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An Equilibrium Desorption Model for the Strength and Extraction Yield of Full Immersion Brewed Coffee

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Introduction

It is well established that the sensory profile of the brew is highly correlated with the strength (i.e., the total dissolved solids, TDS) and the extraction yield E of the brew. Despite the importance of these two metrics to coffee, there are few theoretical models available to predict how different brewing parameters affect TDS and E, with extant models focusing on flow extractions like espresso or drip brew. An equally important class of brews involves full immersion, such as that found in classic French press or the traditional cupping method used by coffee professionals. We derived and experimentally corroborated a pseudo-equilibrium desorption model for the TDS and E of full immersion brewed coffee.

Materials/Methods

A predictive model for the TDS and E of full immersion brewed coffee was derived using a pseudo-equilibrium desorption approach assuming a single species-averaged equilibrium constant K. Coffee was brewed using full immersion method (Figure 1) where coffee grounds were submerged in water over a wide range of brew ratios, brew temperatures, grind sizes, and roast levels. Experimentally measured TDS and E of full immersion coffee brewed at various conditions were analyzed and compared to the model predictions.

Conclusion/Perspectives

In terms of practical implications, our results indicate that full immersion brewing offers precise control over the TDS by brew ratio but little control over E, so the relative simplicity of full immersion brewing is offset by a lack of flexibility in fine-tuning the desired sensory profile.

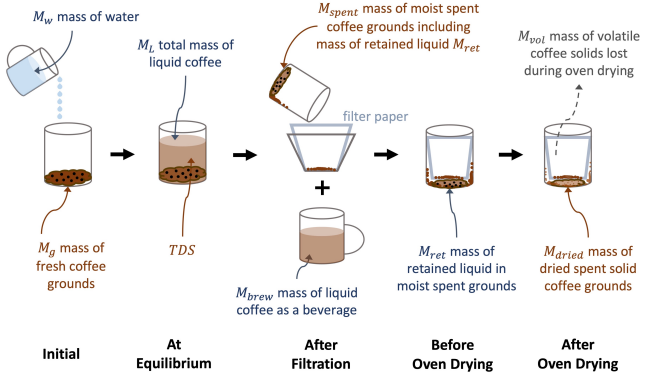

Figure 1: Schematic of a full immersion brew with oven-drying measurement of extraction.

Results/Discussion

Our model yields theoretical predictions indicating that the TDS is approximately inversely proportional to the water/coffee mass brew ratio (Figure 2), while E is independent of the brew ratio (Figure 3). Our experimental results yield excellent agreement with both theoretical predictions, and further demonstrate that the species-average equilibrium constant is surprisingly insensitive to the major brewing parameters including grind size, roast level, and brew temperature over the range 80-99°C. An analysis of the standard oven-drying method for measuring E indicates that it yields significant underestimates of the true value at equilibrium, due to retained brew within the spent moist grounds.

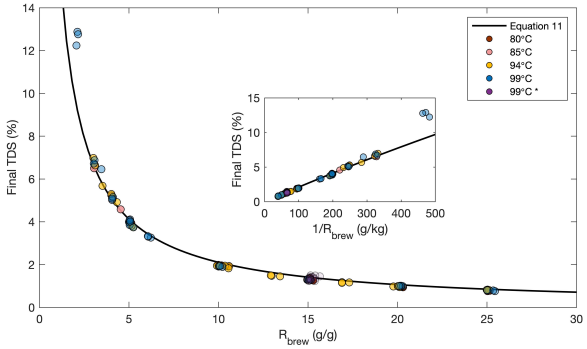

Figure 2: Equilibrium TDS vs. brew ratio for 1-L full immersion brews at various brew temperatures 80-99°C and grind sizes 2-6. The asterisk in legend denotes brews with wide range in grind particle sizes.

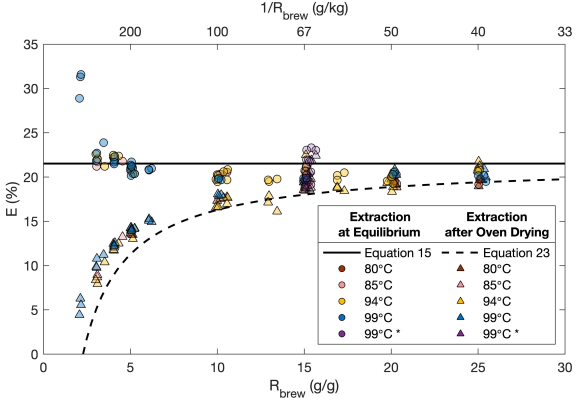

Figure 3: Equilibrium E vs. brew ratio for 1-L full immersion brews at various brew temperatures 80-99°C and grind sizes 2-6. The asterisk in legend denotes brews with wide range in grind particle sizes.

References:

Liang, J., Chan, K.C. & Ristenpart, W.D. An equilibrium desorption model for the strength and extraction yield of full immersion brewed coffee. *Scientific Reports* **11,** 6904 (2021). https://doi.org/10.1038/s41598-021-85787-1

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