

Baking Sciences: Comparing Flours



Flour: n. The finely ground and sifted meal of any of various edible grains.

Lab goal: Students will examine flours, label terms and test differences using a variety of wheat and non-wheat flours in mixtures and baked products.

Introduction: One of the first things a baker learns is that **every flour is different.**

This is because:

- Every year, wheat will vary due to the growing conditions.
- Different types or **classes** are grown in different climates and geographic areas (hard red spring, hard red winter, hard white, soft red winter, soft white and durum).
- In each class of wheat there are thousands of **varieties** that may be grown.
- Millers purchase wheat from a class and variety that will produce the flour their customer (bakeries, cereal, pasta or food company) specifies.

The flour used in a product is critical to baking success.

Teacher Supplies:

- Obtain different flours to show, read and compare labels and use for the lab experiments.
- You may also want to show baked examples that are made from the different flours.
- Have or obtain a probe instant read thermometer and if possible scales to weigh ingredients. (Salter electronic scales are affordable.)
- Need to order? See www.kingarthurflour.com, www.bobsredmill.com, www.hodgsonmill.com
- Scales: www.chefscatalogue.com or www.everythinghome.com
- Ingredients and equipment for the Baking Lab recipes

About Flour:

Professional bakers stock the right flour for the products they bake. They will seldom use an “all-purpose” flour. The wheat farmer raises classes and varieties of wheat for the miller and baker. Millers mill flour specifically for the baker’s needs.

Home bakers use the flour we can buy at the store or order through a catalogue or internet site. Avid home bakers will often buy cake, pastry, bread, whole wheat, and all-purpose flour. They may also be able to buy *patent* or *short patent flour* and *self-rising flour*. Keeping all-purpose and whole wheat flour on hand is also a sure way to be able to bake most products at home.

For **variety**, bakers also buy flours made from a variety of grains (rye, soy, cornmeal, oats, spelt, amaranth, and more). The products made from these are often more than $\frac{3}{4}$ wheat flour and the remainder of the flour is another grain or mixture of grains. These bread products are called “variety”, “multi-grain” or “seven, nine or twelve grain.”

Visual Aids: Help students understand wheat varieties and flour by viewing the Kansas Wheat Commission's "Amazing Wheat" video or the power point "From Field to Flour."

Need-to-know flour terms:

- Flour can be made from many **grains** such as wheat, rye, oats, corn, millet, triticale, quinoa, and sorghum.
- Flours made from wheat are the principle flours we use in baking because of the proteins *glutenin* and *gliadin* that combine to form **gluten**.
- The type or class of wheat milled to make the flour makes a difference in the protein (gluten) quality and quantity of the flour.
- Gluten is formed when flour and water are mixed. Gluten is the elastic "stretchy" strands that give structure to dough. It can hold gas from the leavening agent and help the batter or dough expand and become airy.
- Too much gluten or too little gluten makes a difference in how recipes turn out. Too dry, crumbly, tough, or heavy describe the difference gluten can make.
- Flour or meal made from **non-wheat grains** (rye, oats, corn, spelt), seeds (amaranth, flax), legumes (soybeans, lentils) and even vegetables (potatoes, garbanzo beans) are low in gluten or may be "gluten free." These flours do not produce light baked goods if too high a percent of the flour is non-wheat; 5 - 25% non-wheat flour may be used for best results. (Ex: ½ - 1 oz. non-wheat flour + 3 - 3.5 oz wheat flour = 4 oz (1 cup)).

See the Sites about flours you can use in baking.
Visit www.homebaking.org
Also www.namamillers.org/kids.html

"Hard" wheat classes make flour that is higher in protein. These flours are more absorbent due to the higher gluten or protein. When mixed they will form stronger gluten structures, so are great for yeast loaves, buns, pizza crust, soft pretzels, and whole grain breads.

"Soft" wheat classes often contain less protein and form weaker gluten structures. These will make more tender products such as biscuits, scones, muffins, cookies, cakes, pastries, and crackers.

