out of the oven. I've tried using more baking powder and they rise higher in the oven, but they still dip and/or collapse. Help!" Speculate on what the baker should consider trying and why.

6. She adds that even when her cake volumes and external characteristics are reasonable, tunneling and coarse texture often crop up as problems. Suggest some things that she might try in order to remedy her tunneling problem.

KSU Bakery Science Lab Cake Scoring Sheet **Batter #**

Batter temp (°F) wt (1 cup batter) / wt (1 cup water) = S.G. S.G. = specific gravity pH of batter			
pH of final product			
Template Measures A			
B			
C			
D			
E			
Volume Index = B+C+D			
Symmetry Index = 2C – B - D			
Uniformity Index = | B- D |			
Subjective Scores:			
Crust color (descriptive) Cells & Grain (40 pts) Texture (40 pts) Crumb color (10 pts) Flavor & Aroma (10 pts)			

Total Subjective Score (100 pts. possible)

Lab #3 - Lipid and Emulsifier Variations

Review

As discussed in Lab 2, cake production is dependent on bubble mechanics and relies on air incorporation for stability and volume. Density decreases as aeration increases, and the viscosity will increase as well. Gas bubbles provide frictional resistance to the batter system and increase frictional resistance to flow. Leavening gases then diffuse to the air bubbles during baking, causing expansion. Because no new gas nuclei are created during baking, the batter must contain a large quantity of evenly distributed air bubbles by the end of the mixing process.

Air cells may be incorporated through traditional multi-stage creaming methods or modern single stage methods. High shear forces are used to entrap air directly into the aqueous phase in single stage methods, a quick but relatively instable process. Emulsifiers must be used to reduce interface tension and to reduce bubble coalescence and migration.

Cake Batter Stability

Shortening and Vegetable Oils used in Cake Baking

As mentioned in Lab 2, some of the major functions of shortenings in continuous or single-stage mixed cakes are bite lubrication and tenderization, flavor addition, and heat transfer, as well as aiding an increase in batter viscosity through air entrapment. According to Bakerpedia, fats coat the protein and starch particles during mixing, interrupting the batter's gluten-starch structure and providing a tender, moist bite (Bakerpedia). Volatile flavor and aroma compounds are able to adhere to lipid surfaces, so the use of shortening also helps strengthen and retain flavors during baking.

Structurally, fats and oils are esters (an organic compound) composed of a glycerol backbone and 3 fatty acid chains. Vegetable oils are liquid at room temperature because they are unsaturated; their fatty acid chains contain double bonded, unsaturated areas that allow them to melt at or below room temperature. "Hydrogenation" is the process of adding hydrogens to the unsaturated areas, creating single bonds that raise the fat's melting point. Vegetable shortening, like Crisco, is partially hydrogenated and contains a mixture of double and single bonds, making the fat plastic (solid) at room temperature; the functionality of baking fats is primarily dependent upon their plasticity at usage temperature. Usage temperature for hydrogenated shortening is around 70° F, but emulsified liquid cake shortenings may be used successfully at higher temperatures.

Emulsifies or Surfactants Used in Cake Baking: Review

Emulsifiers, also known as surfactants, have both lipophilic and hydrophilic sites, as well as a hydrophilic "tail" or end. They reduce the interfacial tension between various batter phases; most commonly, α-monoglycerides allow fat and aqueous phases to coexist stably and resist curdling and separation to maintain the overall goal of increased batter viscosity. Therefore, α-monoglycerides indirectly reduce gas cell coalescence and loss.

Due to reduced interfacial tension, emulsifiers promote uniform dispersion of minute shortening particles within cake batter's aqueous phase, yielding a consistent and viscous batter that is better able to incorporate large quantities of small, uniform bubbles. These nucleation sites allow even expansion of leavening gases and a finely textured, even-grained final product. Emulsifiers also increase shelf life.

Cake shortenings may contain a mixture of emulsifiers, usually equal or less to 2.75% of the shortening weight. Common emulsifiers used in cake shortening are mono- and di-glycerides, propylene glycol monosterate (PGMS), lactylated monoglycerides, polysorbate 60, and ethoxylated monoglycerides (EMG) (Pyler 439).

Although most surfactants used in cake systems improve interactions between the liquid and fat phases, some are able to reduce interfacial tension between aqueous and gas phases. PGMS can directly stabilize gas cells in liquid, even without the addition of fats to provide increased batter viscosity.

Use of Fluid Cake Shortening Systems Compared to Plastic Shortenings

Foam formation occurs differently when oil or fluid fats are used instead of plastic shortenings. Air cell stabilization must be accomplished by soluble proteins from flour, eggs, and other ingredients in the cake batter. Additionally, oils have a destabilizing effect on protein foams, so the fat droplets must be isolated from the foam to maintain its structure. This can be accomplished through the addition of α-monoglycerides or other emulsifiers, which create a solid film at the oil-water interface and promote air incorporation.

Fluid cake shortening provides certain advantages, such as easy pumpability, rapid fat dispersion, bowl lubrication, and increased batter flow. Also, fluid shortenings require little hydrogenation, which is a benefit for those wishing to avoid such fats. However, fluid shortenings have little long-term stability, cost more, and may have process constraints due to the specific oil-to-emulsifier ratios needed.

Low Fat Cakes?

In today's cake production lab, Variation 2 demonstrates the possibility of producing a cake without the addition of shortening that is texturally and visually up to spec. However, without fat to interrupt the cake's structure, the product lacks the expected tender and "short" bite and may have a dry and unpleasing mouthfeel. A variety of recommendations have been made to combat these deficiencies, such as adding hydrophilic gums or pre-gelatinized starches to retain more water. These suggestions, however, still do not address the necessity of interrupting the protein-starch network. Further research must be done to address this issue; low-fat cakes with pleasing mouthfeel and texture would be an asset in the baking industry!

Bibliography

Pyler, E. J., and L. A. Gorton. “2.C.6 Improvers.” Baking Science & Technology, vol. 1, Sosland Pub., 2008, p. 439.

“Shortening: Baking Ingredients.” *Bakerpedia,* http://bakerpedia.com/ingredients/shortening.

KSU Bakery Science Lab High-Ratio Cake Procedure

Scaling: Weigh all dry ingredients first. **Use one bowl to weigh individual ingredients; transfer them to another bowl before continuing to weigh.** Don't zero the scale and add ingredients on top of others – it's easy to make scaling errors that way. Weigh the water immediately prior to mixing.

Mix: Mix the cake according to the appropriate formula.

Measure: FBT and SG, using the provided SG cup for the weights of both water and batter.

Record: Using the Excel spreadsheet in SH 109, record the SG and temperature measurements.

Sample: Using a # 20 disher, place a level scoop of the finished batter on the Specific Gravity sample tray. Record the corresponding SG and FBT on the pan liner.

Scale: Line each pan with a fluted cake liner. Scale 380 grams per 8" pan, ensuring the scale has been zeroed. Yields 4-5 cake layers. Make sure to label each cake using the provided KSU tags.

Bake: Double pan, 355°F/179°C for approximately 26 min.
The cake should be set (not jiggly) when touched, but not dry.

Cool: **Allow cakes to cool for 10 minutes.** Holding the pan in the right hand, support the top of the cake with the left. Invert the pan, then re-invert so the cake is right-side up. Keep label with proper product.

Score: Once the cake layers are cool to the touch, sensory and template scores can be taken and recorded.

EXPERIMENTAL ASSIGNMENTS

-Use **All Purpose Shortening** unless otherwise specified.

0% fats, varying emulsifier

1.	0% shortening or oil	0 g
	0% blended emulsifier (Vanlite)	0 g
2.	0% shortening or oil	0 g
	2% Vanlite	11 g

21% shortening, varying emulsifier

3.	21 % A.P. shortening	115 g
	0% Vanlite	0 g
4.	21 % A.P. shortening	115 g
	3 % α-monoglycerides (BFP65PLM)[1]	16 g
5.	21 % A.P. shortening	115 g
	3 % Vanlite 16 g	

41% shortening, varying emulsifier

6.	41 % A.P. shortening	225 g
	0% Vanlite	0 g
7.	41% A.P. shortening	225 g
	3 % α-monoglycerides (BFP65PLM)	16 g
8.	41% A.P. shortening	225 g
	3 % Vanlite	16 g
9.	**C0NTROL-** 41% **emulsified shortening (not A.P.)**	225 g
	2 % Vanlite	

30% Vegetable oil, varying emulsifier

10.	30% veg oil	165 g
	0% Vanlite	0 g
11.	30% veg oil	165 g
	4% Vanlite	20 g

30% Fluid Cake Shortening, varying emulsifier

12.	30% **fluid** cake shortening	165 g
	0% Vanlite	0 g
13.	30% **fluid** cake shortening	165 g
	2 % Vanlite	11 g

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[1] See note on opposite side

Note: The α-monoglycerides hydrate, (BFP65PLM) are to be blended into the shortening or vegetable oil for the best result.

Take 50% of the total weight of the A.P. shortening in your team's experimental assignment **and melt** the shortening down to where it reaches a liquid state (approximately 30- 45 seconds in the microwave). Do not heat excessively; this will change the properties of the fat. Blend in the α-monoglycerides hydrateinto the shortening until dissolved. Pour the blended shortening into the dry ingredients and mix as normal.

KSU BAKING SCIENCE FORMULA

PRODUCT: __ YELLOW HIGH RATIO LAYER CAKE_ FORMULA NO: **LAB 3**

BAKERS %	INGREDIENTS	WEIGHT/ GRAMS	INSTRUCTIONS
100	Cake flour, SRW chlorinated	550	Put all ingredients (except water) into mixing bowl and then: Mix 1st speed: 1 min Scrape down bowl and paddle Mix 1st speed: 4 min Scrape down bowl and paddle
115	Sugar	632	
10	Nonfat dry milk (NFDM)	55	
18.1	Dry whole eggs	100	
2.9	Salt	16	
5.5	Baking Powder (SALP, MCP)	30	
2	B.L.V.	11	
Page 9	Shortening Assignment	Page 9	
Page 9	Emulsifier Assignment	Page 9	
127	Water	700	Add 233 g water Mix 1st speed: 1 min Scrape down bowl and paddle Cont. mixing 2 min., speed 1 Add 233 g water Mix 1st speed : 30 sec Scrape down bowl and paddle Mix 2nd speed: 1.5 min. **Check S.G. Target: 0.87- 0.90** Add 234 g water Mix 1st speed: 15 sec Scrape down bowl and paddle Mix 2nd speed: 1 min Check S.G. & continue mixing on 2nd speed to reach desired S.G. in 30 second intervals.
	Total Weight	**2330 g**	

NOTES:

Dry blend with paddle to stimulate cake mix finisher.

Friction Factor: 5

Desired Final Batter Temperature (DFBT) = 72°F/22°C

Final Desired Specific Gravity (S.G.) = 0.88 – 0.92

Results and Discussion

Construct the following tables summarizing class data for the yellow cake fat and emulsifier choice experiments.

Dependent variable columns for each table:

- cake volume index
- symmetry index
- contour index.
- weighted subjective score sum

After each table, explain why the differences occur. Use outside sources such as Pyler to help explain the underlying mechanisms

1. **Table 1. Effect of Varying Shortening Level (no added emulsifiers)**
   Batters 1, 3, 6

2. **Table 2**. **Effect of Varying Emulsifier Level (no added shortening)**
   Batters 1, 2

3. **Table 3**. **Effect of Varying Emulsifier Type at 21% and 41% Shortening**
   Batters 3, 4, 5, 9 and 6, 7, 8, 9

4. **Table 4**. **Effect of Varying Emulsifier Type at 30% Vegetable Oil and 30% Fluid Cake Shortening**
   Batters 9, 10,11,12,13

   Compare the cakes in this series with the cakes containing shortening (batters 3-9). Explain the differences in volume and grain and why these differences may occur.

5. **If a bakery wishes to make cakes without the benefits of added emulsifiers, how should they change their mixing procedure to more effectively aerate their batters?**

6. **The same bakery typically encounters cake layers that have a rubbery layer toward the bottom of each layer. Explain to them what this layer is, and how it happens. Suggest changes that could be made to prevent this occurrence.**

KSU Bakery Science Lab Cake Scoring Sheet **Batter #**

Batter temp (°F) wt (1 cup batter) / wt (1 cup water) = S.G. S.G. = specific gravity pH of batter			
pH of final product			
Template Measures A			
B			
C			
D			
E			
Volume Index = B+C+D			
Symmetry Index = 2C – B - D			
Uniformity Index = | B- D |			
Subjective Scores:			
Crust color (descriptive) Cells & Grain (40 pts) Texture (40 pts) Crumb color (10 pts) Flavor & Aroma (10 pts)			

Total Subjective Score (100 pts. possible)

Lab #4 – Chiffon, Snack, and Genoise Cakes

In the past, layer and sponge cakes were considered separate product categories and the methods used to create them were very different. As discussed in labs 1-3, layer cakes were often produced using the creaming method, while sponge cakes contained no shortening or creaming but rather took their structure from the creation of an eggy foam. In recent years, the distinctions have become blurry. While layer cakes still typically contain more shortening or vegetable oil than sponge cakes, both systems depend on the incorporation and stabilization of air cells into the aqueous phase.

Foam Cakes

Foams consist of air cells surrounded by a continuous liquid film. Interactions between the two components may be unstable depending upon the materials used to form a foam. Liquids can only form foams if they are relatively viscous and have low air-liquid interfacial tension. For example, egg whites are viscous enough to slow gas cell migration and the beating process partially denatures proteins at the air-liquid interface, strengthening the air cell and reducing interfacial tension. Stabilizers and hydrocolloids help retain air and create “permanent” foams; some ingredients like eggs inherently contain proteins like albumin that perform this function, but other liquids may require the addition of extra stabilizers.

