Kitchen Chemistry

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The Science of Cooking Workshop

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What is really happening to the molecules when you grill a steak? Fry an egg? Steam your broccoli? Bake bread? Most importantly, why does it matter?

When you make dinner there is more going on than you know. On the miniscule level unfamiliar chemical reactions are happening, changing your food in familiar ways. It is easy not to think about but it is important to know so you are better able to make choices that bring out the flavors you love while maintaining the nutrition you need. The various methods of cooking affect your food in different ways. Examining these processes is a fun way to empower the scientist chef inside of you.

Remember though, regardless of the cooking method you try the quality of the food you choose to start with has the greatest effect of the nutrition you end up with.

Grilling:

Most meat is slow twitch animal muscle, 75% of which is water. The rest is protein (about 20%) and fat (5%), as well as small amounts of carbohydrates, acids, and minerals. The meat contains myoglobin as an internal energy source. Similar to hemoglobin, myoglobin is a protein that stores oxygen in red blood cells. This pigmented substance is why your steak is red and why in packaging, deprived of oxygen, might turn brown. So what happens when a piece of raw meat goes on a hot grill?

According to HowStuffWorks, the protein molecules are in bonded coils, but as heat is applied the bonds are disrupted and the coils start to unwind. Meanwhile much of the water content in the muscle fibers leaches out – that's why your fillet steak or chicken breast is smaller after cooking than when it is raw. If it's red meat (lamb, beef) it begins to turn brown as the myoglobin reacts to the heat. The iron atoms in the protein lose an electron and this gradually changes the color from red to brown. White meat (chicken, turkey) has far less myoglobin, so it is pink when raw and turns white when cooked.

But there is more to it than color. There are also molecular changes that alter the flavor of the food you grill. The Maillard reaction, named after the French chemist, is a chemical reaction between amino acids and reducing sugars that gives browned foods their desirable flavor. This occurs rapidly from around 284 to 329 °F. At higher temperatures, caramelization and subsequently pyrolysis (charring effect) become more pronounced.

Learn more here https://en.wikipedia.org/wiki/Maillard_reaction

Although delicious the charred edges of what we grill also contain carcinogenic (HCAs), proven to be detrimental to your health. And what about all that smoke getting into your meat (PAHs)? But there are ways to minimize your exposure to carcinogens when grilling. Ensure your grill is clean of the old burnt bits before you use it again, use marinades with vinegar or lemon (which change the acidity and preventing PAH's from sticking), and don't be afraid to get the char you want then finish off in a hot oven.

But don't let nervousness make you avoid the grill. Stephanie Meyers, a nutritionist at the Dana-Farber Cancer Institute, says "keep the risk in perspective."Grilled foods are not the greatest cancer risk--not wearing sunscreen while at the grill is a bigger deal." So put on some SPF and grill away!

Check out these links to find out more about cooking the perfect steak:

http://recipes.howstuffworks.com/tools-and-techniques/grilling-steak-pictures.htm

http://www.cookscountry.com/101/

Frying:

It wouldn't be a weekend breakfast without an egg. As the most popular breakfast food the average American consumed 245 eggs last year. This familiar food might even be the first thing you learned how to cook. But let's learn more.

"Eggs are rich in protein, especially the egg whites. It's this protein that causes eggs to become hard when boiled. Here's how it works: protein is a chain of amino acids. These amino-acid strings fold back on themselves. The proteins are held in place by weak bonds between different parts of the amino-acid string. When you break those strings, by various methods, you are denaturing the protein**.**

When you heat an egg, the proteins gain energy and literally shake apart the bonds between the parts of the amino-acid strings, causing the proteins to unfold. As the temperature increases, the proteins gain enough energy to form new, stronger bonds with other protein molecules. As the proteins form these new and stronger bonds the water that surrounded each protein molecule when the egg was liquid is forced out."

[By the way: You can do something similar when you whisk egg whites: By exerting mechanical energy in the whisking process, you cause the protein bonds to break, and subsequently re-connect. Once these new, strong bonds are formed, the egg stays in that state. The proteins have formed a network of strong, permanent cross-links. A cooked, chemically-altered or well-beaten egg will never go back to its original state.]

But frying isn't just for eggs and we have all heard of the consequences of consuming too many fried foods. But nutritionists say it is more about *how you fry* that matters. Here are some easy steps to take to enjoy that crispy texture with less concern. Begin with the oil you choose and the temperature you use.

According to nutritionist Hannah Healy the 6 healthiest cooking oils are ghee (clarified butter), coconut oil, olive oil, avocado oil, sustainably sourced palm oil, and sunflower oil. Mono-unsaturated cooking oils will be liquid at room temperature and are preferable. Also check out this link for oils you may not be familiar with and suggested uses

http://www.pccnaturalmarkets.com/guides/tips_cooking_oils.html

Also, the temperature you are frying your food should influence the oil you choose. Various oils have different smoke points. The smoke point is the temperature at which the oil is decomposed and where possibly toxicological relevant compounds are formed. Check out this link for a comprehensive smoke point chart and check the labels when you buy your oil.

http://www.goodeatsfanpage.com/CollectedInfo/OilSmokePoints.htm

But it can be hard to tell what temperature you are frying without knowing your stoves manufactured setting and let's be realistic about you having read the manual. The best way is to pay attention while you cook. Use a temperature high enough to sizzle but not too high as to smoke. Willingness for experimentation and patients will open up a whole new world of flavors to you. So next time you are in the grocery store spend more time perusing the oil section.

Steaming, Boiling, and Blanching:

Using water to cook food is preceded only by using fire. In fact, in the American southwest, steam pits used for cooking have been found dating back about 10,000 years or more. Steaming is thought to be one of the healthiest ways to cook your food because it does the least (besides consuming foods raw) to alter the intact nutritious molecules of what you are eating. But how does it work?