Supermarket basics:

Supermarkets sell a variety of flours and baking mixes. Use the side bar questions and a variety of flour labels to see what you can learn.

- All-purpose (enriched, unbleached or bleached)
- Cake flour (enriched, bleached)
- Pastry flour (enriched or whole wheat)
- Bread flour (enriched, unbleached, whole wheat; 50:50 blend)
- Whole Wheat Flour hard (higher protein) or soft (lower protein); sometimes labeled "stone ground" or "graham"
- Blended flour (50:50) (whole wheat and enriched)
- Baking mixes (companies select the best-suited enriched wheat flour for the product)
- Self-rising flour (enriched, all-purpose flour with leavening and salt)
- Short patent flour (unbleached or bleached; enriched) short patent is the finest (60%) separation of the flour
- Bread machine or baking mixes (enriched, wholegrain)

Label Savvy

Read to See:

- What company made the flour?
- Where is the flour milled?
- What grain is it made from?
- Can you tell from what wheat class it is made?
- Is it enriched?
- Is it bleached?
- Is it whole grain or have the germ and/or bran been removed?
- Compare Nutrition Facts labels for carbohydrate, vitamins, protein, fiber, sugars.
- What influences you to buy this flour or mix?
- What would you bake from each flour?

Food service/bakery flour distributors: Bakers will order any of the flours above, but will have additional specifications for flour (protein, ash, moisture, mixing tolerance) that the miller will use to produce exactly the flour needed for the end product.

Need-to-Know Flour Names:

- **All-purpose flour:** acceptable in cookies, cakes, pancakes or waffles, muffins (quick breads), pizza crust, and some yeast breads. It's generally produced from the type of wheat grown nearby. It is enriched and is made from hard, soft or a blend of wheats—usually wheat is grown near the mill. It may be bleached or unbleached, and it is enriched.
- **Bread flour:** unbleached, higher protein (11 to 14%) “strong” or high gluten flour made from hard winter or spring wheats; best for baking yeast bread products (bagels, hearth breads, pizza crusts, pan bread, rolls, artisan breads, sweet rolls)
- **Cake flour:** enriched, bleached (to modify gluten strength), low protein (7-8%) flour for high ratio, angel food and chiffon cakes
- **Enriched: made from the endosperm of the wheat kernel**—Three B vitamins, iron, folic acid and occasionally calcium, are added.
- **Pastry flour:** bleached or unbleached enriched low protein (8-9%) flour used for cookies, brownies, sheet cakes; made from soft winter red or white wheat.
- **Patent and short patent:**
Straight grade flour is 100% of the flour separated from the wheat kernels or berries.
Patent is the innermost 70 to 80% of the separation.
Clear (first or second) flour is the flour left when the patent or short patent is separated from the straight grade—not best for baking
- **“White” flour:** another term for enriched (not whole wheat) flour—it may be cake, all-purpose, pastry or bread flour.
- **Whole wheat:** contains all the parts of the whole kernel of wheat—bran, germ and endosperm
Graham flour: coarse whole wheat flour named after Rev. Sylvester Graham, an early health advocate of eating whole grain flour products.
Stone Ground flour: Most flour is produced in a roller mill, separating the parts of the wheat with steel rollers. Stone ground flour is wheat ground into flour between stones (once water powered) without separation or sifting.
- **Gluten flour:** flour produced by extracting some of the starch to make it higher protein; used to produce lighter, lower starch breads; often combined with low-gluten strength ingredients (non-wheat flours or meal).
- **Vital wheat gluten:** dried gluten, taken from flour by removing the starch. Used to increase dough strength in breads with non-gluten flour, bran or whole grain. It is 80% protein. Will be added in dough at 1 to 4% of flour weight plus added water 1 to 1.5 times the weight of the gluten.

“It has been fully proved the bulk, or a due proportion of innutritious matter in our food is quite as important to health as nourishment.”
Graham on Bread 1837.

Technology Assignment: Assign students to find 5 resources they could use to help them learn more about flour, milling, baking at some of the following sites.

