The Art of Building Structures in Baking

One of the great challenges in baking is the creation of the necessary structure in a product to give it the texture you want. The right structure makes the product more palatable. In breads, you work to build a structure that will hold gas as the yeast ferments and will set and hold its volume when baked. If you use only wheat flour in the formulation, it's easy. If you add other whole grains, tenderizers (e.g., fat and sugars), inclusions (e.g., nuts and raisins), etc. or if you remove the gluten, as in gluten-free foods, then you have a real challenge. Cakes contain high levels of sugars and fats and little flour, so you depend on the quality of the gluten and starch from the flour, milk, and eggs to set the framework of the crumb. If you use higher amounts of sugars and fats or try to reduce the use of eggs to control costs, it is a challenge to achieve the right framework. Cookies likewise depend on gelatinization of flour and starches and crystallization of sugars, as well as fats, eggs, and milk (if you can afford it), to create the desired texture. Again, if inclusions are added, eggs and milk are taken out, or syrups are substituted for starches and sugars, development of a good framework becomes more challenging.

I am generally a practical baker, and understanding how the various structures are formed in baked goods aids in understanding what interactions are happening between different proteins, various forms of carbohydrates, different fats, and water at the molecular level. When you add in the baking or heating aspect, the effect it has on each individual component, and how the individual components react together in various ratios, you have a real mystery. You have to rely on experience to know what works and what doesn't. In this column I'll share some of what I have learned from my own experiences and from talking to others.

Yeast-Raised Products

Breads and other yeast-raised products typically depend on gluten for their structure. One of my baking teachers, Conrad H. Schild, at the Dunwoody Baking School, said that it all boils down to gas retention. If the dough will hold the gas and rise, you will have bread. There are several varieties of wheat flour to choose from, which I would guess many readers of this journal could teach me a thing or two about. For white pan breads, the most popular flours are hard red winter wheats from the more temperate zones of the American Midwest. For creating stronger crusty loaves, red and white spring wheats, with their higher and stronger protein contents, are preferred. The use of hard white wheat is a relatively new development, becoming more popular starting in the early 1990s. In its whole wheat form, it provides a “sweeter” flavor than hard red wheat, which can have a bitter bite to it. As a result, the popularity of ultramilled white wheat has exploded in the past few years.

When using different whole grains in breads, hard spring wheats can be used to carry the dead weight of the whole grains. An alternative is to use a less-expensive hard wheat and boost its protein content and strength with vital wheat gluten. This will help to a point but will also increase the cost. As a general rule, figure that vital wheat gluten added at 2% of the formula will be needed to raise the protein of the wheat 1% with regard to functionality.

You can use hard red spring wheat to provide strength in doughs containing other grains and inclusions. A dough that is high in fat and sugar, like a Danish pastry dough, is another potential application for hard red wheat. I made a rich Danish pastry dough for the holidays once. Thinking it was going to be very rich and that I would need a stronger flour system than primarily soft wheat with a little hard wheat, I used all hard spring wheat flour. The resulting pastry had a very tough bite. I left it at home, opting not to show it off to my family full of bakers. The lesson—structure development isn’t always a straightforward cause and effect process.

When making breads, you can use the straight-dough method or sponge and dough method. I believe that using a sponge and dough method produces a better structure because everything has more time to hydrate and mellow with the added fermentation time. Depending on how much structure is needed, the amount of flour added in the dough stage can be varied. All things being equal, I believe the sponge and dough system can give you more strength than a straight-dough system.

Structure in gluten-free doughs is a different challenge. Eggs are a big help, as are milk and whey protein concentrates and isolates, in developing gluten-free structures. Flours from grains containing gums or fibers such as β-glucan, arabinoxylans, and pentosans can also contribute to structure. As these components hydrate in the dough, they promote dough cohesiveness, elasticity, and gas retention. Xanthan gum can also aid in gas retention in gluten-free doughs.

Soy protein is a popular protein source for both conventional and gluten-free baked products, although it has limited potential for providing structure in baked products. Typically, soy protein absorbs so much water that it is difficult for the dough to maintain its volume. Because it is high in water, the product usually ends up with either a very dense crumb (or no crumb) or a crumb with very thick, wet cell walls. Soy protein has proven to be helpful in very wet yeast-raised doughs such as English muffin dough. Without soy protein the centers of these
buns would collapse. When soy protein is added in moderate amounts, they have a nice crown.