For use as leavening in foam cakes, egg whites and whole eggs are aerated. A viscous batter is created, and the aerated egg foam is incorporated carefully to maintain its structure. There are three commonly recognized categories of foam cakes: angel food, chiffon, and sponge.

Angel food cakes are composed of a simple formula of egg whites, sugar, salt, and flour. Cream of tartar is used to improve foam stability and crumb color (Oldham et al.) Formulas may also include fruit, nuts, spices, or cocoa for flavoring. Chiffon cakes are similar to angel food cakes in formulation, but also contain fats (usually oil) and egg yolk. These components are folded in gently near the end of mixing. Finally, sponge cakes may be produced using two methods. The traditional method, called *Genoise* in French bakeries, is leavened by whipping warmed whole eggs and egg yolks with sugar to create a foam. They contain no chemical leavener; the light texture and high volume is solely due to the egg foam. However, mass-produced sponge cakes use a single-stage mixing method and modern formulations that contain emulsifiers and chemical leavener.

Sponge Cakes in Detail

Sponge cake variations are used to produce commercially available snack cakes like Twinkies, Swiss rolls, jelly rolls, or strawberry “shortcake” layers (mary-anns). French patisseries make many items based on the traditional *Genoise* formula like Yule logs, petit fours, or lady fingers.

Classic sponge cake formulas only contain eggs, sugar, flower, and salt, and perhaps some added water. The eggs are warmed, softening the fats to allow a faster rate of air incorporation. They are then are whipped with the sugar until the desired specific gravity (0.46-0.48) is reached, and the rest of the ingredients folded in gently to minimize foam disruption (Pyler, *Volume II* 145). The final quality of the cake is dependent on the stability of the egg foam and the amount of air incorporated; if handled gently, sponge cakes produced using this formula can rise to great heights.

The use of both whites and yolks contributes to final sponge quality. Yolks contain lipids and a higher solids content, which limits their ability to create stiff foams like egg whites. However, the yolks are more extensible than the whites because of their phospholipid and lecithin content, which act as natural emulsifiers. More specifically, egg-based foams contain α-tending surface-active lipids which form a strong, plastic membrane at lipid-water interfaces and prevent fats and oils from inhibiting the foaming properties of the soluble proteins in the eggs. The presence of lipid contaminants will destabilize foams and cause poor whipping performance and a short, dense final product. If lipids are present on a poorly-washed bowl, they may still interrupt the foam's structure and ruin the product. However, the natural emulsifiers prevent this from occurring, as well as indirectly enhancing air incorporation and improving finished product volume and grain. Blending egg whites with egg yolks allows the formation of a highly aerated, stable foam.

In most modern commercial formulations, monoglycerides and polysorbate-60 blends are used in place of egg yolks to reduce production costs and enhance air incorporation and foam cell stability. Sponge cake batter may be thin and runny due to the lack of shortening, especially without the addition of egg yolks. Blended emulsifier systems used in sponge cake production need to include lipophilic and hydrophilic components that stabilize air-liquid interfaces and allow better bubble retention to increase viscosity. Single-stage or continuous mixing operations may also help aerate batters fully and create higher resistance to flow as well.

Unlike traditional sponge cake methods, chemical leavening is also commonly added in large-scale sponge cake production to help control pH and to provide continuous gas production and maintain system stability during baking.

Water Activity (A_w)

Water activity is a measure of the total amount of "free" water in a food system. It is crucial in terms of both spoilage and pathogenic microorganisms as well as in terms of shelf life and staling. A_w has a range from 0.00 to 1.00, where 0.00 means all water is bound and cannot be used by microorganisms and will not leave the product. 1.00 means that all water is completely free and available for moisture migration or microorganism growth.

Sugars and salts bind water and put increased osmotic pressure on cell walls. Usually, products with higher levels of sugar or salt will have lower water activity.

Additionally, moisture can and will move between parts of a multicomponent system (like cake and frosting) until all parts have equal A_w values.

Bibliography

Oldham, Anne M., et al. “Effect of Cream of Tartar Level and Egg White Temperature on Angel Food Cake Quality.” Family and Consumer Sciences Research Journal, Blackwell Publishing Ltd, 2 July 2009, onlinelibrary.wiley.com/doi/10.1177/1077727X00292003/abstract.

Pyler, E. J., and L. A. Gorton. “7.A.1.d.ii Specific Gravity.” Baking Science & Technology, vol. 2, Sosland Pub., 2008, p. 145.

CHIFFON AND SPONGE CAKE PROCEDURES:

Prepare Equipment

1. The production of this type of cake will require both the 12qt. and 20 qt. mixing bowls, along with the 12 qt. paddle and 20 qt. wire whip. Make sure that the 20 qt. bowl and wire whip, along with any utensils which come in contact with the 3rd stage ingredients are grease-free. (Wash with soap/salt water solution).

Scaling Ingredients

2. Scale the 1st stage ingredients and place into the **12 qt.** mixing bowl.

3. Using the 2 qt. measure, weight the 2nd stage ingredients (oil, yolks, water and vanilla) being careful not to over-scale. Use cold tap water.

4. Weigh the tempered egg whites (65˚F; 18˚C) using your clean 1 qt. measure. Pour the egg whites into the **20 qt.** mixing bowl with wire whip and allow to drain.

5. Scale the 3rd stage sugar and cream of tartar and set aside.

Mixing

6. Follow the mixing procedures on the formulation sheet. When the batter is mixed, set aside for use later.

7. Now start mixing the egg whites (3rd stage), following the mixing procedures on the formulation sheet. Take specific gravities as needed and observe the changes in peaks obtained as mixing progresses.

8. Blending the two batters is a critical stage. Excess mixing (or folding) will lead to a finished product with a low volume. Check specific gravity after blending to ensure that the batters were folded together correctly

Scaling of Batter

9. **Scale 725 g of chiffon cake batter each into 3 bakeable plastic pans and 1 steel tube pan.**

10. While first filling the cake pans, hold them on an angle and drop the batter at the high side allowing the batter to flow around the bottom of the pan. This helps eliminate air entrapment by the batter.

11. Place the scaled cakes on sheet pans for easier handling and place on the rack by the oven. All cakes will be loaded into the oven at one time with the help of the lab assistants.

12. Record SG of egg white foam and of final batter as well as the FBT. Desired SG:

KSU BAKERY SCIENCE FORMULA

PRODUCT: Chiffon Cakes FORMULA NO: 1-3

Ingredients	#1	#2	#3
1ST STAGE BATTER	ORANGE	LEMON	CHOCO.
Sugar	540	510	468
Chlor. Cake Flour	790	750	688*
Baking Powder	40	28	42*
Salt	18	18	18*
Ground Oranges 15%	130	--	--
Dutched Cocoa 25%	--	--	175*
Ground Lemons 15%	--	130	--
2ND STAGE BATTER			
Vegetable Oil	412	390	358
Egg Yolks	412	390	325
Water (58°F)	600	450	665
Vanilla	32	30	30
Yellow color – liquid	3 drops	4 drops	--
Fresh OJ	15	--	--
Fresh Lemon Juice	--	15	--
MERINGUE			
*Liquid Egg Whites	825	780	716
Cream of Tartar	4	8	4
Sugar	495	467	429
Total Weight	**4248**	**4027**	**4020**

INSTRUCTIONS

1. Use a 12-qt. bowl and paddle for the 1st stage.
2. BEFORE DOING anything else, sift cocoa, baking powder and salt together then dry blend with sugar.
3. Place the 1st stage ingredients into the mixing bowl and dry blend for 20 sec. on 1st speed.

3. Add ½ of the 2nd stage liquids and mix on 1st for 1 min.

4. Add ¼ of the total liquids and mix 1 min. on 1st. Scrape bowl and paddle and continue mixing until smooth.

5. Add the last of the liquids and mix until smooth on 1st, (2-3 min.) scraping the bowl and paddle as needed. **Set the mixture aside.**

6. Check S.G.

MERINGUE

7. Use the 20-qt. bowl and wire whip. Start mixing the egg whites on 3rd for 30 sec. Reduce to 1st, and while mixing, add the sugar and cream of tartar (2-3 min.). Continue mixing on 3rd until stiff peak is reached (approx. 3 min).

Desired S.G. 0.175-0.25

Actual S.G. __________

8. When the egg whites are properly mixed, first combine two handfuls of the meringue with the batter. Next pour about 1/3 of the batter into the meringue and blend by folding the two until they are combined evenly, no streaks.

FOLD IN!   DO NOT STIR!

NOTES: *Egg whites should be warmed to 65°F before whipping if they don’t contain a whipping aid.

KSU BAKERY SCIENCE FORMULA

PRODUCT: **Cold Process Yellow Sponge Cake** FORMULA NO: 4

DATE OF ISSUE:____

BAKER'S%	INGREDIENTS	WEIGHT /GRAMS	INSTRUCTIONS
35	Cold water (tap)	385	1. Use 20 QT bowl with wire whip. **2. Place all the liquids in the bowl first.**
120	Whole Fresh Eggs	1320	
2	Liquid Vanilla	22	
-	Yellow Color	5 drops	
100	Chlor. Cake Flour	1100	3. Put all remaining dry ingredients ON TOP of liquids 4. Mix 30 sec. on 1st speed. 5. Scrape sides and bottom very well. Continue mixing on Speed 3 until the batter thickens. **It should hold a crease**. 6. Mix another 2 min on Speed 2
120	Sugar	1320	
1.5	Salt	16	
4	Surfax (an emulsifier)	44	
10	NDFM	110	
2	Baking Powder (MCP and SAPP)	22	
			Target S.G.: 0.50
Total Weight		4340	Actual S.G.:_______
			D.F.B.T.: 72 F
			Actual F.B.T.: _______

NOTES:

Scaling weight: Scale (3) **1,000 g** samples onto a greased and lined sheet pan. The remaining batter should be scaled into 8-inch lined cake pans at **300 g** each. Bake at 385° F until lightly golden, approx. 12-14 minutes.

KSU BAKERY SCIENCE FORMULA

PRODUCT:**Cold Process Sponge Cake for Snack Cakes** FORMULA NO: 5

BAKER'S%	INGREDIENTS	WEIGHT /GRAMS
100	Cake Flour	1200
	Dextrose	88
6	**WHOLE** dry eggs	72
6	Dry Egg **YOLK**	72
4	NFDM	48
0.2	CMC Gum	2.5
1	Baking Powder (MCP +SAPP)	12
117	Sugar	1404
2	Salt	24
4	Vanlite (Emulsifier)	48
2	BLV	24
120	Water (55 F)	1440
	Total Weight	4435

INSTRUCTIONS

1. Using a 20 QT bowl and wire whisk, add sugar to above and blend on speed 1 for 1 minute.

2. Add these three ingredients to above and blend on speed 1 for 1 minute.

3. Gradually stream in water on speed 1.

4. Once fully hydrated, **scrape bowl and paddle very well.**

5.Mix on speed 2 for 4-8 minutes or until batter holds a crease and SG= 0.60

NOTES: Deposit batter into well greased twinkie and snack cake pans. **Do not fill pans more than 40% full**.

Bake at 385 F/ 200 C for 10-12 minutes or until light color appears. Be careful to not over bake.

Final B.T: _______

Final S.G:_______

Procedure for "Rolling up" Jelly Rolls

ROLL-UP: The three, 1100-gram layers, jelly roll style layers, using the following procedure.

1. Dump the sheets for jellyrolls approx. 5 minutes after removing from the oven**, onto sugar dusted,** kraft paper to prevent sticking.
2. Now slowly pull off the baking liner which was baked under the cake.
3. Spread a thin layer of jelly/filling over the surface with a bowl knife.
4. With both hands, grip the paper liner and start to roll the longest edge of the cake towards yourself, keeping the rolling action even and using downward pressure.
5. Place rolled up jelly roll, seam down on a separate pan to cool.

Results and Discussion

1. **How do sponge cakes differ from angel food cakes and high-ratio yellow cakes?**

2. **Define a chiffon cake. Why would this type of cake be chosen over a sponge cake or snack cake?**

3. **You have just been handed a new challenge from the product development team of your company. They are trying to duplicate a current snack cake out on the market but are having technical problems with their formulation. The snack cake is very dry and crumbly. It comes out of the pans, but has poor structure. When the crème filling is added, the cake breaks apart. What changes need to be made to solve this problem and why?**

4. **Why is the water activity in the crème filling crucial for shelf-life and product quality?**

KSU Bakery Science Lab Cake Scoring Sheet **Batter #**

Batter temp (°F) $\frac{\text{wt (1 cup batter)}}{\text{wt (1 cup water)}}$ = S.G. S.G. = specific gravity pH of batter			
pH of final product			
Template Measures A			
B			
C			
D			
E			
Volume Index = B+C+D			
Symmetry Index = 2C – B - D			
Uniformity Index = | B- D |			
Subjective Scores:			
Crust color (descriptive) Cells & Grain (40 pts) Texture (40 pts) Crumb color (10 pts) Flavor & Aroma (10 pts)			

Total Subjective Score (100 pts. possible)

Lab #5 – Angel Food Cakes

Background

Classic angel food cakes contain no lipids, emulsifiers, or leavening acids, similar to classic sponge cakes. However, the foam component in angel food cakes is composed of egg whites alone, instead of a combination of yolks and whole eggs.

Traditional simple angel food cakes included only egg whites, sugar, and flour. Later, it was discovered that the addition of 1-2% potassium acid tartarate (cream of tartar) neutralized the alkalinity of egg whites, adjusting the pH and stabilizing the foam.