- www.aibonline.org (American Institute of Baking)
- www.farmerdirectfoods.com (White Wheat Producers)
- www.bbga.org (Bread Bakers Guild of America)
- www.homebaking.org (Home Baking Association)
- www.oznet.ksu.edu/dp_grsi (Kansas State Univ. Grain Science)
- www.kswheat.com and its education links (Kansas Wheat Commission)
- www.namamillers.com (North American Millers Association)
- www.rbanet.com (Retail Bakers of America)
- www.wheatfoods.org (Wheat Foods Council)
- www.wholegrainscouncil.org (Whole Grains Council)
- www.baking911.com (Baking 911)

Grain Website Work Sheet

Name: _____

Site Name: _____

URL: _____

List 4 featured sections: _____

Section(s) I visited: _____

Link(s) I visited: _____

What I would use at this site for future baking, nutrition or other interests:

1. _____
2. _____
3. _____

Site NAME: _____

URL: _____

List 4 featured sections: _____

Section(s) I visited: _____

Link(s) visited: _____

What I would use at this site for future baking, nutrition or other interests:

1. _____
2. _____
3. _____

Enquiring Minds Want to Know: What difference(s) will it make if I use (substitute) all-purpose, cake, bread, whole wheat, short patent or a non-wheat flour in a recipe/formula?

Use the **Flour Chart** below and the **Need to Know Flour Basics** in the lab introduction to help you hypothesize what differences substituting flours may make.

Flour Chart: Wheat Classes and Major Wheat Flour Types Used in Baking

Wheat Classes and Flour Types	Flour Uses	Protein	Dough Strength	Water Absorption	Mix Time	Gluten Forming
Hard Spring High Gluten	Bagels, Hearth breads, Thin pizza	12-14% 13.4- 14.4%	High	High 60-65%	Long Mix Time 12-14 minutes High gluten forming	
Strong Patent	Pizza Crust, Hearth breads	12.8- 13.2%				
Spring Patent	Breads Rolls	12.4- 12.8%				
Hard Winter Winter Patent	Pan Breads Artisan bread, Sweet dough, Thick crust pizza	10-12% 11-12%	Medium	Medium 50-60%	Medium Mix Time 8-12 minutes Medium gluten forming	
All-Purpose	Quick breads, Cookies	10-11%				
Soft Winter Pastry	Cookies Brownies	7-9% 8-9%	Medium	Low	Short Mix Time Low gluten forming	
Cake	Sheet cakes, High Ratio cakes; angel	7-8%				

NOTE:

- Gluten, strong patent, spring patent, winter patent are all bread flours.
- Non-wheat flours (rye, soy, cornmeal, oat, sorghum etc) will perform very differently because their protein is low or non-gluten forming.

Lab Note to Teacher: You may organize the following ingredient lab tests in several ways using a favorite graphic organizer. Repeat (replicate) the same tests to compare results.

Option 1: Have two or more students use each of the flours for testing to see how their results compare. Observe, record and compare results.

Option 2: Use Lab #1 as a demonstration and have students assist you with the mixing. Time each mixing length so it is the same and use the same mixing speed for scientific results.

Ingredient Lab: Flour Absorption and Gluten Development

Before you start: Read together all the labels on the various flour packages to compare or determine what class of wheat or type of grain, how much gluten they may have based on the protein content, is it enriched or whole grain. (See Label Savvy question box to get you started.)

Question to test:

- What difference(s) will you observe when substituting different flours one-for-one with all-purpose flour in a mixture? (Observe after mixing the same amount of time and at the same speed.)

Have each student write:

Our lab compared all-purpose flour with _____ flour and _____ flour.

My hypothesis about what I will observe is: _____

You'll Need:

1/2 cup (2 oz or 55 grams) of each type of flour

- All-purpose flour
- Cake flour
- Bread flour
- Whole wheat flour (hard red or white OR pastry/soft wheat)
- Rye, soy, sorghum or other non-wheat flour

Water (3/4 cup or 6 oz. or 175 ml)

Four or more bowls and electric mixers (use standard beaters, not dough hooks).

