An Investigation of the Kinetics and Equilibrium Chemistry of Cold-brew Coffee
Caffeine and Chlorogenic Acid Concentrations as a Function of Roasting Temperature and Grind Size

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Abstract

Recently both small and large commercial coffee brewers have begun offering cold-brew coffee drinks to customers with the claims that these-water-extracted coffee contains fewer bitter acids due to brewing conditions (Toddy website, 2016) while still retaining the flavor profile. Dunkin Donuts’s website suggests that the cold-water and long brewing times allow the coffee to “...rise to its purest form.” With very little research existing on the chemistry of cold-brew coffee consumers are left to the marketing strategies of thefirms and other companies regarding the merits of cold-brew coffee. This research analyzes the caffeine and chlorogenic acid (CGA) content of cold-brew coffee as a function of brewing time, grind size, and roasting temperature of coffee beans sourced from the Kona region of Hawaii using high pressure liquid chromatography (HPLC). Coarse and medium grinds of both dark and medium roasts were analyzed by mixing 350mL of filtered water with 85g of coffee grinds under constant stirring at 20°C. Sampling was performed every 15 minutes for the first hour, then every 30 minutes for the next ten to twelve hours, with a final sample being drawn at 24 hours. Equilibrium concentrations for both 3-CGA and caffeine were reached following 600 minutes. The caffeine concentrations ranged from (385mg/L to 1745mg/L). Variation was seen as a function of roasting temperature, and as so grind size. The 3-CGA concentrations were found to range from (84mg/L to 874mg/L). In both cases, the medium roast coarse grind produced the lowest concentrations of caffeine and 3-CGA, while no experiments agreed well with caffeine and 3-CGA extraction concentrations in both dark roast coffees, showing very similar final concentrations. The medium roast coffees showed deviation from the hot brew coffee with respect to caffeine, indicating the need for additional experimentation to determine the role of temperature in the availability of caffeine during extraction.

Why Cold Brewed Coffee?

Breast milk requires the extraction of compounds from coffee grounds. The suite of compounds give coffee its flavor, pith, and aroma (as well as potential antioxidant characteristics and all-important caffeine content). The concentration of compounds in coffee and the time it takes to extract it is controlled by an interplay between the solids (particulatematter), the liquid solvent (the water), and the movement of the compounds between the solid and liquid phases (diffusion). The movement is controlled by several factors, including (but not limited to) available surface area (grains//grind size), temperature (kinetic energy), and the solubility of compounds in the water extract (intermolecular forces). In this experiment, we vary the concentration of compounds in coffee by brewing at different temperatures, which in turn affects the concentration of compounds in the water extract. The hot brew temperature is 200°C, which is below boiling point, and therefore very little has been published on the kinetics (the speed of extraction) and equilibrium (magnitude of extraction) of these compounds during cold water (cold brew) extraction. Cold brew coffee is said to have a more mild (less acide) taste and less caffeine. A recent article published by Huffington Post (7) titled “Cold Brew Coffee Better” (2017) claim that cold brew coffee is between 600 mg/L and 874 mg/L. However, these values are not comparable to the experimental results found in this study.

Kona Coffee

Kona coffee refers to Arabica coffee cultivated from the slopes of Mauna Kea and Mauna Loa in the North and South Kona Districts of the Big Island of Hawaii. This region of the Big Island is known for its volcanic landscape, the coffee plants must be that of Kona. This region, a variety typical to the Kona region.

We used 100% Kona coffee sourced from the Kona region of Hawaii. In addition to the growing location, the coffee plants must be that of Kona. Because we were able to eliminate many variables that may affect the chemical composition of coffee by buying from a farm directly. Plus, there should always be good coffee available for extraction regardless of water temperature. The medium roast coffees showed over time to be a decrease in the extraction of CGA. While brewing time is also a matter of taste preference, time periods in excess of ten hours do not result in additional caffeine or 5-CGA concentration.

Result and Conclusion

Brewing Time - For all prism set and roasting temperature tested, all samples reached their final concentration by 600 minutes for both caffeine and 3-CGA. While brewing time is a matter of taste preference, time periods in excess of ten hours do not result in additional caffeine or 5-CGA concentration.

Brewing Temperature - Both dark roast coffee showed comparable 3-CGA and caffeine concentrations for cold and hot brewing methods. Maximum extraction concentrations were obtained using a pseudo-first order kinetic equation, which offered a superior fit than the second-order kinetic model. Only ten brewing methods were employed in this study, but these preliminary results suggest that dark roast coffee, these organic compounds are available for extraction regardless of water temperature. The medium roast coffee showed comparable 3-CGA extraction for cold and hot brewing methods, however there was deviation between cold and hot experiments with regards to caffeine. Furthermore, the concentrations of caffeine and 3-CGA in the cold brew experiments fell within the range published by Ho et al, (2005) in their study of hot brew coffee extraction, with the exception of the medium roast coarse grind sample (7). This indicates that contrary to previous results cold brew coffee may contain more 3-CGA (and possibly other CGA isomers) than hot brew coffee. Additional brewing methods need to be tested to evaluate the role of brewing method in extraction efficiency and magnitude.

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References