28th Conference Asic 2021
From 28 June to 1 July 2021

A simple predictive model for the espresso coffee Extraction Yield

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S8-PO-11

Introduction

The flavour of coffee is determined by the physico-chemical characteristics of the coffee powder and the settings of the extraction process. This is a very complex phenomena whose formulation generally gives complicated models, see [1] for details. The simplification of these computational tools for the evaluation of Extraction Yield (EY), is an important step for the coffee industry, providing a concrete possibility to predict the result of the preparation phase. We consider a simple simulation tool for the prediction of the espresso coffee EY.

Methods

The computation of EY is based on a simplified mathematical model that describes the extraction process. It considers the transport and diffusion of chemicals by the water flow, and the diffusion process of the substances through the grains in the solid phase, see [2], [3] for details. A simulation tool, based on a finite difference approximation of such model, allows a fast computation of EY from the knowledge of the extraction parameters and the physical-chemical characteristics of the coffee pod. The accuracy of the model is tested by a comparison with EY values calculated from Total Dissolved Solids measurements of laboratory experiments.

References:

[1] Giacomini, J. et al., *Int. J. Multiph. Flow*, 2020

[2] Cameron, M. I. et al., *Matter*, 2020

[3] Moroney, K. M. et al., *PLoS One*, 2019

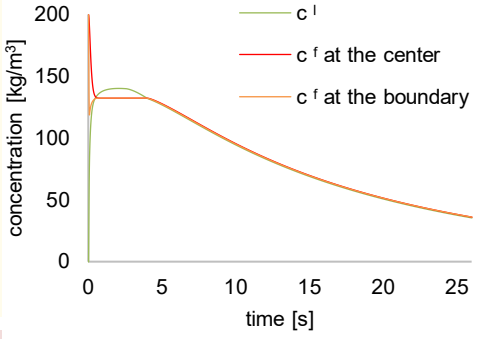

Figure 1: Liquid and fines concentration curves during the simulated extraction of the O_M sample at half height of the coffee powder.

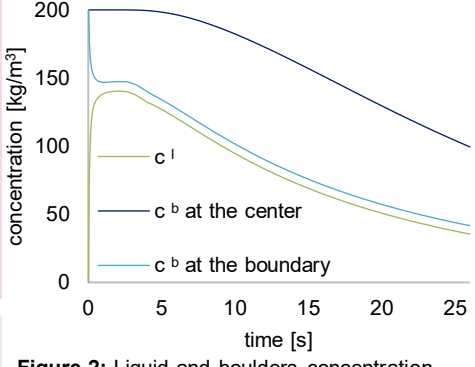

Figure 2: Liquid and boulders concentration curves during the simulated extraction of the O_M sample at half height of the coffee powder.

	EY_E [%]	EY_N [%]
EF_{CA}	21.45-21.80	22.58
F_M	22.07-22.58	21.90
O_M	20.43-20.87	19.76
O_{CA}	20.34-21.35	20.93
C_M	19.09-20.11	19.37
EC_{CA}	18.02-19.11	18.37

Table 1: Numerical and experimental results

Results/Discussion

Table 1 shows the comparison between the EY_N values obtained by the numerical simulations and the EY_E values coming from the laboratory experiments, collected under different conditions of water pressure, temperature, granulometries and coffee types. The EY_N value for the samples O_{CA}, C_M, EC_{CA} falls in the range of the corresponding EY_E value. The remaining samples show an EY_N that is very close to the range identified by the EY_E, in particular, for EF_{CA} there is an overestimation of about 4%, while for F_M and O_M there is an underestimation of about 1% and 3%, respectively.

Conclusion/Perspectives

In the future, this tool for the EY prediction could be integrated into professional coffee machines in order to increase the extraction control. Moreover, having traced the EY, it is possible to study how to increase the extraction while reducing the coffee powder used, so as to satisfy the sustainability goal of coffee industry.