Basic Experiment: What to do.

1. Scoop each type of flour out of their bags and into a separate bowl; label.
2. Stir each flour with a large spoon to “fluff” or unpack the particles.
3. Spoon flour into a 1 cup dry measuring cup, heaping it up, then level it off. (Do not pack, shake or push down on the flour in the cup) **OR** Use an ingredient scale and weigh 4 oz. or 115 grams of each flour.
4. Put each type of flour in a medium mixing bowl. Label with flour name.
5. Using a liquid measuring cup or beaker, placed on a flat surface, add 6 oz. (3/4 cup) or 175 ml cold water.
6. Mix flour and water on LOW speed for 1 minute; record observations. Continue mixing on MEDIUM speed for 2 minutes. Record observations. Be consistent in mixing speed and time.

1,2,3 Report: May use the back of this page.

1. List the flour name(s) your lab used.
2. Describe the differences found in the mixtures after 1 minute mixing and 2 minutes.
3. Discuss concepts such as: how fluid or stiff was the mixture, development of batter structure (gluten strands developing, lumpy, no strands), how much water was absorbed (stiff, fluid, medium stiff), batter/dough strength (hard to mix, not hard to mix).

Baking Lab: Basic Muffins or English Muffin Batter Yeast Bread

- Use a variety of flours, soy, rye, wheat, sorghum and compare their mixing properties or performance in a recipe.
- Make Basic Muffins or English Muffin Bread, varying the flour types. For one variable use a muffin mix or bread mix.

You'll Need:

- Variety of flour types (whole wheat, all-purpose, bread, pastry or cake, rye, soy Self rising flour may be used, but omit leavening and salt from the recipe), baking powder, fast-rising yeast, milk, large egg, vegetable oil or melted butter, granulated sugar, one basic muffin mix or bread mix, baking soda, salt, cornmeal
- Ingredient scale OR standardized dry and liquid measuring utensils; spoon; spatula/level
- Hand or stand mixer with standard beaters
- Instant read probe thermometer (to take internal temperature of Muffin Batter Bread)

What to Do: Prepare four (or more) batters using recipe #1 or #2. Be sure to:

Sample Lab Teams
Team #1: all purpose flour
Team #2: 50% all purpose 50% whole wheat
Team #3: cake flour
Team #4: bread flour
Team #5: soy or rye flour
Team #6: whole wheat flour
More teams? Use pastry flour, cornmeal, oat flour, etc.

- Weigh or carefully measure all ingredients
- ONLY vary the type of flour used (use butter OR oil in all the recipe tests)
- Label each mixing bowl with the type of flour used in that batter
- Write each type of flour on small strips of plain paper; tuck into the side of one muffin cup in each pan to avoid confusion.
- **Use the same amount of mix time and/or mixer speed for each batter**

Question to Test: What difference(s) do you think substituting _____ flour for all-purpose flour will make?

Hypothesis: _____

Recipe option #1: (Minimum 50 minute lab + report on 2nd day)

Basic Muffin - Makes six, medium (2 ½-inch) muffins

<u>Ingredients</u>	<u>Measure</u>	<u>Weight/Volume</u>
All-purpose flour	1 cup	4 oz or 115 grams
Baking powder	2 teaspoons	1/4 oz or 7 grams
Salt	1/4 teaspoon	1 gram
Sugar	2 tablespoons	0.9 oz or 25 grams
Small egg, beaten	1 whole egg	1.5 oz. or 42g
Low fat milk	½ cup	4 oz or 125 ml
Melted butter or cooking oil	2 tablespoons	1 oz or 28g

Instructions:

1. In a medium mixing bowl, using a wire whisk, blend the flour, baking powder, salt and sugar.
2. In a separate small bowl, combine beaten egg, milk and melted butter OR vegetable oil. Add to dry mixture, stirring only until moistened. Do not over mix—batter will be slightly lumpy.
3. Drop by large spoonfuls (ice cream or #20 scooper) into six medium (2 ½-in), greased muffin cups, fill each muffin cup 2/3 full.
4. Bake at 425° F., 18-20 minutes, or until golden. Enjoy warm.

