

## Thomas Keller and the Science of Butter-Poached Lobster

Thomas Keller is a great chef who knows a thing or two about cooking. So, when chef Keller first decided to poach lobster in butter instead of wine or cream, he must have had a good reason (*The French Laundry Cookbook*, 1999). The obvious one is that lobster prepared this way is luscious, moist and super tender. The perfect marriage of flavor and texture!

Is there any science behind poaching lobster in butter that we can build upon for the creation of new dishes like Thomas Keller's lobster poached in butter? The answer is yes, but it may seem counterintuitive. It all has to do with the difference in the *heat capacity* of butter versus wine. When heat is added to a substance, such as butter or wine, the temperature of the substance rises. Mathematically the quantity of heat added to a substance divided by its rise in temperature is called the heat capacity of that substance (heat capacity equals the quantity of added heat divided by the rise in temperature). The quantity of heat is measured in Calories, and the temperature rise in degrees Celsius (the temperature scale used in the laboratory).

The heat capacity of butter and wine are not the same. It takes more Calories of energy to raise wine by ten degrees C than it does butter. Unfortunately, wine and butter are mixtures with varying compositions so their heat capacities may vary. But water and olive are pure substances and their heat capacities can be measured very accurately. Using olive oil and water as surrogates for butter and wine, we can explain the difference in their heat capacities. Water has a heat capacity that is about 2.1 times greater than olive oil. This means it takes 2.1 times more Calories of heat to raise the temperature of water by ten degrees Celsius than it does to raise the temperature of olive oil by the same amount.

But why? We learned in the science of cooking with wine that water molecules have a strong affinity for each other due to an electrostatic attraction, which creates relatively weak associations between water molecules known as *hydrogen bonds*. As a result of these hydrogen bonds it takes lots of energy to pull water molecules away from each other in order to get them to move faster. Recall that temperature is a measure of how fast molecules are moving. In order to speed up the motion of water molecules we have to separate them from each other, and this takes energy. Molecules of olive oil have much less affinity for each other so it takes less energy to separate them and make them move faster.

Ok, so it takes about twice as much energy to heat water (or wine) to 160 degrees Fahrenheit (the temperature scale used in the kitchen) than it does to heat olive oil (or butter) to 160 degrees F. But what does this have to do with poaching lobster in butter? All that extra energy added to water heated to 160 degrees F is transferred to food that is cooked in water or wine. Only half the amount of heat

energy is available to transfer to food cooked in olive oil or butter heated to 160 degrees F, so the food cooks more gently and slowly.

This may seem counterintuitive. Ask most people and they will probably say *oil is hotter than water*, so how can food cook more gently in olive oil than water? They are confusing the fact that oil can be heated to frying temperatures, usually 350-375 degrees F, while water can't be heated any higher than its boiling point of 212 degrees F, so oil must be hotter than water! But if we cook lobster in oil and water, *both heated to 160 degrees F*, the water will contain twice as much energy to convey to the lobster as the oil. The key is the different amount of energy available to transfer to the food when both oil and water are heated to the same temperature.

Skeptical? Not sure you believe this. Here's a simple experiment you can do. Heat two small pans of water and oil to 165 degrees F. In each pan drop one whole egg (removed from the shell) and see which one turns opaque first. The egg that heats fastest is the first to become opaque. Still not convinced? Here's another test you can do to convince even the non-believers. Take two more small pans with water and olive oil and heat them to just 135 degrees F (no higher!). Now, stick the index fingers of each hand into each pan at the same time. Which one feels hotter? These experiments were done at America's Test Kitchen and published in *Cook's Illustrated* (March & April 2012, page 30) where you can read about the results.

Using knowledge of the heat capacity of substances like olive oil it is possible to cook foods very gently in these substances using the sous vide method of controlled temperature cooking. Is it any wonder that Thomas Keller, after creating his luscious recipe for butter-poached lobster, went on to write an entire cookbook about sous vide cooking (*Under Pressure: Cooking Sous Vide*, 2008)? Now you know the rest of the story (who said that?).