

Optimization of citric acid extraction from lime peels using response surface methodology

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Introduction

Citrus fruits, like lime, belong to the most consumed group of fruits worldwide, generating a large amount of industrial waste, such as peels, pomace and seeds¹. Most of this waste is deposited in landfills leading to a negative environmental impact².

Several scientific works demonstrate that this biowaste is rich in valuable molecules, such as organic acids (e.g. citric acid) with scientifically proven bioactive properties^{3,4}.

Objective

The objective of this study was the optimization of citric acid extraction (high antimicrobial power) from lime peels, in order to value citrus biowaste through their recycling into natural ingredients, namely preservatives.

Results and discussion

- ✓ The ethanol proportion affected the extraction through negative linear effects, which means that by increasing the ethanol proportion, the amount of extracted citric acid decreases (Figures 1A and 1B).
- ✓ Quadratic effects were observed for citrus biowaste, induced by the extraction time followed by the ethanol proportion (Figure 2A and B).
- ✓ The ultrasonic power did not cause significant effects nor interaction coefficients between the variables in this extraction process.

When applying the optimal processing conditions (medium ultrasonic power, medium-low time, and low ethanol proportion), it was possible to recover 3.4 g of citric acid per 100 g of dry lime peels (Table 1).

Table 1. Optimal processing conditions that maximize the extraction of citric acid from citrus peels and predicted responses.

	Optimal UAE conditions			Citric acid content
	Time (min)	Ultrasonic power (W)	Ethanol proportion (% v/v)	(g/100 g dry peel)
Lime peel	5.8	141.4	7.0	3.4±0.2

Conclusion

This studied contributes to the valorisation of citrus biowaste through their recycling into a natural ingredient. Lime peels proved to be a good source of citric acid, although a deeper analysis of these ingredients is necessary to allow the industries to implement sustainable extraction techniques and to use citric acid recovered from citrus residues as a food preservative.

Acknowledgements

To FCT (Portugal) for financial support through national funds FCT/MCTES to CIMO (UIDB/00690/2020), for the PhD grant (SFRH/BD/145467/2019) of F. Fernandes, the contract of L. Barros through the institutional scientific employment program-contract and the contracts of M. Carochó (CEECIND/00831/2018), S.A. Heleno (CEECIND/03040/2017) and J. Pinela (CEECIND/01011/2018) through the individual scientific employment program-contract. To MICINN for the financial support Ramón & Cajal given to researcher M.A. Prieto; to the Government of Galicia for the financial support of Axudas Conecta Peme to the IN852A 2018/58 NeuroFood project. To Kontaktotal - Consultores Associados, Lda. - Dep. CuraNatura for collaborating on this project.

Methodology

Extraction optimization – Ultrasound-Assisted Extraction



Response Surface Methodology (RSM)

Combining five levels of the variables

Processing time (2–45 min; t)
Ultrasonic power (50–500 W; P)
Ethanol proportion (0–100%; S)

The Design-Expert software (Version 11) was used to generate the 20 experimental points of the RCCD design

These designs included
8 factorial points
6 axial or star points
6 replicated center points