BEFORE YOU START:

Stir flour if using dry cups to measure. Spoon and level.

Preheat oven to 425°F.

Grease or spray the bottoms only of six, medium (2 1/2-inch) muffin cups.

Technology Option: Take digital food photos of muffin exteriors and interiors.

Recipe Option #2: (Two Day lab+ report day)

English Muffin Batter Bread - Makes one, 8 ½-inch X 4 ½-inch loaf

<u>Ingredients</u>	<u>Measure</u>	<u>Weight/volume</u>
Flour (stir, spoon, level)	2 ½ cups	10 oz.
Fast rising yeast	1 ¼ tsp.	1/8 oz. or 3.5 g
Granulated sugar	1 tablespoon	½ oz. or 14 g
Salt	1 teaspoon	1/6 oz. or 5g
Baking soda	1/8 teaspoon	
Milk, low fat	1 cup	8 oz. or 225 ml
Water, cold	¼ cup	2 oz. or 55 ml
Vegetable oil		
OR melted butter	1 tablespoon	½ oz. or 14 g
Corn meal	Less than 1/8 cup	½ oz. or 14g

Sample Lab Teams Team #1: all purpose flour Team #2: 50% all purpose 50% whole wheat Team #3: cake flour Team #4: bread flour Team #5: soy or rye flour Team #6: whole wheat flour More teams? Use pastry flour, cornmeal, oat flour, etc.

Instructions:

1. Heat (scald) milk in microwave about 1 minute on high—until steaming (200°F). Stir in ice cold water. (Take temperature--mixture should not be hotter than 130°F.)
2. In a large mixing bowl, combine 1½ cups flour, yeast, sugar, salt and baking soda. Stir in liquids and oil or butter; add remaining flour.
3. Mix with standard beaters on low speed 1 minute; then mix on medium speed 5 minutes.
4. Grease or spray one 8½ in. X 4½ in. loaf pan; sprinkle with cornmeal. Spoon batter into the prepared pan. Let rise in warm (90-100°F) place for 20-30 minutes. (Until doubled—batter above the edges of the pan.)
5. Preheat oven to 400°F. Bake for 25-30 minutes or until all sides of the loaf are nicely browned. Take the internal temperature of the loaf with a probe thermometer. NOTE: Bakers go by interior temperature of loaf: Using an instant read probe thermometer take the interior temperature of the loaf. (Insert thermometer in end of loaf.) Temperature should read 200-210°F.
6. Cool loaf on wire cooling rack—remove from pan after 5 minutes. Cool 15 minutes (minimum) or preferably to 90°F (interior temperature) before slicing.

Recipe: Kansas Wheat Commission. Yeast Breads Made Easy. www.kswheat.com

Technology Option: Take digital photos to show comparisons.

1,2,3 Report: May use the back of this page

1. Describe (visual and physical) your lab's batters after 1 minute and completed mixing.
2. Keep each flour-type of muffin separate after baking. Cut in half to record what the crumb (interior) looks like, how dry the muffin is, and other attributes.
3. Taste a small bite of each muffin. Record how each muffin tastes. (May use A Matter of Taste form)

Summary: What flour type or blend would you recommend for this product? Was your hypothesis correct or incorrect? If incorrect, describe why. Why would using a variety of flours be good? How could the muffin/muffin bread be made using a variety of flours?

Have each lab group share their report.

