Experiment #1: The Effect of Brewing Temperature on Coffee Concentration

Stephanie Farrell, Robert Hesketh, and Jeffrey Steingarten
August 30, 2002

Submitted to: Dr. Mariano Savelski
Principles of Food Engineering
0901-501

Abstract

This report describes an investigation of the effect of grinding time on the concentration of Starbuck's French Roast Coffee produced in an Automatic Drip Coffee Maker. Coffee concentration was determined using a spectrophotometer. The concentration of coffee in the brewed product demonstrated an exponential dependence on the grinding time of the roasted beans.

Introduction

The manufacturers of coffee and coffee making equipment advise that choosing the appropriate grind of coffee for the brewing method used is of critical importance in obtaining a good quality product. Using the wrong grind can quickly destroy the flavor of the very best gourmet beans. If the grind is too fine, the coffee will be bitter and over-extracted. If the grind is too coarse, the coffee will taste weak and sour[1].

The grind of coffee is determined by the length of time the roasted beans are ground. One of the primary factors affecting the taste of coffee is the strength, or concentration, of the coffee. The purpose of this study is to determine the effect of the grinding time on the strength of Starbuck's French Roast Coffee, brewed in an Automatic Drip Coffee Maker. The results will be compared to the model developed by Farrell and Hesketh[2].

Theory

Leaching is the process by which a substance is removed from a solid by a liquid extraction medium. Important factors affecting leaching are the temperature, contact time, contact area, and solvent selection[3]. The contact area per unit mass of a solid particle increases with decreasing particle size.

In the preparation of coffee, the particle size is determined by the time for which the roasted beans are ground. Thus the grinding time is expected to have an effect on the concentration of the brewed coffee.

Farrell and Hesketh[2] have shown previously that coffee strength exhibits the following dependence on grinding time:

$$C = k_1 t^2 + k_2 t + k_3 \quad (1)$$

Where C is the coffee concentration (g/L), t is the grinding time (s), k_1 is a constant with units of ($g/L \cdot s^2$) and k_2 is a constant with units of (g/Ls) and k_3 is a constant with units of (g/L). This relationship was developed for La Colombe Breakfast Blend Coffee produced in an automatic coffee maker with a water temperature of 97 ^oC.

Materials and Methods

French Roast Coffee beans were obtained from Starbuck's Coffee (Seattle, WA) and stored in an airtight container at room temperature. A Krups (Nummener, Germany) 203-42 Fast Touch coffee grinder was used to grind the beans. A Capresso (Switzerland) Team Luxe Automatic Drip Coffee maker was used to brew the coffee. Distilled water was used in the brewing. The temperature of hot water was monitored using a type T thermocouple and data acquisition. A Spectronic 21 Spectrophotometer was used for concentration determination.

Experimental Procedure

Approximately 30 g of coffee beans were placed in the coffee grinder and ground for a specified amount of time (6-30 s). 25 g of ground coffee was removed and placed in the coffee maker's gold tone filter. The reservoir was filled with 0.5 L distilled water. After turning on the coffee maker, the temperature of the hot water was monitored to ensure that a constant 97 ^oC was maintained.

Upon completion of the brewing, a 10 ml sample was removed and stored in a sealed glass sample vial for analysis, which was performed after the sample cooled to room temperature.

Coffee concentration was determined using a spectrophotomer with a wavelength of 640 nm. A calibration curve was prepared by plotting known concentrations as a function of Absorbance at 640 nm. The concentration of the calibration samples was determined by drying and weighing the residue.

Results

The calibration curve for the determination of coffee concentration by spectrophotometer is shown in Figure 1. The absorbance, A, increases linearly with concentration according to the equation