Remember that starches begin to gelatinize during baking at 104° F (Pyler, *Volume II* 98). As the starches gelatinize, they absorb water from the system; in the case of angel food cakes the water is largely contained in the protein foam. As the hydration level drops and temperatures continue to increase, the proteins undergo transition, causing them to become brittle and glassy. Further heating causes the proteins to denature, making the transition irreversible. The cake is no longer able to expand and "sets". The gelatinized starches provide filler to support the 3D protein structure. If insufficient starches are present at the end of baking, the cake collapses as lowering temperatures reduce internal gas pressure.

Factors Affecting Egg White Foam Performance

Fresh liquid egg whites have an alkaline pH of 9.0-9.2 However, over time they may become more acidic and reach a pH as low as 5.5-5.8. Potassium acid tartarate, otherwise referred to as cream of tartar, allows pH to move down the scale, closer to the isoelectric point of the albumin proteins. These optimized proteins allow for faster, more even air incorporation and the creation of a stable foam. The amount of cream of tartar required varies and depends upon the pH of the whites at the time of mixing.

Egg whites are composed of varying proteins; mainly globulin, ovamucin, ovamucoid, ovalbumin, conalbumin, and lysozyme proteins. Globulins are the main protein involved in the foaming of the whites during whipping. Foaming agents, like sodium lauryl sulfate, tryethyl citrate, or guar gum, may be used to increase foam formation. Care must be taken to avoid the presence of fats during whipping as lipid will completely destabilize the developing foam. Never include yolks and ensure the bowl and whisk are both thoroughly cleaned before mixing. Plastics are impossible to fully de-grease, so they shouldn't be used when making egg white foams.

Fresh, frozen, or powdered egg whites can all be used when making angel food cakes. If using frozen whites, they should be defrosted and then mixed thoroughly. Otherwise, the total solids will be unevenly distributed and the foam won't form properly. It's best to test a small amount of the egg (in whatever form) to determine its mixing capabilities and pH, and then adjust the formula and whipping time as needed. If using dried egg whites, Robertson and Haney recommend premixing them with salt, cream of tartar, and some sugar, and then adding water in stages (qtd. in Pyler 286). A modification of this technique will be used in lab.

Aeration and Mixing

After initial foam formation, the rest of the formula ingredients need to be incorporated carefully so as not to negatively impact the stability of the cake during baking and cooling. Air must be distributed uniformly to produce a cake with stable structure and ideal volume. If extra air is incorporated, the batter reaches a larger volume, but the air cells will more easily coalesce and may cause the cake to collapse. The recommended specific volume for egg white foams is 0.15-0.17.

Commercial mixing procedures whip egg whites (ideally held at 65-72° F) with salt and cream of tartar until foaming begins. . As discussed in Pyler, Barmore states that the addition of cream of tartar stabilizes the foam and prevents shrinkage during cooling (qtd. in Pyler, *Volume II* 285). Then, 50-60% of the formula sugar is slowly added and whipping continues until a soft, shiny peak is formed. If the whites are whipped beyond this point to a dry peak, the final flour and sugar would not be able to be folded in easily. Excessive mixing would damage the foam's structure and cause a final product with low volume and dense, rubbery texture. After soft peaks are formed, the remaining sugar and all of the flower is folded in to create a batter with a specific gravity of 0.35-0.42 and a final temperature of 70-75° F.

General Angel Food Cake Formula

1. Weight of liquid egg whites = weight of sugar (roughly)
2. Weight of flour and all starchy ingredients (e.g. cocoa) ≥ 1/3 weight sugar
3. Calculated amount of cream of tartar to reach isoelectric point

Sugar, either finely granulated or powdered, should be added in stages. If it is all incorporated in the initial foam, a heavy syrup will be created and the foam won't be able to aerate it thoroughly. Fine sugars incorporate more easily and aid in air incorporation.

Flour used in angel food cakes is usually chlorinated to a pH of 4.8 and has lower protein content, probably around 7-8%. Wheat starch (up to 30% of flour weight) may be used to reduce protein content to 6-7% and improve grain, moisture retention, and shelf life.

Smaller cakes (280-400g) should baked at 375-400°F. Cakes weighing more than 400g should be baked at temperatures of 350-360°F. Higher temperatures cause more internal pressure, creating better volume, tenderness, and moisture retention, but may cause the crust to set too quickly and crack.

Bibliography

Pyler, E. J., and L. A. Gorton. "6.G.3.a. Starch Gelatinization" Baking Science & Technology, vol. 2, Sosland Pub., 2008, pp. 98-99.

Pyler, E. J., and L. A. Gorton. "8.J.3.c. Angel Food." Baking Science & Technology, vol. 2, Sosland Pub., 2008, pp. 284-285.

EXPERIMENTAL TRIALS

Procedure for deciding on mix times to hit target specific gravities on your particular mixer.

- While making the control, note the time it takes to reach a specific gravity of 0.15 - 0.17 on your mixer. Use this time as the mixing time for all subsequent varieties produced.

Variables

1. Control formula – total sugar 300% (page 6)

Effect of Variation in total sugar level (2, and 3)

2. 200% total sugar: 220 g in stage 2 & 220 g in stage 3 (page 7)

3. 400% total sugar: 440 g in stage 2 & 440 g in stage 3 (page 10)

Effect of variation in egg whites (4, 5, and 6)

4. 150 % Dried egg whites: 66 grams of dried egg whites and 396 grams of water (page 8)

5. 220 % Dried egg whites: 123 grams of dried egg whites & 738 grams of water (page 10)

Effect of type of egg whites (No water added)

6. 300% **LIQUID** Egg whites (**Follow the formula on page 11**)

Effect of flour choice (7, 8, and 9)

7. Unchlorinated soft wheat flour: 220 grams (page 10)

8. Chlorinated cake flour 90%: 200 grams (page 10)
   Wheat starch 10%: 20 grams

9. Whole wheat pastry flour 40%: 100 grams (page 10)
   Chlorinated cake flour 50%: 100 grams
   Wheat starch 10%: 20 grams

Procedure:

Measure: Final Batter pH
Final Batter Temperature (F.B.T.)
Batter specific gravity = $\frac{\text{Net wt (1 cup batter)}}{\text{Net wt (1 cup water)}}$

Record: Final batter specific gravity and batter temperature on score sheet.

Scale: Lightly moisten interior of tube pan with water from spray bottle. Scale 725 grams of batter into each pan.

Bake: 380°F for 38-40 minutes, Bake to firmness.

Cool: Invert pans to cool for 30 min. before de-panning. Keep label with proper product.

PRODUCT: **Angel Food Cake** FORMULA NO: Control

DATE OF ISSUE: 2/17/16

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS	INSTRUCTIONS
	STAGE 1		
42.9	Dry Egg Whites	95	**55. Put water in bowl first!** 56. Add remaining Stage 1 ingredients in grease free bowl 57. Mix 2nd speed: 30 second **58. Scrape** 59. Mix 3rd speed: 2 minutes to dry peak 60. Stream Stage 2 sugar in slowly while mixing 2nd speed: 30 sec. **61. Scrape** 62. Mix 3rd speed: 30 seconds 63. Check SG between .15-.17 64. Continue mixing until SG is reached 65. Add sifted flour/powder sugar (Stage 3) in slow stream while mixing 1st speed: 1 minute. **SCRAPE.** 66. Mix 2nd: 30 sec. 67. Check SG between .35-.42 and record.
257.1	Water	566	
2.0	Salt	4.4	
2.5	Cream of Tartar	5.5	
3.0	Vanilla, liquid	6.6	
	STAGE 2		
150	Sugar	330	
	STAGE 3		
	Sift together 2x:		
100	Cake flour	220	
150	Powdered Sugar	330	
	Total weight	1,557 g	

NOTES:
***See experimental assignment page** ____________
Use water temperature: as determined in test bakes
Use grease free 12 quart bowl and whip
Don't over mix! Foam will collapse.
Desired Final Batter Temperature (DFBT) = 72°F/22°C

F.B.T. ____________

Final S.G ______________

PRODUCT: **<u>Angel Food Cake</u>** FORMULA NO: **Trial 2**

DATE OF ISSUE: 2/18/2016

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS
	STAGE 1	
42.9	Dry Egg Whites	114
257.1	Water	680
2.0	Salt	5.3
2.5	Cream of Tartar	6.6
3.0	Vanilla, liquid	7.9
150	Sugar	240
	Sift together 2x:	
100	Cake flour	264
150	Powdered Sugar	240
	Total weight	1,557g

NOTES:
***See experimental assignment page** ____________
Use water temperature: as determined in test bakes
Use grease free 12 quart bowl and whip ______
Don't over mix! Foam will collapse. ____________
Desired Final Batter Temperature (DFBT) = 72°F/22°C
F.B.T. ____________

Final S.G ______________

INSTRUCTIONS

1. **Put water in bowl first!**
2. Add remaining Stage 1 ingredients in grease free bowl
3. Mix 2nd speed: 30 second
4. **Scrape**
5. Mix 3rd speed: 2 minutes to dry peak
6. Stream Stage 2 sugar in slowly while mixing 2nd speed: 1 minute
7. **Scrape**
8. Mix 3rd speed: 30 sec.
9. Check SG between .15-.17
10. Continue mixing until SG is reached
11. Add sifted flour/powder sugar in slow stream while mixing 1st speed,: 1 minute. **SCRAPE.**
12. Mix 2nd: 30 sec.
13. Check SG between .35-.42 and record.

PRODUCT: **<u>Angel Food Cake</u>** FORMULA NO: **<u>TRIAL 4</u>**

DATE OF ISSUE: <u>2/18/16</u>

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS
	STAGE 1	
42.9	Dry Egg Whites	80
257.1	Water	475
2.0	Salt	5.3
2.5	Cream of Tartar	6.6
3.0	Vanilla, liquid	7.9
	STAGE 2	
150	Sugar	396
	STAGE 3	
	Sift together 2x:	
100	Cake flour	264
150	Powdered Sugar	396
	Total weight	1631g

INSTRUCTIONS

1. **Put Liq. Eggs in bowl first!**
2. Add remaining Stage 1 ingredients in grease free bowl
3. Mix 2^{nd} speed: 30 second
4. **Scrape**
5. Mix 3^{rd} speed: 2 minutes to dry peak
6. Stream sugar (Stage 2) in slowly while mixing 2^{nd} speed: 30 sec.
7. **Scrape**
8. Mix 3^{rd} speed: 1 minute
9. Check SG between .15-.17
10. Continue mixing until SG is reached
11. Add sifted flour/powder sugar (Stage 3) in slow stream while mixing 1^{st} speed: 1 minute. **SCRAPE.**
12. Mix 2^{nd}: 30 sec.
13. Check SG between .35-.42 and record.

NOTES:

*****<u>See experimental assignment page</u>

<u>Use water temperature: as determined in test bakes</u>

<u>Use grease free 12 quart bowl and whip</u>

<u>Don't over mix! Foam will collapse.</u>

<u>Desired Final Batter Temperature (DFBT) = 72°F/22°C</u>

F.B.T. ____________

Final S.G ______________

PRODUCT: **Angel Food Cake**

FORMULA NO:
(Trials 3, 5, 7, 8, 9)

DATE OF ISSUE: 2/24/10

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS
	STAGE 1	
TBD	Dried Egg Whites	Page 5
TBD	Water	Page 5
2.0	Salt	5.2
TBD	Cream of Tartar	6.5
3.0	Vanilla, liquid	7.8
	STAGE 2	
150	Sugar Variation	Page 5
	STAGE 3	
	Sift together 2x:	
TBD	Flour variation	Page 5
TBD	Powdered Sugar variation	Page 5
	Total weight	1,839.5g

NOTES:
*See experimental assignment page
Use water temperature: as determined in test bakes
Use grease free 12 quart bowl and whip
Don't over mix! Foam will collapse.
Desired Final Batter Temperature (DFBT) = 72°F/22°C
F.B.T. ____________

Final S.G ______________

INSTRUCTIONS

1. **Put water in bowl first!**
2. Add remaining Stage 1 ingredients in grease free bowl
3. Mix 2nd speed: 30 second
4. **Scrape**
5. Mix 3rd speed: 2 minutes to dry peak
6. Stream Stage 2 in slowly while mixing 2nd speed: 30 sec.
7. **Scrape**
8. Mix 3rd speed: 1 minute
9. Check SG between .15-.17
10. Continue mixing until SG is reached
11. Add sifted flour/powder sugar (Stage 3) in slow stream while mixing 1st speed: 1 minute. **SCRAPE.**
12. Mix 2nd: 30 sec.
13. Check SG between .35-.42 and record.

PRODUCT: **Angel Food Cakes** FORMULA NO: **(TRIAL #6)**

DATE OF ISSUE: 2/24/10

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS	INSTRUCTIONS
	STAGE 1		
300	LIQUID Egg Whites	725	**1. Put Liq. Eggs in bowl first!** 2. Add remaining Stage 1 ingredients in grease free bowl 3. Mix 2nd speed: 30 second **4. Scrape** 5. Mix 3rd speed: **1.5 minutes** to dry peak 6. Stream Stage 2 sugar in slowly while mixing 2nd speed: 30 sec. **7. Scrape** 8. Mix 3rd speed: 1 minute 9. Check SG between .15-.17 10. Continue mixing until SG is reached 11. Add sifted flour/powder sugar (Stage 3) in slow stream while mixing 1st speed: 1 minute. **SCRAPE.** 12. Mix 2nd: 30 sec. 13. Check SG between .35-.42 and record.
0.0	Water	**ZERO**	
2.0	Salt	4.8	
4.0	Cream of Tartar	10	
3.0	Vanilla, liquid	7.7	
	STAGE 2		
150	Sugar	363	
	STAGE 3		
	Sift together 2x:		
100	Cake flour	242 *	
150	Powdered Sugar	363*	
	Total weight	1,717g	

NOTES:
***See experimental assignment page**
Temp. of liquid egg whites should be 68-72° F
Use grease free 12 quart bowl and whip
Don't over mix! Foam will collapse.
Desired Final Batter Temperature (DFBT) = 72°F/22°C

F.B.T. ____________

Final S.G ______________

Measure: Final Batter pH without diluting
Final Batter Temperature (F.B.T.)
Batter specific gravity = Net wt (1 cup batter) / Net wt (1 cup water)

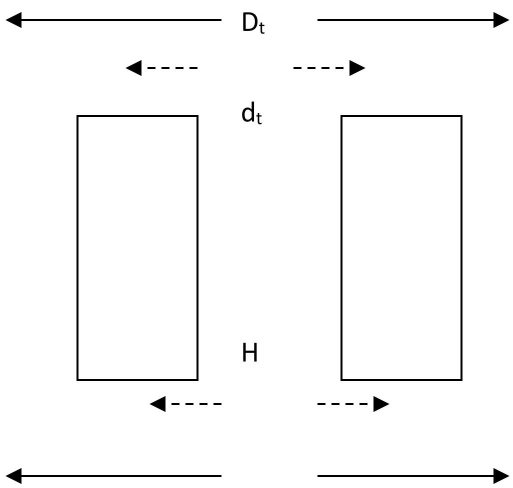
Record: Final batter specific gravity and batter temperature on score sheet.