Levels of citric acid were determined by UFLC-PDA

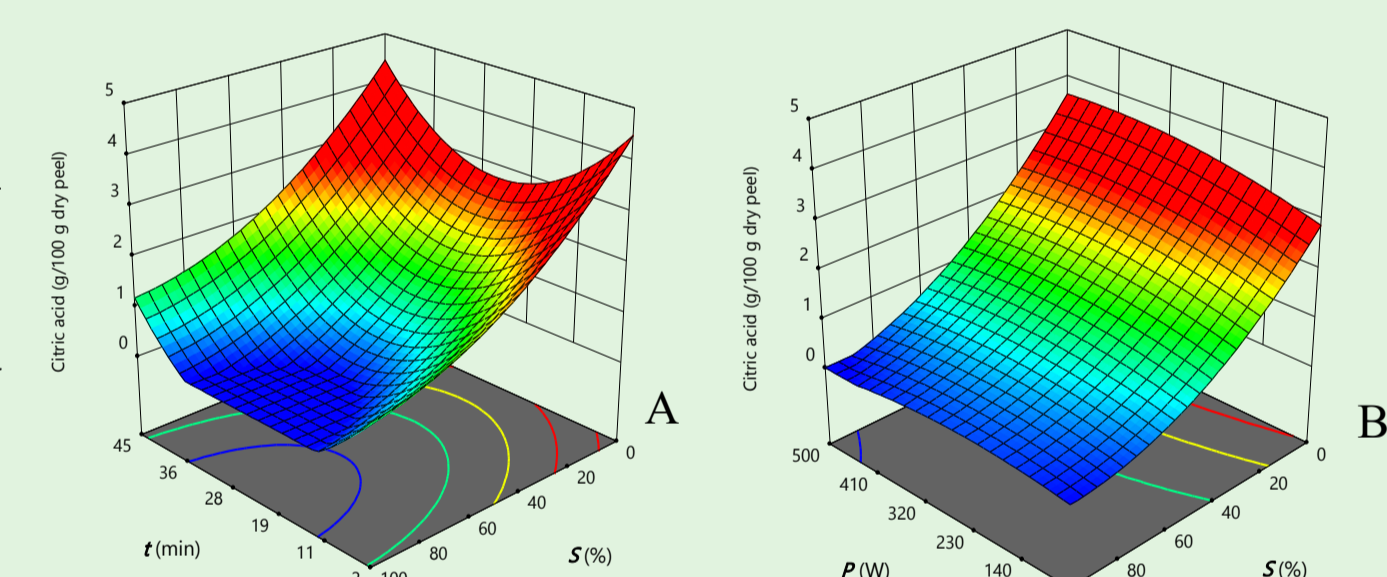


Figure 1. Response surface graph for the effects of the ethanol proportion on the citric acid levels obtained from lime peels.

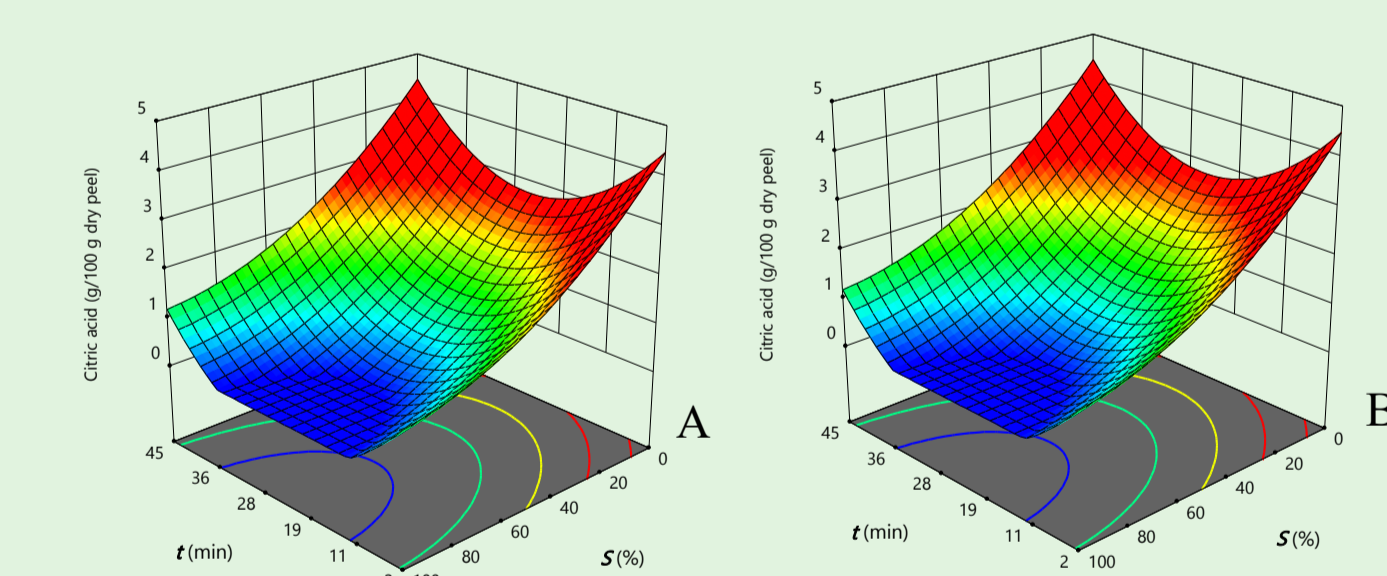


Figure 2. Quadratic effects caused by the extraction time and by the ethanol proportion.