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Application of a research engineering approach to map the physical capabilities of an automated production roaster

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RATIONALE

An infinite number of temperature pathways can be applied to transform coffee from green to roasted, each impacting the final flavour profile. Automated production roasters offer high repeatability of specified input conditions - but optimal process conditions first need to be established by the developer. By systematically mapping the impact of key roasting parameters on roasted coffee properties, the process can be tuned to achieve the target flavour profile.

This study aimed to develop a predictive tool for coffee's physicochemical transformation during roasting based on a research engineering approach.

METHODS

Roaster

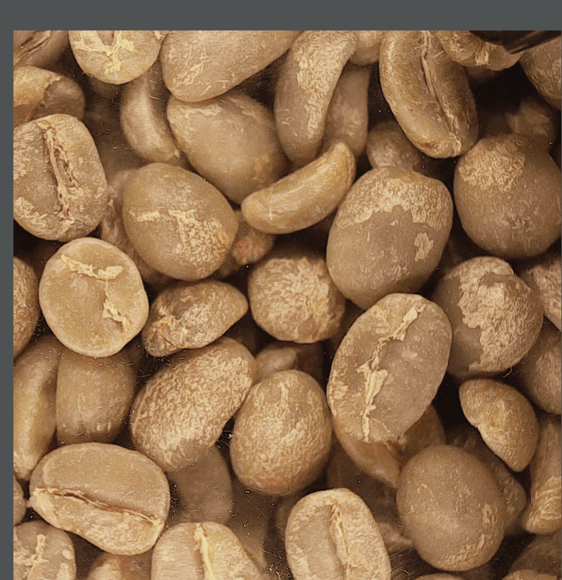
Roest P3000

Green Coffee

Supplied by Raw Material via Muraho Trading Company

Cyesha washing station, Rwanda

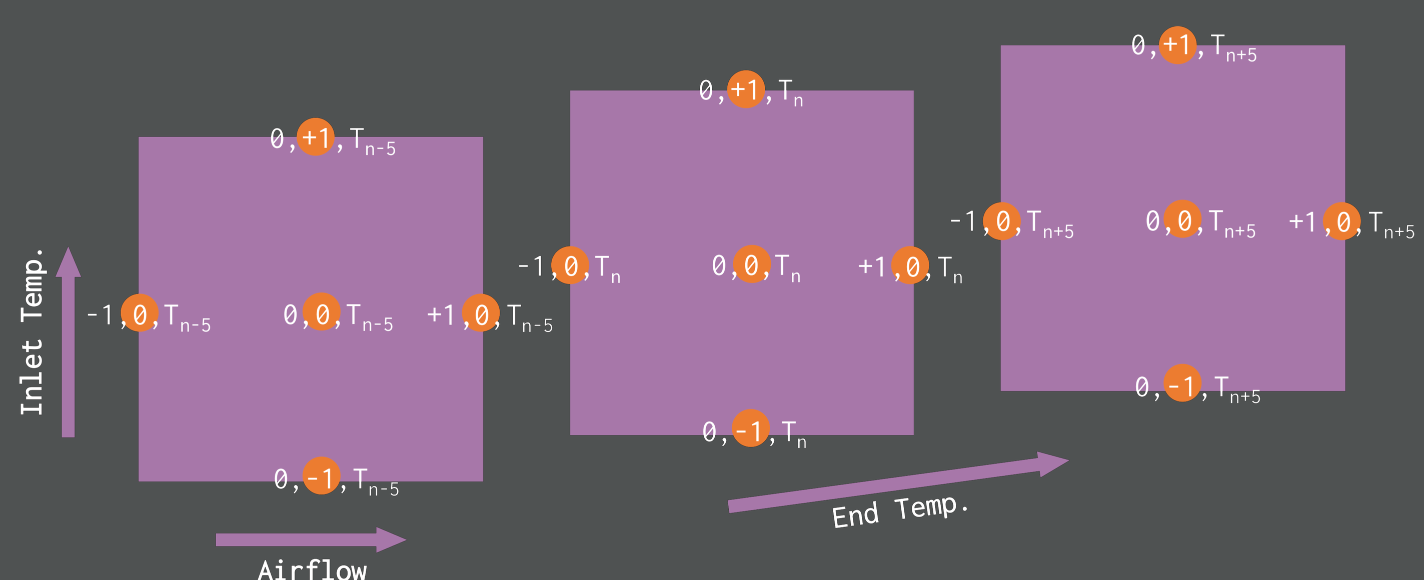
washed-processed



natural-processed

Design of Experiments

A rotated, full-factorial design to explore the impact of airflow and constant inlet air temperature on process responses (time, number of cracks) and coffee's physicochemical properties (density, colour, moisture).



Modelling

A response surface model fitted using data at each temperature end condition:

$$y = \beta_1(\text{airflow}) + \beta_2(\text{inlet temp.}) + \beta_3$$

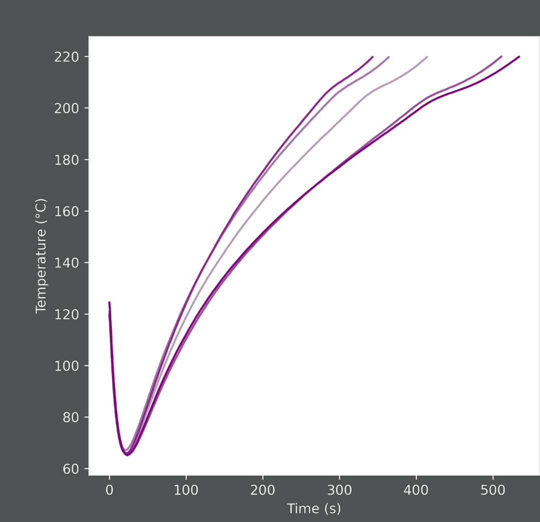
Coefficients of each model correlated with temperature end condition:

$$\beta_n = f(\text{end temp.})$$

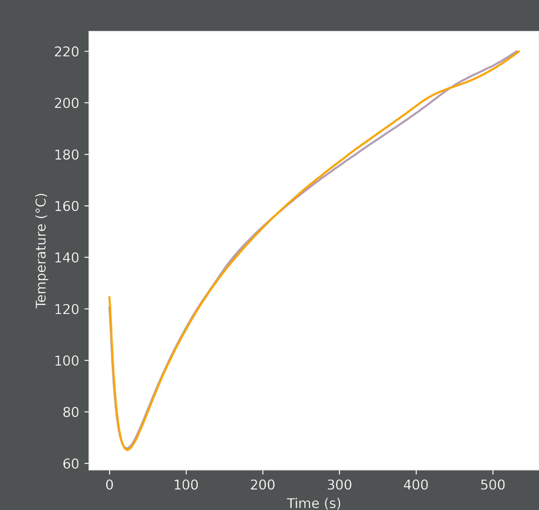
RESULTS

Time-temperature data

Washed-processed coffee, different inlet air temp's and flows with 220°C end temp.

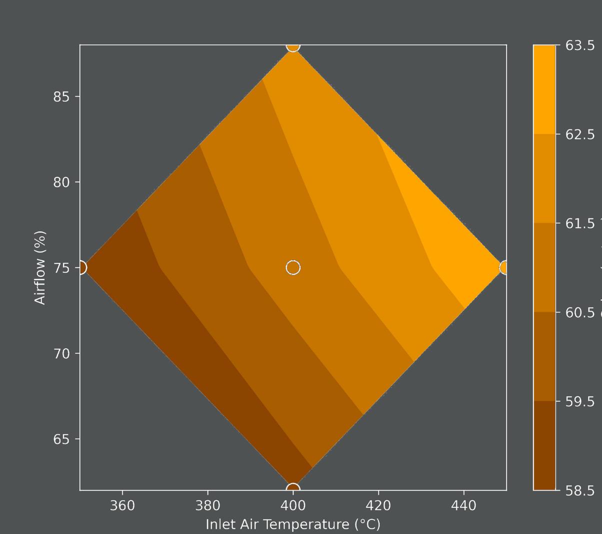


Washed- and natural-processed coffees, low inlet air temp and moderate flow with 220°C end temp.

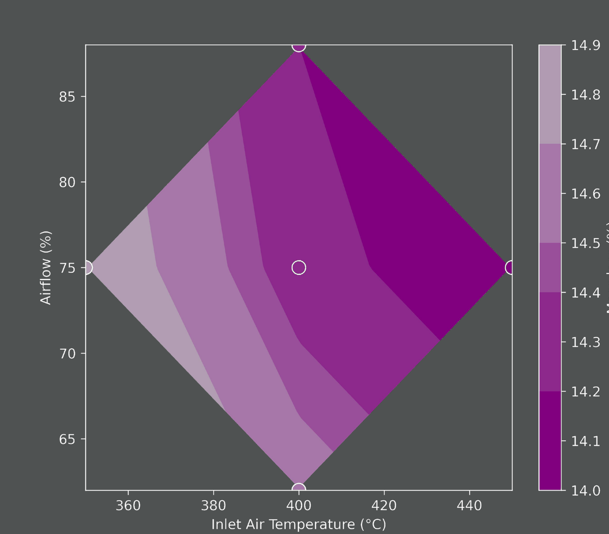


Response surfaces

Impact of airflow and inlet air temp. on colour for natural-processed coffee, roasted to 220°C end temp.

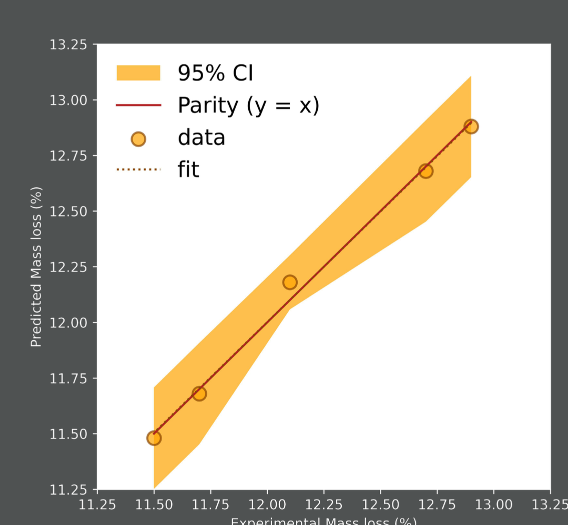


Impact of airflow and inlet air temp. on mass loss for washed-processed coffee, roasted to 220°C end temp.



Modelling

Parity plot for model fitted to mass loss data for natural-processed coffee roasted to an end temp. of 210°C



Coefficients for model fitted to colour data for washed-processed coffee roasted to an end temp. of 210-220°C

End bean temp. (°C)	Intercept	Inlet air temp.(°C)	Airflow (%)
220	38.50	0.047	0.0346
215	26.38	0.060	0.1654
210	17.41	0.085	0.2231

CONCLUSIONS & PERSPECTIVES

Conclusions

A research engineering approach effectively mapped the physical capabilities of an automated production roaster for two distinct coffees. The predictive tool developed here enables optimisation of roasting conditions to achieve coffee's desired physicochemical properties.

Perspectives

This framework provides basis for augmented, virtualised roasting profile development, such that calibrated models can be used by coffee professionals to (i) accelerate product development, (ii) enhance roasting consistency and (iii) improve in-cup flavour profiles.