Scale: Lightly moisten interior of tube pan with water from spray bottle
725 grams of batter into a bake able angle food pan

Bake: 380°F for 38-40 minutes, Bake to firmness

Cool: Cool for 30 min. before de-panning. Keep label with proper product.
Calculate cake volumes according to the procedure on the following page.

Angel Food Cake Volume Calculations:



Example:

D_t = 21.0 cm
d_t = 5.0 cm

H = 8.0 cm

d_b = 5.5 cm
D_b = 23.0 cm

$d = 1/2\ (d_b + d_t)$

d = 1/2 (5.5+5.0) = 5.25 cm

$D = 1/2\ (D_b + D_t)$

D = 1/2 (23.0+21.0) = 22.0 cm

Volume = $1/4\ (D^2 – d^2)\ \pi\ H$

Volume = $1/4\ (22.0^2 - 5.25^2)\ (3.14)\ (8.0)$

Answer: 2,866.44 cubic centimeters

RESULTS and DISCUSSION

Construct the following tables summarizing class data for the angel food cake experiments. Dependent variable columns for each table: **(That means the individual batter numbers should be on the y axis and the characteristics below shown on the x axis)**

- ID of each variable
- Final batter specific gravity
- Final batter temperature
- Final batter pH
- Prebake weight
- Post bake weight
- Cake's subjective score
- Cake's specific volume

Graph cake specific volume vs. each independent variable listed below, where appropriate, to pictorially represent the nature of the continuous relationships.

After each table and graph, refer to underlying mechanisms to briefly explain WHY you see the observed differences. Interpret the data…what do the results show?

1. **Effect of variation in total sugar level** [Batters 1, 2, 3]

   Explain how very high, and very low, sugar levels would be expected to affect angel food cake set-point and volume.

   (Recall from yellow layer cake experiments how sugar level affects the onset temperature of starch gelatinization. Use this plus the mechanisms involved in angel food cake structures.)

2. **Effect of variation in egg white solids** [Batters 1, 5, 6]

   Explain how varying egg white solids levels should affect angel food aeration, air cell and foam stability, cake fragility, and volume.

3. **Effect of flour choice** [Batters 1, 7, 8, 9]

   Summarize the function of flour in angel food cakes.
   Why do we choose chlorinated cake flours?
   How does the WW flour/starch mixture, batter 10, compare to the control

4. **Effect of Liquid Egg Whites** [Batters 1, 6]

   Explain the differences that observed when using liquid egg whites vs. reconstituted dry egg whites.

5. **Effect of Batter Final Specific Gravity vs Specific Volume** (All batters)

   How did the aeration of the individual batter foams impact the cakes' final volume? Explain why and how.

Additional Questions

6. Why are tube pans the most commonly used pans for angel food cake production?

7. Furthermore, why are tube pans sprayed with water and not greased with pan spray or shortening?

8. If fresh or liquid egg whites are used, formula adjustments must be made to compensate for variations in pH. Why? Would similar adjustments need to be made if powdered egg whites were used?

KSU Bakery Science Lab Cake Scoring Sheet **Batter #**

Batter temp (°F) wt (1 cup batter) / wt (1 cup water) = S.G. S.G. = specific gravity pH of batter			
pH of final product			
Template Measures A			
B			
C			
D			
E			
Volume Index = B+C+D			
Symmetry Index = 2C – B - D			
Uniformity Index = | B- D |			
Subjective Scores:			
Crust color (descriptive) Cells & Grain (40 pts) Texture (40 pts) Crumb color (10 pts) Flavor & Aroma (10 pts)			

Total Subjective Score (100 pts. possible)

Lab #6 – Pound Cakes, Quick Breads, Devil's Food Cake, Brownies, Whoopie Pies, and Irish Soda Bread

Pound Cakes

Pound cakes characteristically have a fine, dense grain and smooth texture. The traditional formula for pound cake contained a pound each of sugar, butter, eggs, and flour. Modern commercial formulations include more ingredients to increase shelf life and facilitate processing. The use of chlorinated cake flour allows for the production of high-ratio pound cakes, increasing shelf life and providing a finer texture and moister cake. The inclusion of low amounts of chemical leavening and the use of emulsified shortening allow for a reduction of the amount of eggs and butter, reducing production costs.

Quick Breads

Quick breads are similar to cakes in formulation, but contain less sugar, fat, eggs, and milk. They often have inclusions like chocolate chips, blueberries, zucchini, or other fruits, vegetables, or nuts. As quoted in Pyler, Willyard states that muffin (and other quick bread) formulas use blends of hard wheat flour with cake or pastry flour for both resilience and tenderness (Pyler, *Volume II 293)*. Baking powder is the most common leavening agent, but baking soda may be used as well.

The Society of the Preservation of Irish Soda Bread states that soda bread dates from the late 1830s. Historically, it only contained only flour, salt, baking soda, and buttermilk and was eaten in Ireland as an everyday table loaf (O'Dwyer). The cross on top is said to ward off the devil and to divide the loaf into four segments, like the four kingdoms of Ireland. Soda bread today may contain many other ingredients like honey, raisins, eggs, chocolate, or even whiskey.

Chocolate and Devil's Food Cake

Chocolate cakes are essentially high ratio yellow cakes with added cocoa or chocolate. Formula modifications modifications must be made to account for cocoa's starch content. To convert a yellow cake formula to chocolate, the amount of flour in the formula must be reduced by 37% of the cocoa added. So, if a baker decided to add 100 grams of cocoa, he would need to reduce the flour by 37 grams. The various types of cocoa available must also be considered. Natural (untreated) cocoa has a pH range of 5.2-5.8, while dutched cocoa is natural cocoa that has been treated with alkali (Pyler, *Volume I* 2008). It is darker in color than natural color and has a more intense flavor. The amount of leavening acid used must be adjusted depending upon the type of cocoa used to reach the desired batter pH.

Devil's food cakes are similar to chocolate cakes, but contain more baking soda than baking powder. This creates a more alkaline batter pH that results in a reddish crumb and open grain. In older formulas, baking soda was the only chemical leavening added; these cakes were sometimes called “red devil’s food”.

Generally speaking, if a cake is reddish-brown internally, the system has a higher final pH. If it’s too high, the cake may taste soapy or metallic and have a very coarse, open grain. If a cake is lighter, the final pH is too low.

Brownies

Brownies are actually considered a category of chocolate cake and fall along two distinct lines: cake brownies and fudge brownies. In general, brownie formulas contain higher sugar levels than chocolate cake batters; fudge more so than cake brownies. These extreme high-ratio formulas delay gelatinization so far in to the baking process that very little starch is gelatinized, particularly in fudgy brownies. This lack of gelatinized starch leads to system collapse during cooling, causing a tight, dense grain.

As brownies cool, the sugars may re-crystallize. As internal temperatures drop, the amount of sucrose the cooler water is able to hold decreases. The excess, undissolved sucrose re-crystalizes and stiffens the brownie. This mechanism is also how cookies become crisp. However, brownies should be soft and moist. To prevent sugar crystallization, corn syrup, glucose, or fructose can be included. These monosaccharides interfere with sucrose’s crystallization pattern and help retain sucrose-water syrup to keep the brownie flexible and moist.

Whoopie Pies

Whoopie pies (also called gobs in Pennsylvania) are New England’s most famous treat. Consisting of two chocolate cake layers with marshmallow filling sandwiched in between, they are like a cross between an Oreo and a cupcake. The top and bottom layers are soft, rounded, and have a slight crown. The New England Historical Society suggests that this dessert was created in the 1920s, but its exact origins are unknown. Some claim the Amish first baked the whoopie pie, while others contest that farm wives made the cakes to use up leftover cake batter.

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KSU BAKING SCIENCE FORMULA

PRODUCT: Modern Pound Cake (High Ratio) FORMULA UPDATE: 03/15/17

BAKERS %	INGREDIENTS	WEIGHT /GRAMS
STAGE 1		
100	Cake flour, SRW Chlorinated	1565
110	Granulated Sugar	1636
8	NFDM	124
17	Whole Dry Eggs	264
2	Salt	30
10	42 DE Corn Syrup	155
0.25	Baking Powder (MCP & SAS)	36
47	Emulsified Shortening (w/ PGMEs)	748
22	Butter	342
1	Vanlite	15
1.5	BLV Flavor	22
0.5	Liquid Almond Flavor	8
--	Yellow	Few drops
STAGE 2		
120	Water (72°F)	1820
	Total Weight	6750

NOTES: Use a 20 qt. bowl with paddle (first stage) and wire whip (second stage).

Desired Final Batter Temperature (DFBT) = 72°F/22°C

Final Desired Specific Gravity (S.G.) = 0.80-0.85

INSTRUCTIONS

1. Sift NFDM and Whole dry eggs together.
2. Place all stage 1 ingredients in bowl. Mix for 1 minute on 1st. Scrape bowl and paddle.
3. Mix for 4 minutes on 1st. Scrape bowl and paddle.
4. **SWITCH PADDLE TO WIRE WHIP.**
5. Add about half the water. Mix for 30 seconds on 1st. Scrape bowl and whip.
6. Mix for 1 minute on 2nd. Check S.G. Mix 1 minute more on 2nd.
7. Add remaining water. Mix for 30 seconds on 1st. Scrape bowl and whip.
8. Mix for 1 minute on 2nd. Check S.G. Continue mixing until S.G. is reached.

FBT: ______________

Final S.G.: ____________

Measure: Final Batter Temperature (F.B.T.)
Batter specific gravity = Net wt (1 cup batter) / Net wt (1 cup water)

Record: Final batter specific gravity and batter temperature.

Scale: Spray pan lightly with pan release and place paper liner on bottom.
525 grams per 8 in x 4 in pan or 260 grams per 3.5 in x 6 in pan. Score cake with oiled bowl scraper.
Make sure to label each cake.

Bake: 350°F/179°C for approximately 35-40 min. for small pans or 50-55 minutes for large pans
Bake to touch or when inserted skewer comes out clean.

Cool: After cooling for 10 minutes invert cake onto hand, then re-invert.
Keep label with proper product.

KSU BAKING SCIENCE FORMULA

PRODUCT: Conventional Old-Fashioned Pound Cake FORMULA UPDATE: 03/15/17

BAKERS %	INGREDIENTS	WEIGHT/ GRAMS
113.75	Unsalted Butter, softened	908
127.5	Granulated Sugar	1020
75	Whole liquid eggs, room temp.	600
31.75	Liquid egg yolks, room temp.	250
3.75	Water	30
3.75	Liquid Vanilla	30
1.25	Salt	10
100	Chlorinated Cake Flour, sifted	800
	Total Weight	3650 g

NOTES: Use 12 qt bowl with paddle attachment.

Desired Final Batter Temperature (DFBT) = 72°F/22°C

Final Desired Specific Gravity (S.G.) = 0.85-0.90

INSTRUCTIONS

1. Sift flour. Set aside.
2. Gently mix eggs, egg yolks, water, and vanilla. In a steel bowl. Set aside.
3. Beat butter and sugar in 12 QT bowl with paddle for 3 minutes on speed 2. Scrape bowl and paddle.
4. Add salt, mix another 1-2 minutes on speed 2.
5. Add 1/3 of the flour and mix until just incorporated.
6. Add 1/3 of egg mixture and blend thoroughly.
7. Continue with second 1/3 of flour then second 1/3 of egg mixture.
8. Now, put in last 1/3 of egg mixture, blend thoroughly.
9. Add last 1/3 of flour mixture. Don't over mix.

FBT: _______________
Final S.G.: __________
Final pH: ___________

Measure: Final Batter Temperature (F.B.T.)

Batter specific gravity = Net wt (1 cup batter) / Net wt (1 cup water)

Record: Final batter specific gravity and batter temperature.

Scale: Spray pan lightly with pan release. Scale 250 grams per 3.5 in x 6 in pan. Yield 13-14 cakes. Score cake with oiled bowl scraper.
Make sure to label each cake.

Bake: 350°F/179°C for approximately 35-40 min. for small pans
Bake to touch or when inserted skewer comes out clean.

Cool: After cooling for 10 minutes invert cake onto hand, then re-invert.
Keep label with proper product.