Water is made up of moving molecules, two hydrogen atoms and one oxygen atom. Slow movements mean solid ice, medium movements we recognize as liquid, and fast movements result in steam. By heating water to its boiling point, 212 degrees F, the kinetic thermal energy causes the water molecules to move around so quickly it exceeds the strength of the hydrogen bonds between the molecules which causes them to separate from the other molecules. When this gas escapes, rising into the air, it carries heat with it. Steaming is just transferring the kinetic energy from the hot water vapor into the molecules of the food. Just like in water the faster movement of molecules means hotter feeling foods.

The only difference between steaming something and boiling or blanching it is the food is in direct contact with the water before the molecular bonds are broken instead of afterwards. Transference of thermal energy occurs and BOOM your potatoes are readying for mashing. But food continues to cook even after being removed from the water which is not always what you want. Limiting how long the food stays in the water and controlling when the cooking process stops differentiates boiling from blanching. During blanching food is submerged briefly in boiling water before being removed and plunged into cool water, therefore halting the cooking process which preserves the texture of food.

There are many foods that are enhanced with blanching. Checkout this website with more information about using blanching to parboil your veggies for the grill and prepare your fruits for preservation in either canning or freezing:

http://www.reluctantgourmet.com/how-to-blanch-foods/

Microwave Oven

The most controversial of all the methods the microwave has its fan club and those whom strictly avoid it. As with all things examining both sides and making your own conclusion is prudent. Knowing how microwaves work will help you make an educated decision for yourself.

According the Wikipedia, Percy Spencer invented the first microwave oven after World War II from radar technology developed during the war. It wasn't until 1967 they were small and efficient enough for the general household kitchen. The microwave heats food by exposing it to electromagnetic radiation in the microwave spectrum. This induces polar molecules in the food to rotate and produce thermal energy in a process known as dielectric heating. Unlike conventional ovens, microwave ovens usually do not directly brown or caramelize food, since they rarely attain the necessary temperatures to produce Maillard reactions (discussed previously).

Microwave ovens are popular for reheating previously cooked foods. The concern about eating leftovers is consuming the dangerous bacterial contaminations that have had time to grow on the food. Microwaves, if used properly, can quickly reach the temperature levels necessary to prevent food borne illness.

However, anyone who has microwaved bread knows there is more going on than just reheating. That rubbery substance previously known as a dinner roll occurs because the microwave primarily heats the water molecules, causing the bread to steam and get chewy.

There are many studies about microwaves that I encourage you to research for more information on the benefits and concerns of cooking with a microwave. Some say it is perhaps a choice between convenience and flavor.

Baking:

We can't talk about baking without mentioning bread. One of the oldest foods in the world almost every culture has its form of bread. What do they have in common? On the most basic level, they all involve cooking a mixture of milled grains and water. There are flat breads and raised breads. Raised breads contain some sort of leavener which comes in two main forms: baking powder or soda and yeast.

We can learn more about bread at https://www.exploratorium.edu/cooking/bread/bread_science.html

Baking powder or baking soda works quickly, relying on chemical reactions between acidic and alkaline compounds to produce the carbon dioxide necessary to inflate dough or batter. Baking powder and baking soda are used to leaven baked goods that have a delicate structure, ones that rise quickly as carbon dioxide is produced, such as quick breads like cornbread and biscuits.

Yeast, on the other hand, is a live, single-celled fungus. There are about 160 species of yeast, and many of them live all around us. However, most people are familiar with yeast in its mass-produced form: the beige granules that come in little paper packets. This organism lies dormant until it comes into contact with warm water. Once reactivated, yeast begins feeding on the sugars in flour, and releases the carbon dioxide that makes bread rise (although at a much slower rate than baking powder or soda). Yeast also adds many of the distinctive flavors and aromas we associate with bread.

But leavening agents would just be bubbling brews without something to contain them. Here's where flour comes in. There are lots of different types of flour used in bread, but the most commonly used in raised bread is wheat flour. This is because wheat flour contains two proteins, *glutenin* and *gliadin*, which, when combined with water, form gluten. As you knead the dough, the gluten becomes more and more stretchy. This gum-like substance fills with thousands of gas bubbles as the yeast goes to work during rising.

But why buy new yeast every time you want to make bread? How did people preserve yeast strains because there were no grocery stores? According to http://science.howstuffworks.com/innovation/edible-innovations/sourdough.htm it turns out that sourdough bread represents a centuries-old technology for preserving and storing yeast for long periods of time, and it is this technology that creates the amazing flavor. Yeast breaks down the starches in wheat flour, forming sugar. This is fermentation. When the yeast works on the starch and sugar molecules, it gives off carbon dioxide gas and alcohol. In sourdough yeast fungi are actually kept alive constantly in a liquid medium called a starter. The baker either captures wild yeast that floats in the air to create starter from scratch or gets a cup of active starter from a friend and expands it.

Here is how to care for your sourdough starter: food, water, and time.

Store your starter in the fridge and plan on feeding it once a week. There may be a bit of light amber or clear liquid on top. Either drain this off, or stir it in, your choice; it's alcohol from the fermenting yeast.

Remove all but 4 ounces starter. Use this "discard" to make pancakes, waffles, cake, pizza, flatbread, or another treat. Or, simply give to a friend so they can create their own starter.

Add 4 ounces lukewarm water and 4 ounces flour to the remaining starter. Mix until smooth, and cover. Allow the starter to rest at room temperature (about 70°F) for at least 2 hours; this gives the yeast a chance to warm up and get feeding. After about 2 hours, refrigerate.

See sourdough recipes at http://search.kingarthurflour.com/