$$C = \left(16.81 \frac{g}{L}\right)(A) \tag{2}$$

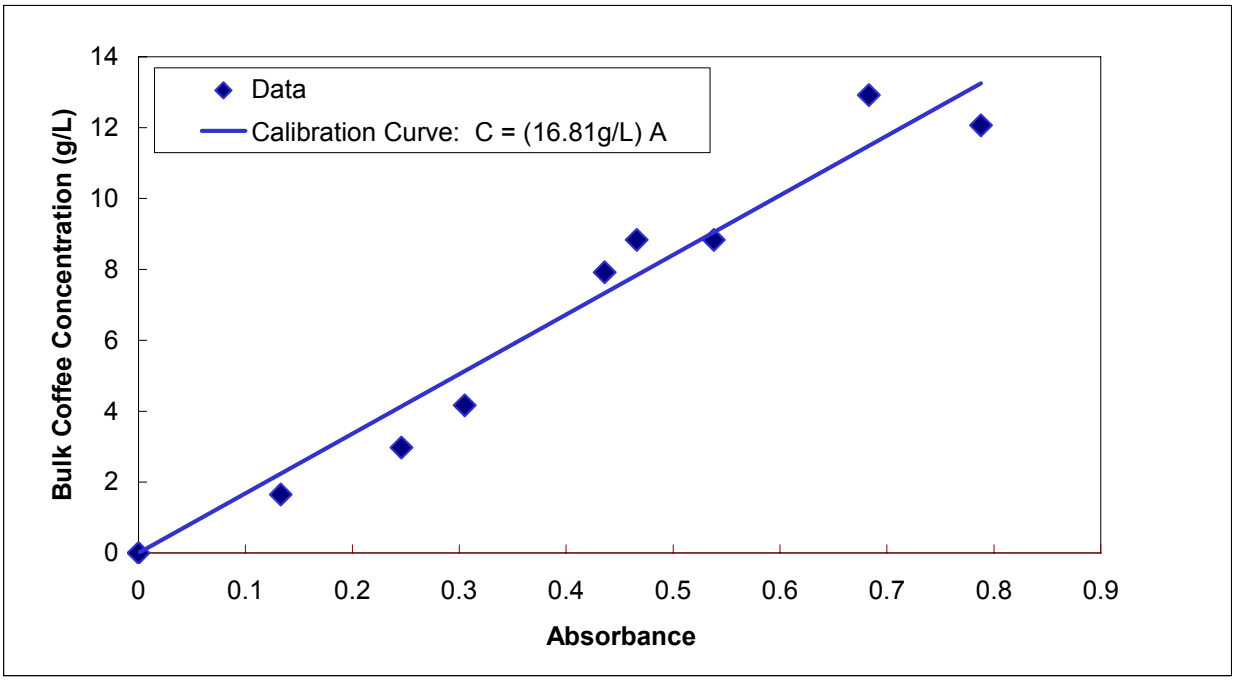

Figure 1. Calibration curve for coffee concentration determination using a spectrophotometer at 640 nm

The coffee concentration exhibited an increase with increased grinding time, as shown in Figure 2. Since the particle size of the ground coffee decreases with increased grinding time, the results are consistent with leaching theory which states that concentration increases with increasing surface area (smaller particle size). The solid line shown in Figure 2 shows the best fit of the data to the polynomial model developed by Farrell and Hesketh[2]. The close agreement between the data and the model shows that the concentration-grinding time dependence of Starbuck's French Roast Coffee brewed in an automatic drip coffee maker can be described by the Farrell and Hesketh[2] leaching model, with k_1=-0.007 (g/ls^2), k_2= 0.3975 (g/Ls) and k_3 = (0.5368 g/L). The Laboratory Data Sheet for this experiment is provided in Appendix 1.

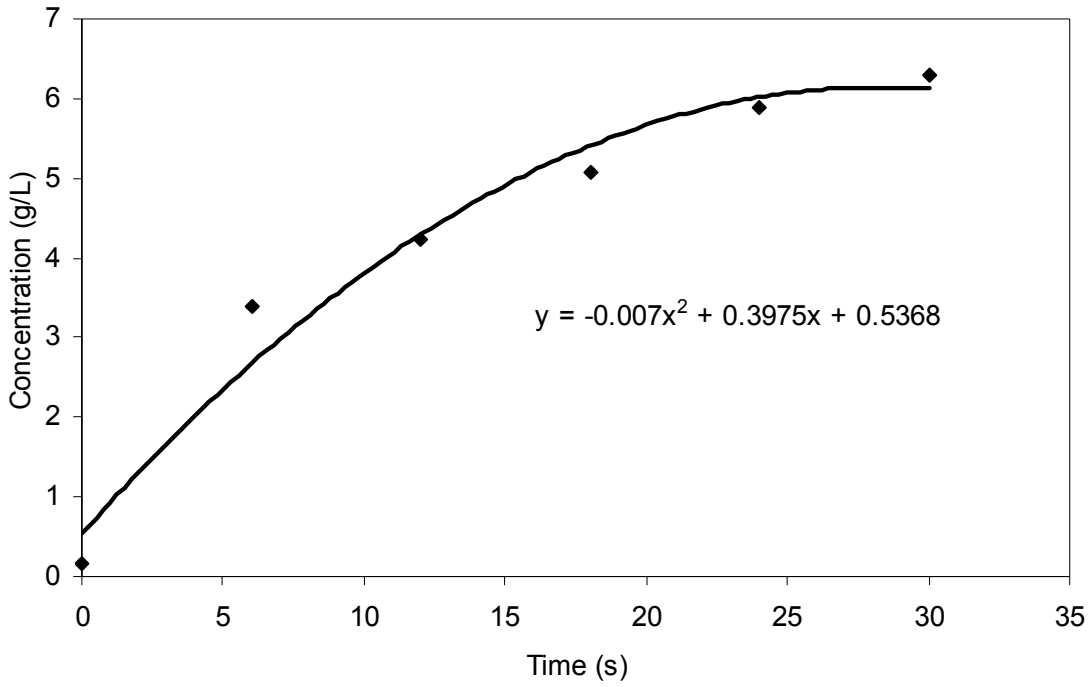

Figure 2. Concentration as a function of grinding time for Starbuck's French Roast Coffee brewed in an Automatic Drip Coffee Maker.

Conclusions

The concentration of Starbuck's French Roast Coffee brewed in an automatic drip coffee maker increases with the grinding time of the bean. The concentration follows a polynomial dependence on grinding time which is consistent with previous results for La Colombe Breakfast Blend Coffee reported by Farrell and Hesketh[2].

Future studies should include the determination of coffee particle size as a function of grinding time. This would allow a direct correlation between coffee concentration and particle size (or area).

References

[1] Caffeine, M.J. and I Colombian,. Factors affecting coffee quality, *Int. J. Coffee*, 35(2) 2001, 23-31.
[2] Farrell, S. and R. Hesketh, Factors affecting coffee strength, *J. Coffee Qual*., 47(3) 2002, 45-41.
[3] Perry, R. and D.W. Green, , Perry's Chemical Engineers' Handbook, 7th ed., McGraw Hill, New York, 1997.