PRODUCT:

King Arthur Flour Brownies (Box mix type Brownie)

LAB FORMULA DATE OF ISSUE:___4/2008__

INGREDIENTS	**BAKER'S %**	**WEIGHT /GRAMS**	**INSTRUCTIONS**
Granulated sugar	232	5840	
Butter	108	2724	***Scale all ingreds before beginning to melt butter***
			Melt butter, then add sugar and stir to combine. Return briefly to heat until hot, but not bubbling.
Dutched cocoa	47.8	1200	
Salt	2.8	70	Sift cocoa and baking powder
Baking powder	2.1	52	
Vanilla (liquid)	7.1	180	Pour sugar and butter mixture into 30-qt. bowl, then go to mixer and use paddle.
Liquid Eggs (room temp)		2400	
			Stir in cocoa, baking powder, salt and vanilla
King Arthur Galahad flour	100	2510	Add eggs gradually, stir until smooth
Chocolate chips	61.7	1550	SCRAPE all the way to the bottom!
Total Weight		16.5 kg	
			Add flour & chips and stir until combined and smooth

Scale into 650g each in 8″ square alum. pans
Bake at 350°F for 25-30 min, on sheet pans

Yield: (24) 8 × 8″ pans

Final Batter Temp ______

Final S.G. ___________

Batter pH _________

FUDGEY BROWNIES
In a 12 qt bowl with paddle

Ingredients	Bakers %	Weight (Grams)
Gran Sugar	166	2270
Salt	4.1	57
Butter (room temperature)	16.5	225
A.P. Shortening	66.6	908
Honey	25	340

Mix on 1st; cream 4 min. on 2nd; scrape

Dutched cocoa	36.7	500
Pastry flour	100	1362
42 DE Corn Syrup	25	340

Add to above. Mix 1 min on 1st; scrape
1 min on 2nd

Whole Fresh Eggs	51.4	700
Vanilla	2.1	28
Water	25	340

Add to above
Mix 1 Min. on 1st speed; scrape
Mix 1 min on 2nd speed

Total Weight 7,070

Final Batter Temp ______

Final S.G. ___________

Batter pH _________

Scaling Procedure:

Scale 3550 g onto an oiled and paper lined sheet pan.
The remaining batter should be deposited onto diff. sized aluminum baking foils.

8”x8” Foil - 500 g

Bake at 380° for approximately 26-28 minutes

CHOCOLATE / DEVIL'S FOOD CAKE FORMULAS (LAB FORMULA)

	Bakers %	Chocolate (g)	Devil's Food (g)
Cake flour	100	500	
Cocoa-alkalized	20	100	
Sugar	135	675	
42 DE corn syrup	5	25	
NFDM	12	60	
Dry eggs	16	80	
Salt	2	10	Same as chocolate cake except for
Baking Soda	3	15	
SALP (NV = 100)	2	10	1.0 % 5 g.
Vanlite	4	20	
Shortening (emul)	35	175	
		1st: 1 min, scrape down 1st: 4 min, Scrape paddle	
B.L.V.	1	5	
Water	170	850	
	Add 283 g water,	2nd: 30 sec	
	Add 283 g water,	1st: 30 sec, scrape 2nd: 5 min	
	Add 283 g water,	1st: 30 sec, scrape 2nd: 1 min; check S.G. Cont. mixing if necessary	

Desired Specific Gravity: 0.88-.92

SCALE: 380g per 8" pan, yields 6 layers

BAKE: 350°F 30 min

Cool 7 min, invert out of pans

KSU BAKERY SCIENCE FORMULA

PRODUCT: Classic Chocolate Whoopie Pie FORMULA NO:__________

DATE OF ISSUE: 3/11/11

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS
	Sir Galahad Flour	1500
	Pastry Flour	400
33.6	Dutched Cocoa	650
3.2	Baking Soda	60
1.0	Salt	20
23.9	Butter (room temp)	454
18.4	AP Shortening	350
82.1	Brown Sugar	1560
40	Whole Fresh Eggs	445
2.0	Vanilla	38
101.3	Whole Milk	1925
	Total Weight	7,402

INSTRUCTIONS

1. Sift together flours, cocoa, baking soda and salt.
2. Beat together butter, shortening and brown sugar on 1st until just combined. Increase to 2nd and beat for 3 min. Add egg and vanilla, beat until combined. Increase to 2nd for 2 min.
3. Add half of flour mixture and half of milk to butter mixture and beat on 1st until combined. Scrape down sides and add remaining flour and milk. Beat on 1st until combined.
4. Spoon mixture into piping bags. Cut tip off of piping bag and pipe 2" cakes.
5. Bake for 9 min at 350°F.
6. DO NOT OVER BAKE!

NOTES: Use 20 quart mixing bowl with paddle attachment.

Yield: 200 pieces or 100 cakes.

Processing: Pipe cakes into 4 x 6 fashion on baking sheets.

Final Batter Temp ______

Final S.G. ___________

Batter pH

KSU BAKERY SCIENCE FORMULA

PRODUCT: Whoopie Pie Marshmallow Filling (with H&H Base) FORMULA NO:__________

DATE OF ISSUE:___

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS
	Powdered Sugar (sifted 2x)	2225
	EMUL Shortening	1475
	NFDM	567
	Cream Whip (H & H Brand)	908
	Cold Water	340-567
	Total	5510-5742

INSTRUCTIONS

1. Cream sugar, shortening and NFDM at low speed until light.
2. Add cream whip and cream on medium speed until light.
3. Cream to full volume while slowly adding water.
4. When finished mixing, put in bucket, label and cover.

Final Batter Temp ______

Final S.G. ___________

Batter pH

NOTES: Use 20 quart bowl with paddle attachment.

Yield: Approx. 5600 g or enough filling for 150-175 pies.

KSU BAKERY SCIENCE FORMULA

PRODUCT: Lemon Poppy Seed Muffins FORMULA NO:__________

DATE OF ISSUE: 03/15/17

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS	INSTRUCTIONS
	1st Stage:		1. Dry blend stage 1 ingredients by hand in large steel bowl. Set aside. 2. Whisk stage 2 ingredients together in kitchen aid mixer. 3. Place a small portion of stage 2 mixture into 12 QT bowl with whisk. 4. Add all the stage 1 mixture into mixing bowl. 5. Add stage 2 wet mixture to mixing bowl in 3 stages. Mixing briefly after each addition. 6. Don't over mix. 7. Scoop in to lined muffin pans. F.B.T: ____________ Final S.G: _________ Batter pH: _________
84	Galahad Flour	1205	
16	Yellow Cornmeal	230	
69	Granulated Sugar	990	
0.06	Lemon Zest	10	
9.7	Poppy Seeds	140	
2.5	Baking Powder	37	
1.2	Salt	18	
	2nd Stage		
73	Fluid Milk (75°F)	1050	
35	Whole, Fresh Eggs	10 eggs	
39	Butter (Melted)	570	
1.7	Liquid Vanilla	25	
1.3	Liquid Lemon Flavor	20	
4.8	Lemon Juice	70	
	Total		

NOTES: Yields 55-60 muffins.
Scale 65-70 grams per muffin cup.
Bake @ 400°F for 16-17 minutes

KSU BAKERY SCIENCE FORMULA

PRODUCT: Spotted Dog
(Americanized Irish Soda Bread)

FORMULA NO:___________

DATE OF ISSUE: 3/9/10

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS
80.9	Milk	890
5.7	Vinegar	63
9.1	Fresh Egg – 3 whole	150
1.1	Baking Soda	12.5
10.9	Sugar	120
.64	Baking powder	9
.77	Salt	8.5
9.1	Butter, diced	100
30.9	Golden raisins	340
100	Red Whole Wheat flour	1200
	Total weight	2800

NOTES:
Use 12 quart bowl and paddle
Some might call this Spotted Dog cake because it has sugar added and is not to be confused with Traditional Irish Soda Bread.

INSTRUCTIONS

1. Combine milk, vinegar, eggs and baking soda in separate container. Allow chemical reaction to occur.
2. In mixing bowl, combine: flour, sugar, baking powder, salt and mix until combined, 30 sec.
3. Add butter and mix 30-60 sec. until mixture resembles coarse meal.
4. Stir in raisins until distributed.
5. Pour in combined milk and vinegar and mix until combined. It should resemble a shaggy mass.

Scale: 700g per 8" ***cake pan*** with pan liner. Yield 4 pans.
Using floured bowl scraper, make cross on top.

Bake: 385°F for approximately 35-40 min.
Bake to golden brown

KSU BAKERY SCIENCE FORMULA

PRODUCT: Irish Brown Soda Bread

FORMULA NO:

DATE OF ISSUE: 3/9/10

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS
19.5	Sir Galahad Bread Flour	363
32.2	Red Whole Wheat Flour	600
48.3	White Whole Wheat Flour	900
13.15	Steel Cut Oats	245
1.1	Baking Soda	21
1.6	Salt	29
76	Liquid Whole Milk	1476
2.25	Vinegar	42
	Total Weight	3616

NOTES:
Use 12 quart bowl and paddle
Using floured hands shape into round.
Use a floured bowl scraper to make a cross on top.

INSTRUCTIONS

6. Combine milk and vinegar in separate container. Set aside to sour.
7. Blend together dry ingredients in mixing bowl.
8. Add combined milk and vinegar. Mix until moistened (approx. 15 sec. 1st speed)
9. Scrape bowl, make sure to get dry ingredients on bottom.
10. Mix additional 15 sec. until combined. Use your hands if necessary to incorporate.

Scale: 700g in lined ***round 8" cake pan***

Bake: Double pan, 385°F for approximately 30 min.

Results and Discussion

1. **Summarize the primary differences between the yellow cake control formula used in earlier labs and both Devil's Food and Chocolate layer cakes produced today.**

2. **Explain the differences between natural and Dutched cocoa.**

3. **Why do the amounts of baking soda vary between a Devil's food cake, a chocolate cake, and a high-ratio yellow cake?**

4. Compare the formulation for the old fashioned pound cake and the modern pound produced in today's lab. Is the old fashioned pound cake a high or a low ratio cake? Explain.

5. What is a brownie and how does it differ in formation and product goals from a chocolate cake?

6. How did the two Irish soda breads compare in appearance, texture and taste? What made the difference?

Lab 7 – Chemical Leavening Agents in Cakes: Variation in acid salts and corresponding variations in release of leavening gases

Gases involved in batter expansion include incorporated air, water vapor, and carbon dioxide and/or ammonia generated from added chemical leavening. In foam type cakes like angel food, incorporated air is the main source of leavening, but in other varieties air may be responsible for as little as 10% of the overall expansion (Pyler, *Volume I* 311). However, incorporated air bubbles provide nuclei for gas expansion. Once mixing is completed, it is impossible to create more air cells; gases must expand in the nuclei already present. This is one of the many reasons why attaining the required specific gravity during mixing is crucial to the production of high quality cakes.

The most common chemical leavening used in layer cake production is sodium bicarbonate ($NaHCO_3$), more commonly known as baking soda. It yields some CO_2 once exposed to liquid, but the chemical reaction is sudden and incomplete. Therefore, acid salts, known as buffering acidulants, are added to control and maintain the reaction, which may be slow, intermediate, and fast depending on the acid chosen.

Leavening Functions in Layer Cakes

The foremost function of added chemical leavening is to contribute to volume expansion through gas evolution. However, gas produced by leavening also helps maintain batter complex viscosity and prevent gas cell coalescence and escape. Finally, it provides a source of ongoing gas production throughout baking, feeding gas into the leaky system to make up for gas lost as batter viscosity decreases during heating.

Timing Gas Evolution

Depending on the acid salt chosen, gas may be generated before or during baking. Gas evolution is desirable during mixing to increase batter viscosity quickly, or may also be desirable during floor time while the cake is waiting to enter the oven to maintain batter viscosity. Generation of leavening gas during mixing is useful early on in the process to give greater volume to the layer and to maintain an elevated minimum viscosity and prevent system collapse, or during later baking stages to support the expanded structure until starch gelatinization is complete and the batter "sets".

Delayed-action "slow" acids like SALP or DCP require heat to drive their reaction with sodium bicarbonate, while early-acting "fast" acids like MCP monohydrate and potassium tartarate don't require heat addition and liberate most CO_2 during mixing. Double-acting systems are a blend of slow- and fast-acting acids which take advantage of both stages of gas production. Choice of leaving acid must be based on the product's desired characteristics and the required timing of gas release. As discussed above, cakes require gas production during mixing *and* baking to maintain viscosity, volume, and final texture.

Neutralizing Value and Formula Balance

According to Pyler, neutralizing value (NV) is defined as the number of parts of baking soda that will be neutralized by 100 parts of acid (Pyler, *Volume I* 310). See the formula below for an example. This value is used to calculate how much acid to use to produce the maximum amount of gas during the baking soda/acid reaction without causing a change in system pH. If the amount of acid is unbalanced, pH changes will affect the texture, flavor, and color of the final product. Small deviations may be used to create desired characteristics (like the reddish color and coarser grain of devil's food cake), but major imbalances will yield unpleasant effects.

$$\frac{Formula\ \%\ NaHCO_3}{x} = \frac{Neutralizing\ Value\ in\ parts\ soda}{100\ parts\ acid}$$

For example, if MCP monohydrate with a NV of 80 is used in a cake formula calling for 2.4 baker's % baking soda, how much acid will be needed to neutralize the soda?

$$\frac{2.4\ \%\ NaHCO_3}{x} = \frac{80\ parts\ soda}{100\ parts\ MCP\ monohydrate} = 3.0\%\ MCP\ monohydrate$$

Leavening Acid Specifics

In general, phosphate leavening contributes to the final structure of baked goods in addition to their gas production functionality. Calcium ++ and aluminum ++ ions bond with proteins and produce fine, thin-walled air nuclei.

Dicalcium Phosphate Dihydrate (DCP)

The slowest leavening acid, DCP has a neutralizing value of 33. It's never used alone because it only reacts after internal temperatures reach 135-140°F. DCP primarily works to adjust system pH in the later stages of baking in products that require at least 20-30 minutes of oven time. It helps prevent cakes from dipping or falling.