LAB Evaluation Forms

A Matter of Taste

Product Tasted: _____ Lab group: _____ Date: _____

I think the food product tastes:

_____ very good _____ good _____ okay but not my favorite _____ needs improvement

The food tastes: _____ sweet _____ bitter _____ salty _____ sour _____ not what I expected _____ just right

The color is: _____ great _____ too pale _____ too dark _____ not right for the product

The aroma (smell) is: _____ too strong _____ too weak _____ just right _____ not good

The food looks: _____ yummy _____ okay _____ not good

I would enjoy eating this food again. _____ yes _____ no _____ maybe

Comments: _____

Lab Rubric	Very Acceptable	Okay	Not Acceptable
Type of flour used: _____			
Top and bottom crust	Evenly golden, Not burned or pale	Edges browed	Very pale, Greasy or doughy appearance, Brown on only top OR bottom
Volume	Doubled in height	Raised somewhat	Same height as when dough
Interior crumb	Flaky, tender	Moist and not too dry to eat	Dense, wet, crumbly or doughy Oily or greasy
Flavor	Rich, a little sweet, wheaty, pleasant	Pleasant flavor	Too much oil or fat flavor Coats mouth; unpleasant
Keeping quality after 1 day	Still flavorful, Good aroma/ flavor	Edible but could be better	Crumbly or off flavor Flat flavor; Dry or tough

Alternative Flours Lab Experiment Worksheet

Name: _____ Hour: _____ Lab#: _____ Date: _____

Product made: _____ We use _____ flour

Product Comparison Chart:

	All-Purpose Flour	50% All-Purpose 50% Whole Wheat	Cake Flour	Bread Flour	Rye, Soy, or Oat	Whole Wheat
Visual differences in batters						
Color of baked products						
Texture Rating						
Moisture Rating						
Flavor Rating						
Flour Type						

Ratings: Texture = 1 - 5
soft - tough

Moisture = 1 - 5
very moist - dry

Flavor = 1 - 5
desirable - undesirable

Flour Type Recommendation = 1 - 6
best - worst

- On the back of this chart note what flour(s) you used in the lab.
- Write a summary of the experiment, your observations and an explanation of your texture, moisture, flavor and recommended ratings.
- If the product did not rate very high in most areas, state what you might change in order to improve the batter.
- If the product was great, what would you name the product to sell it?

_____ (Product Name)

Flour Lab Resources and References

A Bakers Dozen Tips for Baking Success. (Video/DVD). 2005. Home Baking Association. www.homebaking.org

Amazing Wheat Video. www.kswheat.com

Baking for Success. Video and lesson. Home Baking Association. www.homebaking.org

Baking 9-1-1. Sarah Phillips. How Baking Works. www.baking911.com

Bread Comes to Life. A Garden of Wheat and a Loaf to Eat. 2005. George Levenson. www.bread-comes-to-life.com or 800.827.0949 An ALA notable children's video.

Breads the Significant Edge. Sharon Davis. KS Wheat Commission or Wheat Foods Council. 1991. www.kswheat.com or www.wheatfoods.org

Farmer Direct Foods. www.farmerdirectfoods.com

From Wheat to Flour. Sharon Davis. 1998. North American Millers Association/Wheat Foods Council

Get on the Grain Train. USDA, 2003. www.nutrition.gov

Practical Baking. William J. Sultan. 5th Edition. 1990. Von Nostrand Reinhold, NY.

Quantity Yeast Breads from Start to Finish. Kansas Wheat Commission, Kansas Dept. of Education Child Nutrition & Wellness. 2005. Contact Toll-free 866.75WHEAT -www.kswheat.com

Quick Breads. More on <http://www.baking911.com/quikbrds101.htm>

The New Food Lover's Companion. Sharon Tyler Herbst. 2nd Edition. Barron's Educational Series. www.barrons.com

US Wheat grain card (six classes of wheat) available from Kansas Wheat Commission. www.kswheat.com

Yeast Breads Made Easy. Sharon Davis. www.kswheat.com

Power Point: Baking Ingredients—Quick Breads section

Sites to Cite:

- www.aibonline.org
- www.baking911.com
- www.foodnetwork.com (Click on Cooking Demos; Baking)
- www.kswheat.com
- www.homebaking.org
- www.namamillers.org (Go to Kids Zone)
- www.oznet.ksu.edu/sp_grsi/
- www.thepreparedpantry.com
- www.wheatfoods.org
- www.kn-eat.org