**Chemically Leavened Products**

When thinking of chemically leavened products, a wide variety of cakes, muffins, cake doughnuts, and cookies come to mind. For these types of products, structure-building ingredients are more straightforward—sort of. The common ones are, of course, flour, eggs, and milk. Sugars and starches with proper characteristics also help build structure.

For cakes, eggs are generally the main source of structure. However, what if you are trying to make a foam cake, such as a sponge cake, from a dry mix instead of from scratch, whipping the eggs up and folding in your flour? I did this once, and it proved very interesting. It turns out that it matters what part of the egg you use, how much you use, and, interestingly, how the egg is processed. For dried egg ingredients, it matters whether a whole egg (white and yolk together) is dried as a whole as it comes from the egg versus each component being dried separately and blended together. When using xanthan gum and egg that is dried as a whole, you can make a sponge cake with a nice grain that is suitable for making a jelly roll. If the dried egg is a recombined product, the sponge cake will have large, coarse cells, and the jelly roll will not roll. It will crack at each turn.

For high-ratio layer-type cakes, the eggs used are important, as are the flour and level of flour bleaching. The more bleach (chlorine gas) is used the lower the pH of the flour, as well as the gelatinization point of the starch, which in turn provides the structure or grain of the cake crumb. Milk helps form the structure in a cake by improving the cohesiveness of the crumb. The less milk used (e.g., when nonfat dry milk is used), the more crumbly will be the crumb. Low-egg and low-milk formulas usually result in vertical cracking around the edges of a layer cake, as well as a crumbly crumb. When using a dry egg ingredient it is also important to make sure the ingredient is only egg. If the ingredient is called an “egg product” as opposed to “dry egg,” it is likely dry egg, or one of its components, diluted with corn syrup solids or some other extender and is a lower cost product. Using this in a high-ratio layer cake will result in a crumbly cake that is so tender it breaks apart when handled. (This is a lesson learned from one of the baker friends.)

Cake doughnuts are one of the most sensitive products created in a bakery and the most challenging to make consistently. You don’t want to try and make cake doughnuts from scratch because they are extremely sensitive to fluctuations in flour and other ingredients. A prepared mix is the only way to go for cake doughnuts. The flour content, which is typically a blend of hard and soft wheats (both white and red soft wheats), affects the break and starring in the hole of the doughnut. To create volume, the flour blend and level of dry egg yolks are key. Egg yolks are expensive, so other ingredients, such as soy flour and gelatinized corn flour, can help increase the volume and keep costs down.

For cookies, at first blush the structure does not seem to be as important as in other baked goods. However, structure is critical to ensuring dry cookies don’t crumble and soft cookies don’t have a dense bone (i.e., a dense layer in the middle of the cookie). Making sure the cookies fit in the package every time is important as well. If they don’t fit in the package, they don’t ship. Spread control is maintained through the flour and sugar ratio used and through the type of flour used and degree of flour bleaching (i.e., flour pH). Keeping the spread the same from cookie to cookie is critical to getting the product on the shelf. Soft cookies are especially sensitive to flour quality fluctuations. Dry wire-cut cookies are less sensitive to spread fluctuations due to flour quality. Creating dry wire-cut and rotary-type cookies that are hard or crisp depends more on the types of sugars used than on the structure of the cookie. Corn syrup is an easy way to make them crisp or hard, but not necessarily tender. The trick is to bake them out dry.

Dough and flour pH play a big role in cookie structure, in addition to helping control spread. They can also have a large impact on the tenderness of a cookie. A good example is a snickerdoodle cookie, which is a light colored cookie traditionally made with cream of tartar, which lowers the pH of the dough. The bite is tough and sometimes chewy. I have seen this with other “golden” colored cookies as well. It is surprisingly challenging to make them soft, not tough.

In cookies, if you replace sugars with syrups, which are typically cheaper than granulated sugars, obtaining a good structure becomes more challenging. Syrups bring with them moisture, which in addition to fat and sugars makes it difficult for the structural components to maintain a raised structure so the core of the cookie doesn’t collapse into a dense bone. A cookie with a bone will dry out faster and harder more quickly than a cookie without a bone, which limits its shelf life. In this case, you need to limit the total moisture going into the cookie or provide more structure-building ingredients to hold it up. Unfortunately adding more structure builders can add to the cost and offset any savings from using a syrup system. It all has to be balanced.

Reflecting on the structure of baked goods when writing this column, structure really is key to making a good baked product. Yet, how structures are formed and created and how the different components interact to form those structures are among the least understood parts of baking. To this point, I guess, this is what keeps the art in baking.