Monocalcium Phosphate Anhydrous (AMCP)

AMCP is relatively slow to dissolve and react, and has a neutralizing value of 83. 20% of available CO_2 is released during mixing, 40-50% releases during 10-15 minutes of floor time, and the remaining 30-40% is released quickly during early baking.

Monocalcium Phosphate Monohydrate (MCP)

MCP (NV 80) reacts more quickly than AMCP. 60% of total gas production occurs during mixing. A chemical intermediate is also formed during mixing, dicalcium phosphate. This intermediate lies dormant until heated, when the rest of the system CO_2 is released. MCP must be combined with other, slow-acting acids to be useful – cakes produced solely with MCP will collapse later in the oven.

Potassium Acid Tartarate (PT)

Potassium acid tartarate is also called cream of tartar. It reacts quickly and is not often used in commercial baking applications. PT is a byproduct of winemaking and may also be used as a stabilizer, thickener, or antimicrobial agent (21CFR184.1077).

Sodium Acid Pyrophosphates (SAPP)

There are several different types of SAPP available for use depending on desired final product attributes and gas release timing. SAPP can have a neutralizing value of 72-74. Finally, SAPP may have a bitter aftertaste if the formula is imbalanced; however, this does not reduce its popularity in bakery applications. Because it is semi-soluble in cold water, SAPP can be used in cold batters and refrigerated doughs (Pyler, *Volume I* 306).

Sodium Aluminum Phosphate (SALP) and Sodium Aluminum Sulfate (SAS)

SALP has a neutralizing value of 100, while SAS has a neutralizing value of 104. Both of these acids react very slowly at room temperature, so they are often used in conjunction with MCP monohydrate. The aluminum ++ ions combine with flour proteins to strengthen the gluten structure, therefore increasing the complex viscosity of the batter to more efficiently retain gas cells during baking. The use of either of these two leavening acids provides a fine texture and reduces tunneling and coarse grain. SALP and SAP also do not have bitter aftertastes like SAPP.

Double-Acting Baking Powders

Acids may be combined to balance the timing of gas generation and provide optimum batter stability. Fast-acting leavening acids help inflate gas cells incorporated during mixing, increasing batter viscosity. Later stages of fast-acting acids or intermediate acids control the rate of gas production during bench time to maintain complex viscosity and retain incorporated gas cells. Finally, late-acting acids react in the oven, causing final baking soda disassociation and CO_2 production. Gas production must be constant and uniform over the baking period to help fill the space left by air and gas cell leakage and to maintain viscosity above the V_{min} range to maintain stability and prevent collapse.

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KSU Bakery Science Lab High-Ratio Cake Procedure

Scaling: Weigh all dry ingredients first. **Use one bowl to weigh individual ingredients; transfer them to another bowl before continuing to weigh.** Don't zero the scale and add ingredients on top of others – it's easy to make scaling errors that way. Weigh the water immediately prior to mixing.

Mix: Mix the cake according to the appropriate formula.

Measure: FBT and SG, using the provided SG cup for the weights of both water and batter.

Record: Using the Excel spreadsheet in SH 109, record the SG and temperature measurements.

Sample: Using a # 20 disher, place a level scoop of the finished batter on the Specific Gravity sample tray. Record the corresponding SG and FBT on the pan liner.

Scale: Line each pan with a fluted cake liner. Scale 380 grams per 8" pan, ensuring the scale has been zeroed. Yields 4-5 cake layers. Make sure to label each cake using the provided KSU tags.

Bake: Double pan, 355°F/179°C for approximately 26 min.
The cake should be set (not jiggly) when touched, but not dry.

Cool: **Allow cakes to cool for 10 minutes.** Holding the pan in the right hand, support the top of the cake with the left. Invert the pan, then re-invert so the cake is right-side up. Keep label with proper product.

Score: Once the cake layers are cool to the touch, sensory and template scores can be taken and recorded.

KSU BAKING SCIENCE FORMULA

PRODUCT: YELLOW HIGH RATIO LAYER CAKE FORMULA NO: Control

BAKERS %	INGREDIENTS	WEIGHT/ GRAMS
100	Cake flour, SRW chlorinated	500
125	Sugar	625
10	Nonfat dry milk (NFDM)	50
18.2	Dry whole eggs	91
3.0	Salt	15
2.4	Baking Soda	12
variable	Assigned Leavening Acid	Page 7
variable	Assigned Leavening Acid	Page 7
2	B.L.V.	10
46	Emulsified cake shortening	230
1	Cake emulsifier (Vanlite brand)	5
132	Water	660
	Total Weight	2210.2g

INSTRUCTIONS

Put all ingredients (except water) into mixing bowl and then:

Mix 1^{st} speed: 1 min
Scrape down bowl and paddle

Mix 1^{st} speed: 4 min
Scrape down bowl and paddle

Add 220g water
Mix 1^{st} speed: 1 min
Scrape down bowl and paddle
Cont. mixing 2 min., speed 1

Add 220g water
Mix 1^{st} speed : 30 sec
Scrape down bowl and paddle
Mix 2^{nd} speed: 2 min.
Check S.G. Target: 0.87- 0.90

Add 220g water
Mix 1^{st} speed: 15 sec
Scrape down bowl and paddle
Mix 2^{nd} speed: 1 min

Check S.G. & continue mixing on 2^{nd} speed to reach desired S.G. in 30 second intervals.

NOTES:

Dry blend with paddle to stimulate cake mix finisher.

Friction Factor: 5

Desired Final Batter Temperature (DFBT) = 72°F/22°C

Final Desired Specific Gravity (S.G.) = 0.88 – 0.92

RESULTS and DISCUSSION

Results and Discussion

1. **Construct tables comparing**
   a. **The effect of varying SALP levels (batters 1-3)**
   b. **The effect of using various single acids (batters 4-8)**
   c. **The effect of using various combinations of leavening acids (batters 10 & 11)**
2. **After each table, discuss the optimum level, acid, or combination. What worked? What did not? Why?**
3. **How does ongoing gas production help improve and stabilize batter viscosity?**

KSU Bakery Science Lab Cake Scoring Sheet **Batter #**

Batter temp (°F) $\frac{\text{wt (1 cup batter)}}{\text{wt (1 cup water)}}$ = S.G. S.G. = specific gravity pH of batter			
pH of final product			
Template Measures A			
B			
C			
D			
E			
Volume Index = B+C+D			
Symmetry Index = 2C – B - D			
Uniformity Index = | B- D |			
Subjective Scores:			
Crust color (descriptive) Cells & Grain (40 pts) Texture (40 pts) Crumb color (10 pts) Flavor & Aroma (10 pts)			

Total Subjective Score (100 pts. possible)

Lab #8 – Cake Doughnut Production

Background

Technically, all bakery products that are deep-fat fried are considered "doughnuts". Cake doughnuts are chemically leavened and require no rise time; fluid batter is deposited into hot fluid shortening where the rings are quickly cooked. Frying transfers heat rapidly through conduction and gives doughnuts their characteristic texture and color.

Production Goals:

An ideal cake doughnut should be tender and moist, but not underdone, which requires the starch to be gelatinized adequately. Timing each stage correctly is the main means of controlling the doughnut production process and creating high quality products! The internal structure and grain should be fine and uniform, while the outside crust should be symmetrically shaped and uniformly golden brown. Mechanically produced doughnuts should have a "star" shaped hole. The presence of the star is a strong sign that the batter viscosity and chemical leavening are appropriately balanced. Controlling fat absorption is critical to producing quality doughnuts with clear flavors; the taste shouldn't be greasy or rancid. Finally, doughnuts should not change flavors, crack, or exhibit oil syneresis (weeping) during shelf-life (variable from a few days to multiple months, depending on formulation).

Mixing

Even ingredient distribution is essential, as is an optimum level of gluten development. If doughnuts are undermixed, they will be weak and fragile and absorb too much fat. However, if cake doughnuts are mixed for too long, doughnuts will become tough and unpalatable.

Water Level

Water is the controlling factor in batter viscosity and is necessary to incorporate ingredients. Moisture present in the batter during frying is released as steam and helps reduce fat intake. Doughnut batters with too little water will be stiff and difficult to extrude; they will also crack during frying and absorb too much fat. However, batters produced with excess water won't be sufficiently viscous, creating doughnuts that spread too much and fry up flat and porous. The increased surface area and "spongy" texture will lead to excess fat absorption as well. Doughnuts will sweat once packaged, damaging their coating and reducing shelf life.

Batter Temperature

Batter temperature influences gas production and therefore batter viscosity. Colder batters will have low gas production rates because the leavening acids will not react. Warm batters will expand too quickly during floor time and early in frying, which may cause blistering, a misshapen center, dark crust color, and higher fat absorption.

Belshaw-Adamatic and Dawn Food Products suggest a final batter temperature of 70-72°F (Dawn 1992).

Floor Time

Dry ingredients take up water during floor time and the batter relaxes. Fast-acting acids will react with baking soda and trigger CO_2 production, reducing batter density and increasing batter viscosity. Expanding gas cells help lift the doughnuts to the surface during frying, so determining the appropriate amount of floor time is crucial to achieving doughnuts that are fried properly and reach 11-21% fat absorption. Pyler suggests 10-20 minutes for optimum hydration (Pyler, *Volume II* 303).

Frying

As the single most important step in cake donut production, care must be taken during frying. High quality fat should be used and replaced regularly, as fats break down over time. Old fats will impart a rancid and unpleasant taste, and may negatively impact the shape, color, and texture of the final product. High levels of free fatty acids (FFAs) are unhealthy and lead to excess oil absorption. However, fresh frying oil is not ideal for optimum frying; the presence of 0.4-0.6% FFAs help create doughnuts with optimum fat absorption, eating quality, and surface characteristics.

After the batter rests, it is extruded through a depositor, which creates a ring of batter directly in the fryer[2]. The ring will sink in the heated fat (360-380° F) until expansion begins and the leavening gases bring the doughnut to the surface (Pyler, *Volume II* 297). Once floating, cake doughnuts are fried 45-60 seconds on each side. The batter is approximately 75-80° F upon first contact with the fat. However, as one side is frying, the other side is warming up, losing moisture, and developing "pores" or small holes on the surface. When the doughnut is flipped, this side will absorb approximately 5% more fat due to increased porosity and decreased moisture availability for steam production (Pyler, *Volume II* 298).

Cooling

Doughnuts must be cooled to 90-95° F for maximum sugar adherence, or to 80-85° F for glazes and icings. If the doughnuts are too hot, oil will remain on the surface and reduce coating evenness and stability. Too much cooling will also create non-uniform surfaces. In some cases, doughnuts are cooled to 80-85° F, and then heated using infrared to 88-92° F to ensure coatings apply evenly. Packing should be done as soon as possible after coatings are applied to prevent damage and cracking.

INGREDIENTS

[2] Small-scale bakeries may make "bench-cut" doughnuts, which are rolled out and cut with doughnut cutters, like yeast doughnuts (King Arthur Flour). These formulas have lower water content (50-60%).

Flour

Flour is used to provide structure to the cake doughnut, but must not create an excessively tough product. Flour is one of the main determinants of the batter's performance during mixing and frying.

The higher protein levels found in hard wheat flours may limit batter spread during frying and create an unpalatable, tough doughnut. Therefore, soft and hard wheat blends with a 9-10% protein content are often used; the hard wheat fraction will provide batter structure and help the product hold its shape in the frying oil, while the soft wheat will lend tenderness and increase desired texture characteristics.

Chlorinated cake flour is not typically used to produce cake doughnuts, unless the formula contains an unusually high amount of sugar. In that case, the rapid swelling and gelatinization of the starch granules will aid in structure retention and prevent falling. Finally, if chlorinated cake flour is used, the leavening acid must be adjusted to account for the flour's lower pH (4.6-4.7).

Sugar

One of sugar's main functions in doughnut production (other than adding flavor and sweetness) is to trap and structure water, which delays the onset of starch gelatinization, tenderizing the final product. The addition of sugar also helps lower the water activity, which delays moisture migration and lengthens shelf life.

Sucrose is traditionally used in cake doughnut batter. Dextrose may be added to contribute to the Maillard reaction and improve crust color, while HFCS or corn syrup solids may be added to help reduce sucrose crystallization and improve moisture retention. High levels of sucrose may lead to the absorption of excessive frying fat and a greasy finished doughnut. Too much sugar may also damage the structure of the product and create a fragile, crumbly doughnut.

Shortening

Cake doughnut batters contain a surprisingly low amount of shortening: only 3-9% based on total flour weight. Most of the fat present in the final product, 20-25% of the total weight, comes from fat absorption during frying. Shortening increases tenderness, provides a soft and moist mouthfeel, improves the texture of the crumb, and may even affect the color and shape of the final product.

Emulsifiers

Cake doughnut formulas almost always contain some level of emulsifiers to reduce interfacial tension between aqueous and hydrophobic phases. Without the use of emulsifiers, it would be very difficult to disperse the shortening evenly in the batter. Emulsifiers extend shelf life and "shorten" the bite, increasing tenderness and contributing to a pleasing mouthfeel.

The main issue doughnuts face in regard to shelf life is moisture migration between components. For example, powdered sugar doughnuts may become sticky and "clumpy" if moisture migration is allowed to occur – water will move towards the drier powdered sugar and cause undesirable effects. Emulsifiers and hydrocolloids interact with water, binding and restructuring it to reduce moisture migration and reduce staling (Eduardo et al. 636)

Emulsifiers also aid frying fat absorption by acting as a "wetting" agent, allowing the hot fat to more easily penetrate the doughnut. For this reason, low levels of emulsifiers must be used to control fat absorption; blended emulsifier systems are the most functional.

