Making Stock of Things

French chef François Pierre de La Varenne (1615-1678) is credited with publishing the first preparation of a simple stock for flavoring a dish in his cookbook *Le Cuisinier François* published in 1651. In his book the frugal La Varenne describes a recipe for mushroom stock made from blemished mushrooms rather than discarding them. It was more than 150 years later that the great French chef Marie-Antoine Careme' (1784-1833) perfected the basic process still used today of soaking meat in cold water followed by slowly warming and simmering the mixture to avoid overly coagulating the protein while concentrating the relatively clear stock. The French have been masters at making great stock ever since.

Careme's procedure can be broken down into three basic steps: Extraction, filtration and reduction. The first step extracts flavor molecules from the ingredients with water or wine, while the second step removes unwanted coagulated protein, fat and insoluble ingredients to produce a clear stock. The last step evaporates some of the water to produce a concentrated more flavorful stock. Each of these steps plays a role in creating the flavor of the stock. The ingredients determine the specific flavor molecules that are extracted, while heating time and temperature control both the loss of volatile aroma compounds and the formation of new flavor molecules. Filtration not only produces a clear stock but also removes undesirable bitter tastes present in coagulated protein (scum) and rancid fat. The reduction step concentrates flavor as well as provides additional time for the creation of more flavor molecules. In addition to the creation of flavor, the heating steps (extraction and reduction) release gelatin from the collagen in the connective tissue of meat and bones. Gelatin provides viscosity and a pleasing unctuous mouth-feel to the stock.

A traditional stock usually calls for meat (or fish), bones, and vegetables, typically onions, carrots and celery. Raw meat, bones and vegetables may be placed in cold water to start the extraction process, or they may first be roasted in the oven prior to extraction to enhance the flavor of the stock. The process starts with extracting the molecules we taste and smell from the bones, meat and vegetables. During the optional oven roasting step non-volatile nucleotides are derived from the energy-storing compound ATP, (adenosine triphosphate), proteins break down to non-volatile peptides (small fragments of proteins) and even smaller amino acids, while onions and carrots release non-volatile sugars. Because they are non-volatile we cannot smell any of these molecules. But they are all soluble in water so they can be extracted and tasted in the stock. The peptides and amino acids combine with the nucleotides to produce a potent savory, meaty umami taste, while the sugars, and an amino acid called glycine, lend sweetness. Under the conditions of dry heat in the oven volatile aroma molecules that we can smell are also produced. The peptides and amino acids react with certain of the sugars (called reducing sugars such as glucose and fructose, but not sucrose) by the Maillard reaction to produce very potent volatile

aroma molecules. These include caramel-like 4-hydroxy-2,5-dimethyl-3(2H)-furanone, along with popcorn smelling 2-acetyl-1-pyrroline, and the meaty smelling sulfur-containing compound 3-(methylthio)propanal. In addition, the fats are oxidized to compounds with a deep-fried smell, such as 2,4-decadienal and 2,6-nonadienal. These two compounds are soluble in fat but not water. During the slow extraction step in simmering water the onions (or leeks) produce a sulfur-containing water-soluble compound called 3-mercapto-2-methylpentane-1-ol (MMP). The strong meaty aroma of this compound is the most potent contributor to the flavor of stock, along with 2, 4-decadienal, mentioned above (Journal of Agricultural and Food Chemistry, 2011). But MMP is formed only when the onion is finely chopped, not when it is left whole. Don't forget to chop the onion!

After slowly simmering for many hours any protein scum that has floated to the top is removed by skimming and the extract filtered until clear. The last step in the process is reduction. Most cookbooks call for reducing the stock to a specific *volume* to concentrate the water-soluble non-volatile taste molecules rather than specify *how long* the stock should be heated. During this step some of the volatile aroma compounds are lost with the escaping steam. At the same time additional aroma compounds are slowly formed. This is especially true of the very important compound MMP, which takes several hours to form significant amounts. All the while the proteins continue to break down to peptides and amino acids, especially umami-tasting glutamate, while nucleotides continue to be formed by the break down of ATP. This is very important because recent research (Food Chemistry, 2010) has shown that not only the reduction volume affects flavor, but also how long the stock is heated. And the two are not directly related. Depending on the amount of heat applied (high or low flame) the stock can be reduced rapidly or slowly. Fast reduction drives off some aroma compounds without sufficient time to generate new flavor molecules. Compounds like MMP and 2,4-decadienal require a certain amount of time to be formed so a slow simmer over a longer period of time forms more of these crucial compounds. Another study (Journal of Food Science) found the optimum temperature and time to form peptides and amino acids from proteins, and nucleotides from ATP, is 185F for a minimum of 60 mins. The flavor of the stock clearly changes with time so it is advisable to reduce the stock slowly.

In addition to the slow formation of flavor compounds gelatin is also formed very slowly by the breakdown of collagen in the connective tissue of meat and bones. Collagen breakdown takes hours at relatively low temperatures. At around 185F, the temperature at which water slowly simmers, it takes about 6 hours to form significant amounts of gelatin. Therefore, the extraction and reduction steps are best conducted over a period of at least 6-8 hours to increase the formation of gelatin and important flavor molecules such as MMP. It is not uncommon to heat a stock for 16-20 hours, although it is unclear if this much time is necessary. But it does explain why the preparation of a concentrated demi-glace by slowly

reducing the stock to 25-50% of its original volume produces such a flavorful concentrate. It is far more than just the reduction in volume.

Several other factors are important. When the extraction step is started with cold water the proteins slowly coagulate and float to the top so they can be easily removed by skimming the surface as well as during filtration. Starting with hot water and boiling the liquid breaks the coagulated protein down into small bits of protein, which are hard to remove and result in a cloudy stock. Finally, veal bones are frequently added in the preparation of both veal and beef stock. Because veal is produced from a young calf rather than an older steer the collagen in the connective tissue of veal bones is much less cross-linked than in beef (the degree of collagen cross-linking increases with the age of the animal). That means the collagen in veal bones breaks down more rapidly and completely to gelatin so veal bones yield a lot more gelatin.

Can you identify in this photo (from Wikipedia) what the cook is doing incorrectly to make a really flavorful stock? Send me your answers.