Chemical Leavenings

Think about the double-acting baking powders typically used in layer cake production. Double-acting baking powders are composed of sodium bicarbonate to provide carbon dioxide, a fast-acting acid that generates gas during mixing, bench rest, and early on in frying, as well as a slower-acting acid that produces gas only at elevated temperatures and helps keep the system from collapsing. These powders are timed specifically to work with the stages of layer cake production; if they're used in cake doughnuts they will lead to poorly shaped cake doughnuts that rise at the wrong time and that will absorb too much fat.

Therefore, a leavening acid blend must be created for cake doughnuts that will work well within the very short processing time allowed and that will generate gas at the appropriate points during floor time and frying. In conjunction with sodium bicarbonate, Doughnut Pyro (SAPP) is frequently used for the fast-acting acid, SAPP 28 for a medium-acting acid, and SALP is often used for the slowest-acting acid. Cake doughnuts usually undergo a 10 minute bench rest, in which sufficient leavening gas should be produced to lighten the density of the batter. This gas production should continue until the early frying stages to aid buoyancy and help the doughnuts rise to the surface of the fat after 4-7 seconds. If the cake doughnuts stay submerged for too long, the crust will set on both sides and reduce expansion. Further gas production from the slower-acting acids helps continued batter flow and expansion later on in frying, and helps keeps the doughnuts "inflated" until the starch gelatinizes.

Salt

Salt is used at 1-2%. As well as enhancing flavor, salt aids in lowering the water activity through bound water and affects shelf life. Altering salt levels can change structural characteristics as well as the rate of frying fat absorption.

NFDM

NFDM is used at 3-6%. It binds water, improves gas retention through structural formation, helps prevent excess fat absorption, and contributes to crust color through the reducing sugar lactose.

Caesin proteins create a fat barrier that reduces the amount of fat that the doughnut is able to absorb. Due the lack of these proteins, many NFDM replacers successfully used in layer cakes (like soy-whey blends) don't function well in cake doughnuts because they are unable to perform the same fat-blocking functions.

Dry Egg Yolks

Egg yoks contribute lipids, lecithin, and proteins and improve flavor, color, tenderness, volume, rise time, and frying tolerance. They may be used at levels from 0.5-3.0%; levels higher than 3.0% show little quality improvement. The addition of excess egg yolk may cause an undesirably dark crust and increased frying fat absorption.

If dry *whole* eggs are used, the white component will add structure, but will also cause unwanted toughness. Additional shortening must be added to reduce this effect.

Lecithin

Lecithin is a naturally occurring emulsifier and is almost always used in commercial cake doughnut production. Like other emulsifiers, it functions as a wetting agent, improves batter flow, and helps control fat absorption. Soy lecithin may be used instead of egg yolks to reduce cost.

Soy Flour

Soy flour's main function is to decrease frying fat absorption by binding water, contributing soluble proteins, and increasing batter viscosity. It also helps increase shelf life. Usage should not exceed 1-3%, as excess soy flour may make doughnuts tough.

Gums and Modified Starches

Gums are used to aid water retention and reduce fat absorption at levels of 0.010-0.25%.

Potato flour, potato starch, or pregelatinized starches are used to bind excess free water, reducing fat absorption, slowing down the staling process, and reducing the breakdown of doughnut coatings like icing or cinnamon sugar.

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EXPERIMENTAL ASSIGNMENTS

Control Formula

1. Formula on following page

Sugar Level Variation [Batters 2, 1, 3]

2.	sucrose	20.0%	200.0 g
3.	sucrose	50.0%	500.0 g

NFDM Level Variation [Batters 4, 1, 5]

4.	NFDM	1.0%	10.0 g
	corrected water	use 68.5%	685.0 g
5.	NFDM	4.0%	40.0 g
	corrected water	use 68.5%	685.0 g

Egg Solids Type, Level [Batters 6, 1, 7]

6. no eggs 0.0% 0.0 g
   decrease water 3.0 % to total of 720g

7. dry **whole** eggs 12.0% 120 g
   increase water 1.0 % to total of 760g

Use of Soy Flour. (Batters 8, 1)

8. Add 2% soy flour 20g
   And water total of 750g

Use of Premixes from 50# Bag [Batters 9, 10 & 1]

9. Follow instructions on bag and scale Batter 9, Dawn Majestic Vanilla
   Mix: 2,268g.
   Water: 1,025g.

To calculate water temperature to obtain desired batter temp. (D.B.T.)

Room temp. = ________
Flour temp. = ________
Friction Factor = 0

Calculate water temp. = 3 x D.B.T. – (RT + FT + FF)

KSU BAKING SCIENCE FORMULA

PRODUCT: Cake Donuts- Control Formula DATE OF ISSUE: 3/17/08

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS
50	Pastry Flour	500
50	Bread Flour	500
32.7	Granulated Sugar	328
1.6	Dextrose	16
2.18	Salt	22
8.18	NFDM	82
8.18	Powdered Egg Yolks	82
1.46	Baking Soda	14.3
1.4	Donut Pyro (SAPP-36)	14
0.5	SAPP-40	5.0
0.25	Nutmeg	8.0
0.15	Mace	1.5
6.05	All-purpose shortening	62
75	Water	750
0.49	Liquid Vanilla	5.0
	Total Weight	2,226

NOTES:

Desired F.B.T. 75-76°F

Actual F.B.T. ___________

You will be checking for fat absorption. Make sure you record the pre fry and post fry weight of the same SIX (6) donuts.

INSTRUCTIONS

68. Use 12 qt. bowl and paddle
69. Calculate water temp to obtain F.B.T. of 75-76°F
70. Scale all dry ingredients
71. Scale shortening and add to top of dry ingreds. Mix 5 minutes on speed 1. **Pour out of mixing bowl**
72. **Scale water and vanilla. Put into mixing bowl!**
73. Put all dry ingreds back into mixing bowl, on top of water.
74. Mix 1 min speed 1, **scrape thoroughly**.
75. Continue mixing 2 min. on speed 2.
76. Record final batter temp.
77. Bench rest batter in bowl for 10 min.
78. After bench rest, transfer batter into depositor right on top of previous batter.
79. FRY: 45 sec./side @ 375°F
80. Deposit a few units into fryer to finish running remnants of previous batter through system.
81. Pull depositor head back into open area, deposit 3 rings onto a tared plastic scraper, obtain net wt. of these 3, then calculate batter wt/unit. Replace batter into depositor.
82. The individual batter weight should be 32 g ± 0.5 g. 95-97 g for all three rings
83. You'll need to save 6 donuts for scoring. The rest are yours to take home.

KSU BAKING SCIENCE FORMULA

PRODUCT: **Dawn Pre Mix** Cake Donuts

FORMULA NO:____________

DATE OF ISSUE: 3/17/08

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS
	Dawn pre-mix	2268
	Water	1025
	Total Weight	3,293g

NOTES:

Desired final batter temp. 75-76°F

INSTRUCTIONS

1. Use 12 qt. bowl and paddle
2. Calculate water temp to obtain F.B.T. of 75-76°F
3. Put water in bowl first.
4. Add in premix.
5. Mix 1 min speed 1, **scrape thoroughly**.
6. Continue mixing 2 min. on speed 2.
7. Record final batter temp.
8. Bench rest batter in bowl for 10 min.
9. After bench rest, transfer batter into depositor right on top of previous batter.
10. FRY: 45 sec./side @ 375°F
11. Deposit a few units into fryer to finish running remnants of previous batter through system.
12. Pull depositor head back into open area, deposit 3 rings onto a tared plastic scraper, obtain Net wt. of these 3, then calculate batter wt/unit. Replace batter into depositor.
13. The individual batter weight should be 32 g ± 0.5 g. 95-97 g for all three rings
14. You'll need to save 6 donuts for scoring. The rest are you're to take home.

CAKE DONUT SCORING AND ANALYSIS

1. Weigh 6 typical donuts
2. Calculate fried weight/unit
3. Calculate Difference:

   DIFF= Unit Batter Weight

4. Calculate % Fat Absorption

   % Gain/ Loss = $\frac{\text{DIFF}}{\text{Unit Batter Weight}}$

   = $\frac{\text{Amount of Frying Fat Absorbed}}{\text{Unit Batter Weight}}$

5. Save your 6 typical donuts and perform volume and subjective scoring using the following score sheet.

Batter wt of 3 rings Ave batter wt per ring				
Fried wt of 3 donuts Ave fried wt per donut				
Diff= Avg. unit fried wt Avg. unit batter wt % fat abs ≈ % wt gain = Diff/ave batter wt				
Diameter of 6 donuts ***** Average diameter (2r) **All measurements in cm** Height of 6 donuts ***** Average height (h)				
Spec. Vol. = $\frac{\text{volume}}{\text{Wt.}} = \frac{\pi r^2 h}{\text{avg. fried wt per donut}}$ Average fried wt. per donut				
Subjective:				
Uniform color (10 pts)				
Uniformity, symmetry (20 pts)				
Lack of ruptures (20 pts)				
Crumb grain (10 pts)				
Tenderness (20 pts)				
Flavor (20 pts)				
Total subjective score (100)				

*** Make all measurements in centimeters**

RESULTS and DISCUSSION

Construct the following tables summarizing class data for the cake doughnut ingredient and process variation experiments.

Independent variable column: as specified according to the title of each table.

Dependent variable columns for each table should be:

- % frying fat absorption
- average unit specific volume
- weighted subjective score sum
- finished batter temp (right after mixing)

After each table, briefly describe which batter performed best. Does this make sense based on the underlying mechanisms?

1. **Sugar Level Variation** [Batters 2, 1, 3]

2. **NFDM Level Variation** [Batters 4, 5, 1]

3. **Egg Solids Type, Level** [Batters 6, 1, 7]

4. **Use of Soy Flour.** [Batters 8, 1]

5. **Use of Donut Premix** [Batters 9 and 1]

Discussion Questions

9. **Retail shops in the Midwest and west sell far more yeast-raised doughnuts than cake donuts, which apparently indicates a definite product preference in those regions. Yet wholesale producers mostly manufacture cake doughnuts and neglect yeast-leavened doughnut product lines. Why is this the case?**

10. **Soy flour and NFM both reduce fat absorption. Knowing the structure of these ingredients, explain why this would be true.**

11. **Batter flow in the frying kettle is very important to donut quality. Describe which ingredients have a significant effect on flow and why?**

12. **Why does the addition of HFCS to cake doughnuts reduce sucrose crystallization?**

Lab #9 – Effects of Mixing Time and Fat Type on Pie Crust

Pie – quintessentially American, beloved by many, does $700 million in business a year, according to the American Pie Council. Pies may be filled with fruit, custard, pudding, or savory fillings like meat or vegetables. All pies have a bottom crust, composed of flour, shortening, water, and salt. Some formulas include flavorings, herbs, or spices in the crust as well. Finally, pies may be topped with another crust, with a crumb/streusel topping, or with meringue or whipped cream.

The characteristic flakiness of pie crust is developed by "cutting", or briefly mixing, fat into flour and other dry ingredients. Home bakers use their hands or a pastry blender, while commercial mixers like the Hobart require the use of the pastry knife attachment, which looks like a U-shaped paddle. Mixing is usually brief and leaves chunks and flakes of fat dispersed throughout the dry ingredients. Upon baking, the bits of fat melt to form small pockets in the crust's interior. As the temperature increases, steam builds pressure inside the pockets and expands the dough, creating flaky layers beloved by children and adults alike. This process is a striking example of a mechanically leavened system – neither chemical leavening nor yeast play a part in pie crust's creation.

Pie crust's tenderness is dependent on low levels of gluten development and on preventing the fat from being absorbed by the flour. Fat acts as a lubricant and tenderizer, but should not be completely mixed into the dough for optimum flakiness.

INGREDIENTS

Flour

Soft wheat "pastry" flour is frequently used in the production of pie crusts. If the only flour available has higher protein levels than desired, up to 20% starch may be used to reduce "strength" and lower the total protein content.

Fat

Butter, lard, hydrogenated shortening (like Crisco), and vegetable oil may all be used in pie dough production. The first three are solid at room temperature and are easy to handle when chilled. Butter provides the best flavor, but has a lower melting point than lard and shortening at about 89° F., which can cause difficulties in processing. Shortening is most commonly used due to its low cost, higher melting point, and ease of use, although lard may be used if a saltier or richer flavor is desired.

All fats should be incorporated into the doughs at 60° F to yield the ideal finished product. Warmer temperatures will cause excessive softening during mixing and will reduce the tenderness and flakiness of the final product.

Salt

Salt is included as a flavor enhancer and may be used from 1-3%, depending on the final attributes desired.

Nonfat Dry Milk

NFDM is added at levels of 3-6% to bind water and improve flavor and color. Dextrose, a reducing sugar, is added at 2-3% to enhance crust color through the Maillard reaction.

Water

Ice water is used to control dough temperatures and prevent the fat from softening excessively. It also helps create limited gluten development, but the principal function of water in pie crusts is to wet the ingredients and aid incorporations. The ideal water pH for use in pie crusts is 6; trisodium citrate may be added to adjust water pH if need be.

Mixing

In terms of controlling crust flakiness, mixing is the most important step (Pyler 148). To create optimum flakiness, total mixing must be minimized and the dough kept cool. A chilled resting period after mixing, but before processing, will allow the dough to hydrate and relax while re-hardening the fat, reducing later liquefaction. While overmixing may not cause excess gluten development, it may allow the fat to be absorbed by the flour. The lack of larger fat pieces will lead to a crust that is be unable to puff up during baking due to the lack of discrete fat “pockets”. The final product will be finely textured, crumbly and “mealy”.

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Procedure for shaping pie shells

1. Use a bowl scraper to remove the pie dough from the mixer.
2. Gently mold the dough into a log shape, approximately 3 inches in diameter, and then place it on a lined and labeled sheet pan.
3. The dough will now relax in the retarder for a minimum of one hour.
4. Remove the dough and cut three discs at 195g each. Put each disc into a pie tin.
5. Use the pie press as directed in lab to press out each dish.
6. Take half the remaining dough and using the reversible sheeter, sheet the pie dough down to 8 mm. Turn the dough 90°, then sheet down to 3.5 mm. Brush off the top surface and cut out four discs with the donut cutter.
7. Carefully lift all four discs off the sheeter surface with the spatula.
8. ***Weigh each disc*** in grams and then place them on the marked sheet pan.
9. Once all groups are done, all the discs will be baked off at 450° for 8-10 minutes. This will be done to make texture comparisons between varieties.
10. Weigh all four disks after baking. Calculate moisture loss in baking by using the formula below.

$$\frac{Weight\ before\ baking - weight\ after\ baking}{Weight\ before\ baking} * 100 = \%\ moisture\ lost$$

<u>**Pie Crust Makeup**</u>

2-crusted fruit pies:

Sheet bottom piece of dough and place in center of pie plate. Press the shell out using the pie press, being careful not to drop the arm too violently.

Fill pie shell with fruit filling and spray lightly with water.

Sheet top piece gradually down from 8 mm to 4 mm, turn 90°, then sheet down to 3 mm, lay over the filled pie, when instructed to do so.

Flute and seal edges, dock top crust once in middle to allow steam release.

BAKE: 450 °F for 35+ min

1-crusted cream pies: (Blind baked pie crusts)

Place a sheeted piece of dough in center of pie plate.

Dock a few times with a fork to prevent excess puffing.

Place another pie plate inside the shell, invert, then:

BAKE: 6 minutes at 450°F. Check crust color and continue baking if necessary.

KSU BAKERY SCIENCE FORMULA

PRODUCT: Pie Dough (**Flaky Crust**)　　　　FORMULA NO:__________

DATE OF ISSUE:11/1/12

Baker's %	INGREDIENTS	WEIGHT/ GRAMS
60	AP Shortening/Lard	600
100	Treatment Flour(s) see assignment sheet	1,000 total
4	NFDM	40
3	Salt	30
1	Dextrose	10
30	Water (32°F; no ice)	300
	Total Weight	1,980

NOTES: *12 quart bowl and paddle are in the retarder, in order that they are chilled as possible.

INSTRUCTIONS

1. Scale out the fat. Divide into small pieces; chill.
2. Combine NFDM and chilled flour into 12 qt bowl with paddle.
3. Put shortening on top of flour/NFDM.
4. Mix:
   1st speed: 15 sec; scrape
   2nd speed: 1 minute; scrape.
5. While mixing above, combine salt, dextrose and water in pitcher and whisk wildly.
6. With mixer stopped, add salt/dextrose/water blend to mixer all at once.
7. Mix:
   1st speed: 15 sec; **scrape bottom of bowl and paddle thoroughly.**
   2nd speed: 25 sec then stop
8. Use bowl scraper to remove all pie dough from mixing bowl
9. Gently mould your pastry dough into a log shape, the diameter of your wrist. Place your log in the retarder on the sheet pan previously marked with your group's number
10. All pie dough will now be allowed to relax minimum of one hour, covered, in the retarder

KSU BAKERY SCIENCE FORMULA

PRODUCT: Pie Dough (**Mealy Crust**)

FORMULA NO:___________

DATE OF ISSUE: 11/1/12

Baker's %	**INGREDIENTS**	**WEIGHT/ GRAMS**
60	AP Shortening/Lard	600
100	SRW Pastry Flour	1,000
4	NFDM	40
3	Salt	30
1	Dextrose	10
30	Water (32°F; no ice)	300
	Total Weight	1,980

NOTES: *12 quart bowl and paddle are in the retarder. So they are as chilled as possible; divide into smaller pieces/cubes.

INSTRUCTIONS

1. Scale out the fat. Divide into small pieces; chill.
2. Combine NFDM and chilled flour into 12 qt bowl with paddle*.
3. Put shortening on top of flour and NFDM.
4. Mix:
   1st speed: 15 sec; scrape well;
   2nd speed: 4 minutes; scrape.
5. While mixing above, combine salt, dextrose and water in pitcher and whisk wildly.
6. With mixer stopped, add salt/dextrose/water blend to mixer all at once
7. Mix:
   1st speed: 15 sec; **scrape bottom of bowl and paddle thoroughly**
   2nd speed: 25 sec. and stop.
8. Use bowl scraper to remove all pie dough from mixing bowl.
9. Gently mould your pie dough into a log shape, the diameter of your wrist. Place your log in the retarder on the sheet pan previously marked with your group's number
10. All pie dough will now be allowed to relax a minimum of one hour, covered, in the retarder.

KSU BAKING SCIENCE FORMULA

PRODUCT: Chocolate or Coconut Cream Pies FORMULA NO:___________

DATE OF ISSUE: 2/26/08

TRUE%	INGREDIENTS	WEIGHT/ GRAMS
19.26	Sugar	2823
0.22	Salt	32
7.29	NFDM	1068
50.51	Water (hot)	7402
9.15	Water (cold)	1341
4.00	Starch	586
7.97	Whole Eggs	1168
1.36	Butter	200
0.24	Liquid Vanilla	35
100	Total	14,655

NOTES:
Should yield enough to make 22-24 (8 inch) pies

INSTRUCTIONS

1. Put hot water into steam kettle and turn to med high heat.
2. Dry blend sugar, salt and NFDM by hand, in a separate bowl.
3. While whisking water in kettle slowly add the dry ingredients.
4. Prepare starch/egg slurry mixture in a one gallon measure.
5. When 1st stage in kettle boils, it will suddenly foam and rise up. BE PREPARED to add starch/egg water slurry.
6. As first stage boils, stream in second stage slurry while constantly whisking. Continue stirring until mixture boils again.
7. Turn off kettle and blend in butter and vanilla.
8. Split the batch in half and continue with the following:

Coconut Cream: Add 400g of flaked coconut to filling not remaining in kettle.

Chocolate Cream: To filling left in kettle add 300q chocolate liqueur, 100 g natural cocoa and 250q water. Blend thoroughly.

9. Fill pre-baked pie shells while the filling is still hot.
10. Refrigerate the filled pies to set the filling

When the pies are cooled to 60°F they are ready to be topped.

Results and Discussion

1. **Construct a table comparing and summarizing the pre- and post-bake weights and the average bake loss of the pie discs from all varieties.**
2. **Why does bake loss vary between fat types?**
3. **What role does fat choice play in texture and final eating quality of pie crust?**
4. **If an egg and some sugar were added to the basic pie crust formula, what would this pastry be called in a French *patisserie*? What types of baked goods could be produced with this "fancy" pie dough?**

Lab #10 – Gluten Free Baking

Gluten is a protein complex formed by two proteins found in wheat, glutenin and glidadin. (Pyler, *Volume I* 29). This complex provides extensibility and elasticity to doughs and enables them to retain gas and maintain their structure, as well as the familiar "chewy" texture characteristic of breads and other baked goods.

Once the gluten protein enters the digestive tract, it is broken down into peptide chains. These chains are longer than those caused by the breakdown of other proteins. In individuals with Celiac disease, the longer peptide chains trigger an immune response and causes bloating, gas, and other unpleasant symptoms. Over time, this autoimmune disorder may damage the lining of the small intestine and reduce the body's ability to absorb nutrients (Mayo Clinic). Those affected by this disease must avoid wheat and other cereal grains from the triticiae family, including barley and rye. For a product to be considered gluten free in the US, it must contain less than 20 ppm of gluten (Gelski).

Producing gluten free baked goods has proved challenging due to gluten's structure forming and gas retaining properties. It is difficult to find a replacement for this protein, although some bakeries use gums and starches to help give structure to and elasticize gluten free batters. Blends of various grains and pseudocereals are used to mimic wheat flour.

Commonly used "flours" include white and brown rice flour, potato starch, almond meal, coconut flour, sorghum flour, and tapioca starch, among others. The addition of hydrocolloids to gluten-free formulas has been shown to aid in structure retention and final product volume (Hüttner et. al). Other flours, like oat flour or oat flakes, technically not containing gluten, are nevertheless controversial.

The growing season of oats is similar to that of wheat and harvest often ends up happening around the same time. This may cause cross-contamination or grain co-mingling. However, if the products made with oats contain less than 20 ppm of gluten, they are still considered gluten free.

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KSU BAKERY SCIENCE FORMULA

PRODUCT: Gluten Free Flour Blend   FORMULA NO:__________

DATE OF ISSUE:_________

Amount	INGREDIENTS	WEIGHT/ GRAMS	INSTRUCTIONS
3 ¾ cups	Chickpea **OR** soy flour	462	84. Thoroughly mix all flours together for master gluten free flour blend.
3 cups	Cornstarch	413	
3 cups	Tapioca Flour	371	
3 cups	Rice Flour	446	
	Total Weight	1692	

NOTES:____
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KSU BAKERY SCIENCE FORMULA

PRODUCT: Gluten Free French Baguette FORMULA NO:__________

DATE OF ISSUE:_________

Amount	INGREDIENTS	WEIGHT/ GRAMS
12 cups	Gluten Free Flour Blend	1692
2T + 2 t	Xanthan Gum	22.6
4 t	Salt	24
¾ cup	Sugar	156
¼ cup	Instant Yeast	39
2 T	Dry herbs	5
¼ cup	Olive oil	56.7
6 cups	Warm water	1360.8

NOTES:
T = Tablespoon, t = teaspoon

INSTRUCTIONS

1. Sift first 4 ingredients. Put into 12 quart mixing bowl. Add yeast and herbs.
2. Mix to incorporate ingredients.
3. Blend olive oil and water into dry ingredients on speed 1 until incorporated.
4. Mix on speed 2 for 4 minutes.
5. Using a disher, dollop the very wet dough/batter onto a lined sheet pan.
6. Proof 30 minutes, double in size.
7. Bake 400°F for 25-28 minutes. (Or 350 degrees F for 35 min.)
8. Bake to color.

KSU BAKERY SCIENCE FORMULA

PRODUCT: Gluten Free Pumpkin Bread
Developed by Sue Ruan

FORMULA NO:___________

DATE OF ISSUE: 4/6/10

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS
	Sorghum Master Mix:	
100	Sorghum Flour	445.1
12.4	Tapioca starch	55.4
12.4	Dry Egg white	55.4
12.5	Granulated Sugar	55.5
1.2	Xanthan gum	5.4
1.2	Guar gum	5.4
4.16	Baking Powder	18.5
2.4	Salt	10.8
25.1	Shortening	111.7
1.2	Monoglyceride, GMS-90	5.4
2.7	Cinnamon	12
0.9	Nutmeg	4
151.65	Granulated Sugar	675
33.36	Vegetable Oil	148.5
124.96	Pumpkin filling	556.2
66.7	Whole Fresh Eggs	297
54	Water or milk	240.3
	Total Weight	2801.6

NOTES:
Deposit 650g into 3.5x7.5" aluminum loaf pan – 50 minutes
350g into 2.5x5" aluminum loaf pan – 45 minutes
Bake at 350°F for approximately 45-50 minutes.

INSTRUCTIONS

1. To make Sorghum Master Mix, combine in 12 quart mixing bowl. Mix 1st speed 1 minute.
2. Scrape
3. Mix 2nd speed 4 minutes.
4. Place in alternate bowl and set aside.
5. Add cinnamon and nutmeg to flour mix.
6. In mixing bowl combine wet ingredients. Mix 1st speed 1 minute.
7. Scrape
8. Mix 2nd speed 2 minutes
9. Add dry flour mix.
10. Mix 1st speed 1 minute.
11. Scrape.
12. Mix 2nd speed, 1 minute.
13. Mix 15 seconds on speed 3.

KSU BAKERY SCIENCE FORMULA

PRODUCT: Gluten Free Chocolate Chip Cookies FORMULA NO:__________

DATE OF ISSUE: 4/6/10

BAKER'S%	INGREDIENTS	WEIGHT/ GRAMS
39.51	Butter, softened	260
28.57	Corn Syrup	188
36.78	Brown Sugar	242
17.63	Liquid Whole Eggs*	116
2.43	Vanilla, Liquid	16
40.72	Tapioca Starch	268
53.2	Sorghum **OR** Brown Rice Flour	350
6.08	Corn Starch	40
0.61	Xanthan Gum	4
0.91	Baking Soda	6
0.61	Salt	4
333.43	Chocolate Chips	700

NOTES: Use 12 quart mixing bowl and paddle
Makes approximately 30 cookies, level scoop size
*Crack fresh eggs into bowl, whisk, then measure grams.

INSTRUCTIONS

1. Place first stage ingredients into mixing bowl. Mix on 1st for 1 minute.
2. Scrape
3. Mix on 2nd speed for 2 minutes.
4. Add combined dry ingredients and mix on 1st speed, 1 minute.
5. Scrape
6. Mix 2nd speed, 1 minute.
7. Add chocolate chips and mix 1st speed, 1 minute.
8. Deposit level scoops on lined sheet pan. 3x5
9. Bake 12-14 minutes at 350°F

Discussion

1. **List the big 8 food allergens as recognized by the U.S. Food and Drug Administration.**
2. **What are the four major proteins found in wheat flour?**
3. **Which of the four proteins is the major cause of celiac disease? Explain the complications and health risks caused by this specific protein.**
4. **From the processing aspect what makes producing gluten free baked products so challenging?**
5. **Did you witness any of the above problems with the products produced in lab today? Explain.**
6. **From the sales and marketing aspect, what makes the sale of gluten free products so difficult?**
7. **There is an ongoing debate as to whether old fashioned whole grain oats are gluten free. Please explain what the rationale is behind both sides of the issue.**